ISSUES AND TRENDS IN RADIOACTIVE WASTE MANAGEMENT

Proceedings of an International Conference, Vienna, 9–13 December 2002

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International Atomic Energy Agency

ISSUES AND TRENDS
IN RADIOACTIVE
WASTE MANAGEMENT

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ON ISSUES AND TRENDS
IN RADIOACTIVE WASTE MANAGEMENT
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AND THE OECD NUCLEAR ENERGY AGENCY
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FOREWORD

Radioactive waste is an inevitable residue from the use of radioactive materials in industry, research and medicine, as well as from the use of nuclear power to generate electricity. The management and disposal of such waste is, therefore, an issue relevant to almost all countries. The strategies and techniques for the safe management of the various types of waste arising from the different applications are well established and extensive experience has been obtained in most, if not all, areas. Nevertheless, radioactive waste remains an important item on the agenda of many countries, not least because of the perception by the public and by politicians that it is a problem that has yet to be solved. Therefore, the subject continues to be highly topical and considerable efforts are being expended nationally and internationally to solve the remaining problems.

With this in mind, the IAEA organized an International Conference on Issues and Trends in Radioactive Waste Management. The objective of the conference is to foster information exchange on current issues in the area of radioactive waste management and to promote international coherence on strategies and criteria for their resolution. The conference was organized in co-operation with the European Commission and the OECD Nuclear Energy Agency, and held in Vienna from 9 to 13 December 2002. Within the IAEA, the conference was organized jointly by the Department of Nuclear Safety and the Department of Nuclear Energy.

The conference was structured to promote discussion of selected topical issues in the subject area and, where possible, to reach conclusions and recommendations on how to proceed to the resolution of the issues, especially in an international context. After an opening session and a session in which an international overview of the radioactive waste management scene was given, the main part of the conference consisted of nine sessions in which topical issues in radioactive waste management were addressed. Each session typically consisted of one or two introductory presentations by senior experts followed by a panel discussion in which there was an intensive exchange of views between panel members and the audience. In the final session, the Chairpersons of the individual technical sessions presented the results, conclusions and recommendations from each of the panel discussions. The conference was closed after a summary presentation by the Conference President.

These proceedings contain a conference summary and all the presentations and summaries of discussions together with the opening and closing addresses and the summaries of the Session Chairpersons and the Conference President.

The contributed papers are provided on a CD-ROM which accompanies this publication.

EDITORIAL NOTE

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EXECUTIVE SUMMARY

REPORT ON THE INTERNATIONAL CONFERENCE ON ISSUES AND TRENDS IN RADIOACTIVE WASTE MANAGEMENT

The International Conference entitled 'Issues and Trends in Radioactive Waste Management' was organized by the IAEA, in co-operation with the European Commission and the OECD Nuclear Energy Agency. The conference was held in Vienna from 9 to 13 December 2002 and was presided over by A.J. Baer of Switzerland. The following is a summary of the findings of the conference.

At its outset, the conference was made aware of the general progress that has been made in recent years towards the resolution of the problems in the radioactive waste management area. In particular, the progress towards establishing geological repositories for high level radioactive waste in Finland and in the United States of America was noted.

The entry into force of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management was recognized as a 'landmark' event — setting the stage for a process of systematic international improvement of waste management safety.

Long term surface storage, as opposed to the final disposal of radioactive waste and spent nuclear fuel, is becoming a reality in many countries. This is occurring for various reasons, including:

— Delays in final repository programmes;
— Lack of resources;
— Uncertainties about whether spent fuel should be considered a waste or a resource;
— Lack of public acceptance of disposal;
— Lack of political will to proceed with disposal.

It was concluded that, in the long term, surface storage is unsustainable because of the need to maintain institutional control to guarantee the safety of the storage facility. This is an important issue on which a clear, internationally agreed policy would be valuable.

A recurring issue was the problem of providing institutional mechanisms for the long term safety of radioactive waste, especially for the waste types that are not isolated from the human environment, and of ensuring that knowledge of the existence of the waste and of the associated hazards is not lost.

Throughout the conference, the need to involve concerned members of the public in national decisions related to radioactive waste management was emphasized. The discussions showed that solutions to waste management problems can rarely be achieved by purely technical means; socio-political input is required. The theme is not new, but it was given particular significance during the conference. It raises the question of the role of the IAEA in this regard, and the extent to which the IAEA, which is concerned principally with technical matters, can and should become involved in the resolution of socio-political issues in the context of radioactive waste management.

Some specific findings include the following points:

(i) In some parts of the world, policies for the control of radioactive discharges to the environment are now being determined mainly by social and political factors. There is a danger that such policies are being developed without proper regard for broader waste management and energy supply implications.

(ii) It is generally recognized that the fundamental science and technology of deep geological disposal is well established. In many countries, the key issue in the process of establishing underground waste repositories is obtaining local acceptance of the siting of disposal facilities. Experience shows that for local acceptance to be obtained, processes have to be established which allow concerned local people to have a proper role in decision making.

(iii) With the recent progress in some countries towards developing geological repositories for high level waste, the time has come for the IAEA to clarify the requirements for nuclear safeguards in this context.

(iv) To date, the main focus in the context of the problem of disused sealed sources has been on bringing them under regulatory control. In the longer term, however, it is necessary to provide for their safe disposal. The discussions which took place during the conference suggested that international action could be helpful in finding solutions to the problem, for example, by facilitating the return of sources to suppliers through the improvement of arrangements for their transportation between countries and by providing international guidance on the feasibility and safety of the borehole disposal option.

(v) It has been recognized that significant radiation doses can arise from waste associated with industries other than the nuclear industry, mainly from waste containing naturally occurring radioactive materials. Different approaches to the regulation of the industries in question and to the disposal of the waste are being adopted. Improved coherence and consistency of approach is desirable, and international guidance may help, provided that it gives the flexibility necessary to allow for case by case solutions.

(vi) Radioactive waste from past activities and events exists in many countries. Recovery and remediation programmes are under way, but there is often debate concerning the most appropriate standards to apply. Standards based on health protection considerations are sometimes being rejected in favour of more restrictive standards influenced by public concern. The issue requires further consideration at the international level, with the objective of having standards that will be universally applied.

(vii) Opinion polls show that the public's perception of the nuclear industry is heavily influenced by concern over radioactive waste. This situation will change only when the nuclear industry and its representatives have established, through policies of openness and transparency, a convincing 'track record' of responsiveness to the concerns of stakeholders.

(viii) An international regime for radioactive waste safety now exists, comprising a legally binding convention, a set of internationally agreed safety standards, and mechanisms to ensure compliance with both the convention (a review process) and the standards (international peer review teams). Member States now need to work with the IAEA in using those mechanisms to raise the levels of safety in radioactive waste management worldwide.

OPENING SESSION

Chairperson

A.J. BAER
Switzerland

WELCOMING REMARKS

D.B. Waller
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On behalf of the Director General of the International Atomic Energy Agency, I would like to welcome you to Vienna and to this conference on Issues and Trends in Radioactive Waste Management. I also welcome you on behalf of the two co-operating organizations, the European Commission and the OECD Nuclear Energy Agency (OECD/NEA).

The implementation of publicly accepted solutions to radioactive waste management and disposal is an issue central to the future of nuclear technology. The current scene has sometimes been characterized as a contrast between three 'realities': the physical reality, the technological reality, and the social reality.

The 'physical reality' is simple: waste exists, and the volume of high level waste continues to build. After four decades of generating nuclear energy, we have yet to construct and operate, anywhere in the world, a permanent geological repository that can receive spent fuel or high level radioactive wastes. The key point to be taken from this reality is that our discussions this week will not be a theoretical exercise. Until feasible solutions have been operationally demonstrated, the problem will continue to grow.

The 'technological reality' is far more encouraging. Disposal solutions are in place and working well for short lived and low level radioactive waste. And in dealing with the lack of near term solutions for permanent disposal of high level waste, the scientific community has continued to develop more stable waste forms, improved containers for storage and transport, and novel approaches to the partitioning and transmutation of long lived radioactive species. The benefit of these efforts is that we have in place a broad array of technologies for safely managing radioactive waste well into the future. However, until permanent disposal solutions are implemented, these technologies in most aspects only postpone dealing with the 'physical reality'. In this regard, the progress made in the past year towards permanent disposal facilities — at the Olkiluoto site in Finland and the Yucca Mountain site in the United States of America — is particularly gratifying.

The 'social reality' for radioactive waste issues reflects a significant gap in perception between scientific community in general, and the public at large.

Despite agreement among most experts that the transport, storage and disposal of spent fuel and radioactive waste can be safe, technologically feasible, and environmentally sound, the public remains largely unconvinced — and the sluggish pace of moving towards demonstrated solutions has only reinforced this negative perception.

As Marie Curie once said: “Nothing in life is to be feared. It is only to be understood.” Like most members of the nuclear community, I believe that public fears associated with waste storage, transport and disposal often stem from a lack of technological understanding. Nuclear science itself is complex, and the multiple classification systems and regulatory schemes associated with radioactive waste management make the topic seem even more mysterious and inaccessible to the layperson. In my view, we will only alleviate these fears once disposal solutions have been demonstrated for all forms of radioactive waste.

This brief overview of the so-called physical, technological and social realities encapsulates some of the points of discussion that should merit your attention this week — but there are other important issues to be addressed. Examples include the changing policies in some countries related to discharge controls; the management and disposal of disused sealed radioactive sources; the management of waste that includes large volumes of naturally occurring radioactive material; and the merits of developing an ‘international regime for waste safety’ — a topic that is receiving greater attention with the coming into force of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (the Joint Convention).

Those of us representing the IAEA take very seriously its statutory role in accelerating and enlarging the peaceful uses of atomic energy throughout the world — but we also take seriously our responsibility to ensure that nuclear technologies are applied in a safe, secure and environmentally sound manner. Our work in developing Safety Standards for radioactive waste management and disposal is in keeping with that sense of responsibility. Through this conference, we hope that your exchange of insights and opinions on these timely and important issues will help to direct and sharpen the focus of the IAEA’s work in this area. I wish you every success in your deliberations this week, and I look forward to seeing a positive and useful outcome from the conference.

OPENING ADDRESS

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More than two and a half years after the successful Cordoba Conference, the time has come to take stock of what has been achieved so far and to examine what remains to be done. You will hear the views of some important international stakeholders in a few minutes.

The International Atomic Energy Agency, in co-operation with the European Commission and with the OECD Nuclear Energy Agency (NEA), should be praised for planning and organizing this international conference on Issues and Trends in Radioactive Waste Management and for inviting us to what promises to be a most interesting week.

I am very honoured to have been asked to preside over this conference and I am looking forward to a week of presentations and debates that will bring us closer to our common goal, that of safe management of all radioactive waste.

A number of sessions of this conference will bring us up to date on the status of our present knowledge. The programme brings to my mind a colloquial US expression: "You've come a long way, baby!" Yes, we have come a long way and we can be proud of it.

Over the last 50 years or so, we have learned to recognize, sort out, handle and transport the various types of radioactive waste. We have developed a number of storage techniques. We have examined and evaluated just about every practicable (and some impracticable) methods for disposal and we have come to a general agreement that deep geological disposal is the best approach to dispose of high level radioactive waste. We have made considerable progress in dismantling and decommissionning nuclear installations and, most importantly, we have written the book on safe management of radioactive waste in the form of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, a convention that has now been in force for over a year.

Yes, we have done well over these last decades.

And yet...and yet, we have not done as well as we were hoping to. We have run into unexpected difficulties and the pace of our achievements has been progressively slowing down.

In his opening address at the Cordoba Conference, A.J. González, speaking for the IAEA, aptly summarized the situation:

> "the technological problems of assuring the safe management of radioactive waste seem to have been solved. However, as a result of certain public perceptions about the risks attributable to radioactive waste, the final disposal of high level waste has become infeasible in many parts of the world."

In other words, progress as we understand it is being held in check.

As you know, numerous possible remedies have been proposed, and some aspects of this very issue will be discussed more specifically on Wednesday afternoon and on Thursday morning. To find effective remedies, we need to understand what the illness is and to recognize its roots. We must, therefore, make further efforts to comprehend what has been happening, and why it has.

One interesting suggestion offered by some is that the problem lies in the lack of a lobby for radioactive waste disposal. Indeed, who wants to lobby in favour of radioactive waste disposal? Certainly not politicians, they cannot win elections on that platform. Scientists and technologists contend that this is a political issue and that they are not competent. The nuclear industry is in no hurry to spend money on disposal and anti-nuclear groups argue that safe disposal is impossible.

In the absence of any lobby, the great majority of the people that we conveniently call 'the public' is extremely upset whenever disposal is being proposed, but is strangely complacent about the present situation of a de facto long term storage. It does not see any urgency to act, as if storage was safe because we keep the material at surface, whereas disposal is not safe because the waste disappears at depth. We might logically conclude that long term storage is the solution that the public prefers. I will come back to this issue later, but note that disposal and long term storage will be the topics of Tuesday's sessions.

We technologists have developed a rational approach to the safe management of radioactive waste. Our progress has been based on observations, on logical reasoning and on increments of knowledge accumulated in a systematic, linear way. The physical laws that our approach is based on are universally valid.

In the world at large, however, this objective approach is not the rule, but the exception. Subjectivity and emotions control human societies. Individuals interact subjectively with their surroundings and develop a network of personal perceptions of the physical, social or political context in which they live. Political positions will be subjective, emotional and may well have a local, a regional or even a national importance, but they will never possess the universal value of a technological realization. Seen in this light, the session of

Thursday afternoon on international regimes for the safe management of waste may take another dimension.

I believe that for years, the technological waste management community has systematically ignored the subjective world around it. We have made great progress in our objective understanding of issues at stake but we have gravely neglected this subjective world, which we fail to understand anyway and with which we have now come in serious conflict.

In more and more meetings, including the Cordoba Conference, we are now insisting on the need for greater transparency, for better communication and for greater involvement of stakeholders. This is all well and good but we need more. We need to aim for a symbiosis between the objective and linear world of technology and the non-linear networked world of the public, to reach a situation that a biologist would call ‘mutualism’, where two organisms grow together because they both benefit from this situation, even though each one would be able to survive independently.

Is this wishful thinking only or a realistic possibility? Some answers may well come out of what you say throughout the week. I will evidently be listening carefully!

I sincerely believe that the better we understand the fundamental nature of the problem, the more appropriate our response will be and the faster our progress.

A disposal or a storage site must satisfy technical requirements, but must also satisfy those requirements given by the group of people which is directly affected. These demands will not simply have to be taken into account, but they will dominate and control all future developments, even if they contradict our technological approach. The technology that we apply to the management of radioactive waste, including its disposal, is universal but the way in which it will be applied is not. There *can* only be and there *will* only be local solutions.

Technologists will evidently insist that waste be managed safely, but I do not know of any objective way to measure safety. The answer to the famous question: ‘How safe is safe enough?’ is a subjective one. We must, therefore, be ready to accept that the solution which is finally adopted in any particular case is not the best from the technological point of view, but the one that the population concerned judges subjectively to be the most appropriate.

You and I know that deep geological disposal of high level radioactive waste for periods of several tens of thousands of years is the best solution available for this waste. We also know that near surface disposal of low level waste on appropriately designed sites for periods of 300 years or more is the best solution available for this particular waste.

In a majority of countries, however, progress on such disposal sites is facing determined opposition from inside society. I use ‘society’ here to mean not only knowledgeable stakeholders but also all those people who have a right to vote and, therefore, a right to influence the politics of a given State. As far as a majority of the citizens of those countries is concerned, storage of radioactive waste does not appear to cause much concern, even though the volumes in storage are increasing year after year. This state of affairs would appear to suggest that in these countries, society favours long term storage over disposal, at least tacitly. In other words and whatever we, the technologists, may be saying or doing, a technically inferior solution is being preferred to a technically superior one. Our achievements are being ignored and our knowledge is being disregarded.

What should we do? We could of course let people have what they want. After all, as every politician will tell you, after losing an election or a referendum, 'in a democracy, electors are always right!' We could adopt a similar, falsely philosophical attitude which would considerably simplify our existence, but would not help us in our search for rational answers.

Can we not come up with better solutions?

Before we repeat well known arguments to convince ourselves once more that we, the technologists, were right anyway, I believe that we should step back and re-examine with an open mind the entire philosophy of waste management and disposal. We have made considerable progress and we have learned much over the last 50 years.

We have discovered the critical importance of subjective, emotional decisions in the decision making process. We know that there will be as many solutions as there are sites, and we may just find out that, with a little more imagination and a little more sensibility — or, more accurately, what this untranslatable German word 'Fingerspitzengefühl' means — we will find solutions that are acceptable to most stakeholders.

Why not, for instance, build disposal sites for hundreds of thousands of years as we have been suggesting, but license them for 100 years only? This would allow for retrievability and reversibility. After 100 years, one would want to take into account recent scientific and technological developments before renewing a licence for another century. By contrast with longer periods, a century is a period of time that most people can still subjectively relate to. It is also sufficiently short, relative to the time that we expect disposal sites to last where, presumably, no major correction would be necessary at the time of a licence renewal. When you think of it, buildings and constructions of previous generations have lasted much longer than one century. Think of the Romans, or of the cathedral builders of the Middle Ages, or of the Incas and of many more. Except under tropical conditions, damage to these earlier structures built at surface has more often been caused by humankind than by nature. This, incidentally, does corroborate my personal opinion that rather than protecting humanity from the effects of radioactive waste, it is imperative to protect radioactive waste from future human activities.

Periodic licence renewal of disposal sites is of course not a new idea, but such an approach would seem to offer better safety conditions than most interim storage arrangements and, in the final analysis, the only concern common to all stakeholders is the safety of the management of radioactive waste.

I have presented to you a very personal view of some of the issues that will be extensively debated during this week. I believe that we have reached a point where debate is more important than ever. No topic should be taboo and discordant opinions are particularly important. A few years ago, I used to complain that the nuclear community would only organize meetings to talk to colleagues sharing their own opinion. I am, therefore, particularly pleased to see that this conference is making a genuine effort to get away from such an unfortunate practice.

As you know, a conference such as this one does not simply happen. It is planned, organized and realized by hard-working people. In your name and in mine, I wish to congratulate and thank first the organizations that have made this conference possible, the IAEA, the OECD/NEA and the European Commission. Talking of hard work, let me thank in particular the IAEA and specifically the Conference Organizer, Ms E. Janisch; the Scientific Secretaries, Mr. G. Linsley and Mr. M.J. Bell; the members of the Programme Committee and all those who have generously given of their time for this conference to be held under the best possible conditions.

THE SAFETY OF RADIOACTIVE WASTE MANAGEMENT
Towards an international regime

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1. INTRODUCTION

Waste characterizes the development of human society from the time of homo habilis until today. It can be found wherever settlements flourished, and it serves as a basis for anthropological studies. Historically, human beings — including those in highly developed civilizations — cared little about managing the waste they produced. Disposing of their waste into the surrounding habitat was the usual management practice, and concern about neighbours or about environmental protection was certainly not an issue (latrines were introduced mainly in connection with purity rites rather than for protecting the natural world, and sewers are a fairly modern development).

But it seems that such societal behaviour, so common during the industrial revolution, is finally changing. Concern for our fellows and for generations to come, for nature and for sustainable development is high on the agenda of today's society. Perhaps the cornerstone was laid by the United Nations Conference on Environment and Development (Rio de Janeiro, 1992) and its influential conclusions. People have at last realized that the waste they produce has to be managed properly, not only for their own and their descendants' protection, but also for the preservation of their habitat and for the long term progress of their society. This recent change will have far-reaching consequences, but it is still by no means complete, as only highly developed countries have in place functioning, comprehensive policies for waste management.

The age that started with Becquerel's discovery of radioactivity, and gathered momentum with the advent of nuclear power, has unavoidably — like other periods of human development — generated its own type of waste. The waste of the nuclear power age is — not surprisingly — radioactive waste. Society has approached the management of radioactive waste differently from the management of other waste types. The radioactive remnants from the peaceful uses of nuclear energy are treated with utmost care (unlike, on the whole, the military waste generated during the Cold War period). The extraordinary capacity of the environment to absorb vast amounts of human 'leftovers' was utilized for dealing with radioactive waste. Rather than diluting radioactive waste and dispersing it into the environment, the current generation has decided to contain and confine it. This is the first time in the history of human civilization that such a decision was taken consciously, as a matter of ethical principle; encouragingly, this prudent approach is now being extended to other waste.

As would be expected, after half a century of utilization of nuclear energy the human race has accumulated, contained and confined significant amounts of radioactive waste — most of it of military origin. Regrettably, the prudent approach has backfired: no universal agreement has been reached on how society could permanently and safely dispose of its radioactive waste. As a result, further developments in the area of nuclear power production — and in other areas where nuclear energy is used for beneficial purposes — are blocked.

However, the public and its political representatives are becoming more and more aware that new approaches to the management of radioactive waste from nuclear power generation are needed. They feel themselves to be stakeholders in the process, and they have highly ambitious safety and environmental protection requirements which challenge the imagination of the scientific and technological communities. Moreover, while wanting the scientists to provide sound decision aiding advice, they want to participate in the decision making themselves.

Within its field of competence, the IAEA is matching these developments, and this paper describes the relevant IAEA efforts. This conference, for example, is expected to address a number of issues and trends in the safety of radioactive waste management and provide an updated picture of the international situation. It is a natural follow-up to the first International Conference on the Safety of Radioactive Waste Management, held in Córdoba, Spain, in March 2000 — a little over two and a half years ago. The Córdoba Conference was the first step towards an international regime for the safety of radioactive waste management, and the IAEA hopes that this conference will be a further step.

2. THE CÓRDOBA CONFERENCE

The Córdoba Conference was organized by the IAEA in co-operation with the European Commission, the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development (OECD/NEA) and the World Health Organization (WHO) and hosted by the Government of Spain. When convening it, the IAEA took into account the impending entry into force of the Joint Convention on the Safety of Spent Fuel and on the Safety of Radioactive Waste Management (commonly referred to simply as the Joint Convention). The Córdoba Conference would become a major international event in the field of radioactive waste safety, identifying issues needing to be resolved at the international level in order to address the obligations of States party to the Joint Convention. It was attended by senior regulators and operators, and by a number of broader stakeholder parties with an interest in the safety of radioactive waste management; they represented not only countries with large nuclear power programmes, but also other countries making extensive use of radioactive materials — in industry, medicine and other areas. Moreover, the Córdoba Conference addressed not only issues relating to radioactive waste from uses of 'artificial' radioactive substances, but also ones associated with the large amounts of radioactive waste generated in a diverse range of human activities involving elevated levels of naturally occurring radioactivity [1].[1]

2.1. The genesis of an international regime

The Córdoba Conference addressed a number of basic policy issues. Firstly, participants stated unequivocally that they were striving for consensus among all stakeholders on the disposal of radioactive waste in order to bring about rational universal solutions acceptable to all. Secondly, it was suggested that radioactive waste management decisions should not depend on new technological developments — rather that available technology should be used without delay as there was no objective reason for restraining the final disposal of radioactive waste by adopting a 'wait and see' approach pending the possible advent of new technologies. Thirdly, participants considered that the safety of waste disposal should be seen not purely as a national problem but rather as one of international concern. Consequently, it was suggested that the IAEA should continue facilitating the establishment of a consensus-based international regime for the safety of radioactive waste management. The following three key elements of such a regime were highlighted:

— A commitment on the part of States to legally binding international conventions;
— The establishment of globally agreed international safety standards; and
— International provision for the application of those standards.

[1] The IAEA published the Proceedings of the Córdoba Conference under the symbol STI/PUB/1094 and posted the findings of the Conference on the web site: http://www-rasanet.iaea.org/downloads/meetings/Córdoba2000_findings.pdf.

2.2. The findings of the Córdoba Conference

The Córdoba Conference identified certain topics that must be completed in order to enhance the safety of radioactive waste management internationally. They include:

- Establishing a common and coherent framework within which to manage all types of radioactive waste in a safe and cost effective manner;
- Identifying the safety implications and assessing the sustainability of radioactive waste storage for extended periods;
- Achieving international consensus on safety standards for the geological disposal of high level waste, including spent fuel regarded as waste;
- Developing a coherent and consistent approach to the removal of radioactive materials from regulatory control;
- Ensuring that safety standards for radioactive waste management and the technology needed for complying with them are available and applied consistently throughout the world;
- Guaranteeing that information important for the longer term safety of radioactive waste management (particularly radioactive waste disposal) is preserved and passed on to succeeding generations in a manner that will provide them with an assurance of the safety of the facilities in question;
- Effectively involving all stakeholder parties interested in and affected by radioactive waste management facilities and decisions regarding their safe development.

2.3. The international action plan on the safety of radioactive waste management

The findings of the Córdoba Conference strengthened the IAEA's focus in the area of radioactive waste safety. An international action plan on the safety of radioactive waste management, based on those findings, was approved by the Board of Governors of the International Atomic Energy Agency and — in Resolution GC(45)/RES/10.A — endorsed by the General Conference of the International Atomic Energy Agency in September 2001. The action plan is being executed by the IAEA Secretariat.

2.4. Revisiting issues and trends

Now, at the end of 2002, the time seems ripe to consider what has happened in the radioactive waste management area since the Córdoba Conference. The work of the IAEA has been influenced by a number of major developments since then, not least the welcome progress made towards the establishment of geological disposal facilities, particularly in the United States of America, Finland and Sweden. On the darker side, the events of 11 September 2001 have focused attention sharply on the potential consequences of malevolent acts involving the use of radioactive materials, including radioactive waste. This has given rise to much introspection about the safe and secure handling, treatment, storage and disposal of radioactive waste.

3. THE SIZE OF THE PROBLEM

Since the Córdoba Conference, there have been no substantial changes in the estimates of the radioactive waste being generated, in its relative importance vis-à-vis other types of waste and, therefore, in the size of the problem.

3.1. The relative importance of radioactive waste vis-à-vis other waste types

Most of the radioactivity of the radioactive waste generated by the production of nuclear power remains confined within the sealed fuel elements containing the fissionable material — uranium and sometimes plutonium. After use, the fuel elements may be discarded (i.e. placed in storage facilities with a view to permanent disposal) or reprocessed with a view to reuse of their remaining fuel content. Their volume is very small compared with that of fossil fuel generating the same amount of power (see Fig. 1).

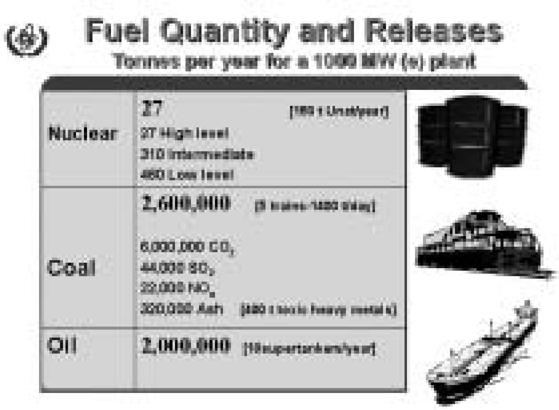

FIG. 1. The relative volumetric importance of waste generated in the production of electrical energy.

3.2. Waste from operating nuclear power plants

The worldwide trends in the management of spent fuel and radioactive waste from the peaceful uses of nuclear energy have been periodically summarized in status reports prepared by the IAEA. The IAEA's Nuclear Technology Review 2000 [2] provided the relevant information referred to at the time of the Córdoba Conference, and the estimates of the radioactive waste being generated by operating nuclear power plants have not changed substantially since. The more than 400 nuclear power plants operating at present produce about 10 000 t of spent fuel a year. Most of this spent fuel is treated as waste; only a small fraction is reprocessed. According to preliminary estimates, by the year 2010, the cumulative amount of spent fuel will surpass 340 000 t (see Fig. 2).[2]

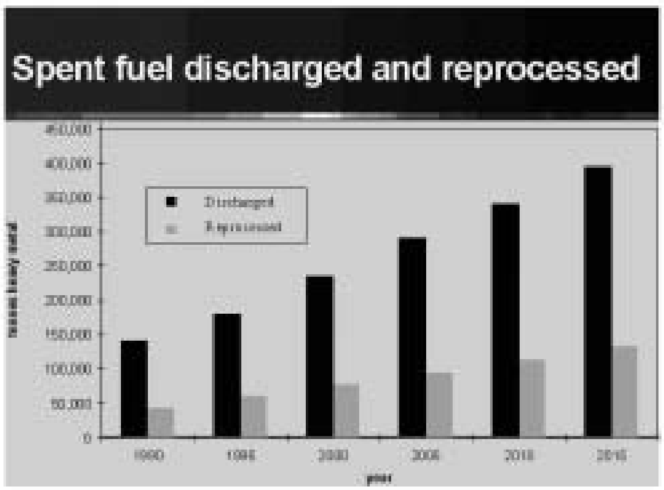

FIG. 2. Spent fuel discharged and reprocessed (1990–2015).

[2] It should be noted that, in addition to nuclear power plants, research reactors give rise to spent fuel. According to the IAEA's Research Reactor Database [3], 58 countries, including 40 developing ones, are operating 293 research reactors, and 15 more research reactors are under construction. Almost 60% of the world's research reactors are more than 30 years old, with the age of a further 20% between 20 and 30 years. Research reactors have usually been associated with the development of nuclear power, but some are used solely for the production of radioisotopes or for pure scientific research, and some have been involved in military research. The spent fuel from research reactors, while of a much smaller quantity and generally of a much lower radioactivity level than that from power reactors, also contains radioactive waste that requires storage and ultimate disposition. Many discharged fuel assemblies remain at the reactor site, and some have already been in on-site storage for more than 30 years;

Before reprocessing or final disposal, spent fuel can be safely stored for long periods in wet or dry facilities. Such facilities have in some cases already been in operation for over 30 years. Approximately 30 t of spent fuel are discharged annually by a nuclear power plant generating 1000 MW(e). At the end of 1999, the spent fuel discharged worldwide over the previous four decades amounted to some 220 000 t, of which 75 000 t have been reprocessed. That leaves some 145 000 t stored at or away from the reactor site. By the end of 2010, the cumulative amount of spent fuel will have surpassed 340 000 t, with 110 000 reprocessed, leaving 230 000 t in storage. The excess storage capacity worldwide is roughly 100 000 t, and planned construction should maintain this excess capacity over the next few decades. At some sites, however, the storage pools are nearly full and additional storage capacity is necessary.

3.3. Relative volumetric importance

If the world's annually generated 10 000 t of spent fuel could be reprocessed, the high level radioactive waste from one year of global production of nuclear electricity could — with vitrification — be accommodated within a volume of 1000 m^3 . This is the volume of a 10 m cube (i.e. smaller than the room where this conference is taking place), and from a volume point of view it cannot be described as a large problem.

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it is estimated that there are some 63 000 discharged assemblies in on-site storage — in addition to the approximately 23 000 assemblies still in reactor cores. Of the assemblies in on-site storage, some 46 000 are in industrialized countries and 17 000 in developing countries.

It should also be noted that the largest amount — in volume, not in radioactivity — of the radioactive waste from nuclear power production is low level waste (LLW). Volume minimization has reduced LLW generation to some 100^3 annually per 1000 MW(e), a tenfold decrease over the past 20 years. Decommissioning can add several thousand cubic m of LLW, but future efforts will probably reduce the amount. Much of this waste is easy to manage, requiring no shielding at all during handling and transport. It can be isolated in near surface disposal facilities where radioactive decay reduces radioactivity levels rapidly, by a factor of about 100 in 200 years, so that values comparable to the natural radioactivity background are reached. More than 100 disposal facilities for LLW have been built and more than 30 are under development. Some of these facilities receive radioactive waste not only from nuclear power production but also from medical, industrial and research activities; in fact, roughly 40% by volume of the radioactive waste sent to commercial disposal facilities is not from nuclear power utilities.

3.4. Relative radioactive importance

There have been no changes — hopefully — in the laws of physics since the Córdoba Conference; hence there have been no changes in the amount of radioactivity in that volume of waste. That amount can be calculated simply by multiplying the amount of generated wastes by the amount of radioactivity per unit of spent fuel (see Fig. 3).

Thus, it is a straightforward matter to estimate the order of magnitude of the amount of radioactivity being generated by the nuclear industry as radioactive waste: it is around 100 EBq/a, in other words, 100 E is 1 followed by 20 zeros. One way to put this large number in perspective is to compare it with other radioactive contents. Nuclear power production and other beneficial nuclear activities are relatively modest generators of radioactive waste. Unexpectedly for many, the largest generator of radioactive waste is nature itself — for example, through erosion processes and volcanic eruptions. As to human-made radioactive waste, Cold War military activities were the chief generator. The existing volume of non-usable, naturally occurring radioactive materials and of military radioactive waste puts the nuclear power waste problem into perspective (see Fig. 4).

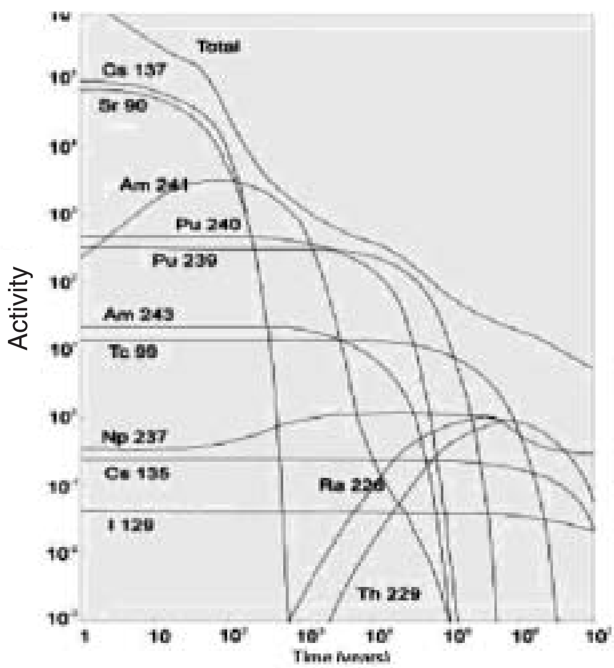

FIG. 3. The amount of radioactivity per unit of spent fuel.

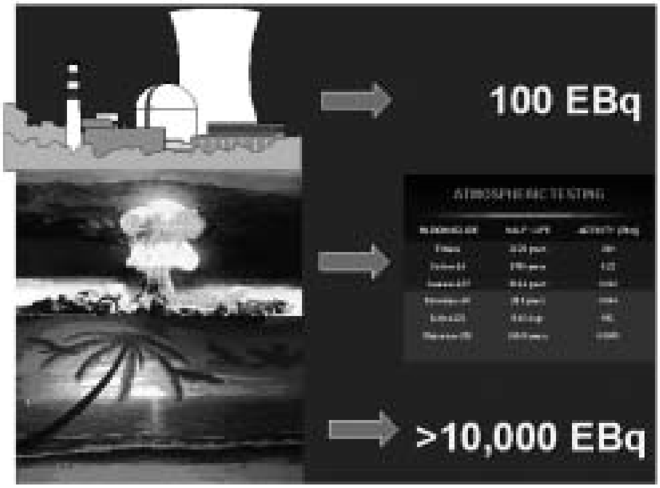

FIG. 4. The amount of radioactivity generated by the nuclear industry vis-à-vis that generated by atmospheric testing and natural radioactivity in the seas.

In addition to the production of radioactive substances by the cosmic rays that continuously bathe the earth, there is an enormous inventory of primordial radioactive materials beneath the earth's crust and on its surface. Natural phenomena such as volcano eruptions, mineral water springs and the deposition of sand often bring parts of this inventory into the human habitat, where they remain as radioactive residues. The amount of radioactive waste thus produced by nature is formidable, but it has usually been ignored. In the areas affected, the levels of public radiation exposure attributable to this waste can be an order of magnitude above the limits established in international standards for the radioactive waste generated by nuclear power. Mineral sands containing monazite in Kerala and Tamil Nadu, India, and Espírito Santo, Brazil; thorium-bearing carbonite in Mombasa, Kenya; volcanic intrusions with mixed thorium and uranium mineralization in Minas Gerais, Brazil; and situations in vast areas of China — in all cases, natural radioactive waste is causing radiation exposures of up to 30 times higher than those limits. In the surroundings of the populous city of Ramsar, Islamic Republic of Iran, radioactive waste deposits (similar to mining and milling 'tailings') resulting from mineral water spring desiccation are reportedly causing exposures more than two orders of magnitude higher than those limits.

Moreover, since it became industrialized, the human race has enhanced these natural processes by extracting primordial radioactive materials from the earth, using some of them and leaving the rest as radioactive residues. The mining, milling and industrial use of what is called NORM (naturally occurring radioactive materials), including nuclear materials such as uranium and thorium, are examples of human activities that generate radioactive waste of natural origin — a general issue considered at the Córdoba Conference. The main activities involved include: phosphorus production; phosphoric acid production; fertilizer production; primary iron and steel production; coal tar processing; coke production; coal and gas fired power plant operations; the extraction of coal, peat, oil and gas; cement production; the ceramics industry; mineral sand mining; and titanium pigment production. In addition to the radioactive mining and milling tailings from uranium and thorium production, radioactive waste containing high concentrations of radionuclides are produced during the mining and processing of heavy mineral sand such as ilmenite, leucoxene, rutile, zircon and in particular, monazite and xenotime. The world inventory of radioactive waste that has been generated by the ancestral human processing of naturally occurring radioactive materials is largely unknown.

The most striking example of 'natural' radioactive residues, however, is the radioactive inventory of natural radionuclides in the sea, which is in the order of 10 000 EBq! If all the radioactive waste being generated by the nuclear industry were to be homogeneously diluted in the sea, there would not be a significant change in the sea's radioactivity content. This sentence should not be construed as support for the discharge into the sea of radioactive waste being generated by nuclear power plants. The regulation of the nuclear industry, unlike that of most other human enterprises, has been extremely prudent, strictly limiting the releases of radioactive substances into the environment and preferring the option of concentration and storage for radioactive waste.

While the radioactive waste from the peaceful uses of nuclear energy is stringently regulated and has a relatively small volume, vast quantities of largely unregulated military radioactive waste accumulated at numerous sites around the world during the Cold War period. A significant amount of radioactive waste has entered the environment owing to nuclear weapons production and testing, large scale radiation accidents at military facilities and the disposal of military radioactive waste into the sea. Furthermore, large amounts of radioactive residues remain from military operations conducted in various parts of the world. Especially during the early part of the Cold War, there occurred several mishaps which led to discharges of radioactive waste into the environment. The radioactivity that was uncontrollably discharged by the testing of nuclear weapons in the environment is, according to estimates of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), more or less of the same order of magnitude as the radioactivity of the waste that has been generated by nuclear power production, albeit with a different radioisotopic composition.

4. HEALTH EFFECTS ATTRIBUTABLE TO RADIOACTIVE WASTE

4.1. No changes in the UNSCEAR estimates of potential health impacts

One important piece of news since the Córdoba Conference is that there has been a confirmation of the international estimates of the potential health impacts attributable to radioactive waste. This may be obvious to specialists, but it is certainly not obvious to the public. Just a few months after the Córdoba Conference, UNSCEAR submitted to the United Nations General Assembly a report — the UNSCEAR 2000 report — in which it confirmed the estimates that form the basis of the current international Safety Standards for Radioactive Waste Management. Above the prevalent background dose, any increment in dose which could conceivably occur as a result of radioactive waste management practices would result in an extremely low proportional increment in the probability of incurring deleterious health effects of 0.005% per mSv. A level of radiation dose around the current regulatory dose limits the risk would be around 5 per 100 000 (see Fig. 5). In the context of radioactive waste management, this number would imply a negligible risk since it is known that potential doses hypothetically attributable to current radioactive waste management practices are much lower than the limits. However, misinterpretations of the UNSCEAR estimates continue to cause real or perceived problems regarding the regulation of radioactive waste that, properly managed, will give rise to relatively low radiation doses. These problems continue to exacerbate the academic

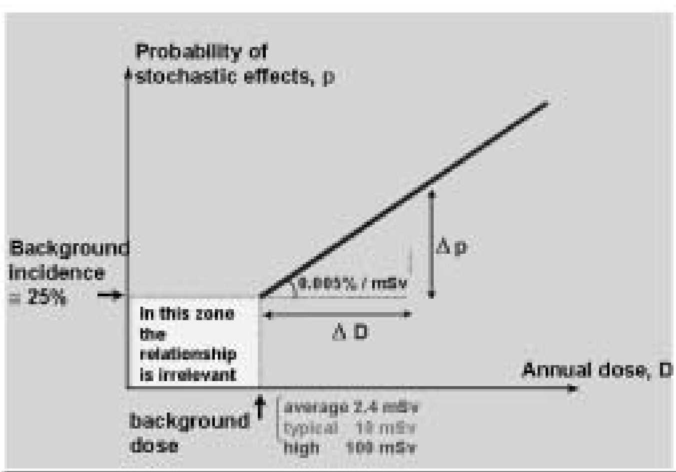

FIG. 5. The 'LNT' controversy: properly managed radioactive wastes are expected to deliver [cause] exceedingly low levels of radiation dose.

controversy — involving radiobiologists, regulators and others about the linearity of the relationship between radiation doses and biological response — known as the 'linear non-threshold' or 'LNT' hypothesis. An undesired outcome of this controversy has been a general loss of public confidence.

The overwhelming international consensus (in which the United Nations family joins) is that the relationship is probably linear at low doses. However, the international consensus does not apply to linearity at whatever radiation level, however low, but rather to linearity between increments of dose and likelihood of effect. In fact, the international consensus is as follows: above the prevalent background radiation levels and above the prevalent normal incidence levels of comparable health effects (both of which are high), an increment in the radiation exposure will induce a proportional increment in the probability of incurring deleterious effects, such as cancer.

The level of background radiation is very high in some parts of the world. Because of the ubiquity of ionizing radiation, it is reasonable to take the highest level as the prevalent one for purposes of regulation. Below this prevalent level, the shape of the regulatory relationship is irrelevant for regulatory purposes.

4.2. No significant risk of hereditary effects

Another important occurrence since the Córdoba Conference relates to the risk of hereditary effects. A few months before this conference, UNSCEAR submitted to the United Nations General Assembly a report — the UNSCEAR 2001 report — on the hereditary effects of ionizing radiation. UNSCEAR now estimates that the risk of radiation-induced hereditary effects is absolutely negligible (an order of magnitude lower than the risk of radiation-induced cancer), being less than 1% of the baseline frequency of spontaneous hereditary effects. This is another piece of good news, as the practice of radioactive waste disposal has been accused of committing future generations to apocalyptic hereditary prospects.

5. THE RADIATION PROTECTION APPROACH

5.1. The ICRP recommendations

Another very important piece of news since the Córdoba Conference is that there have been no changes in the recommendations of the International Commission on Radiological Protection (ICRP), which provides the radiation protection basis for the international Safety Standards for Radioactive Waste

Management. The ICRP has provided radiation protection recommendations for radioactive waste management in a number of publications: ICRP Publication 77 addressed the radiation protection policy for the disposal of radioactive waste; ICRP Publication 91 contained recommendations particularly tailored to the disposal of long lived solid radioactive waste; and ICRP Publication 92 is used as universal guidance for protecting the public in situations of prolonged radiation exposure such as those that can conceivably arise from the long term management of radioactive waste.[3]

5.2. Radioactive waste management is not a significant radiation protection issue

The recommendations in these ICRP publications imply that, once a basic decision has been taken not to dilute radioactive waste and disperse it into the environment, but to concentrate and retain it, thereby aiming at its delayed incorporation into the environment in the long term (see Fig. 6), radioactive waste management cannot become a serious radiation protection problem.

> “Early or deferred releases of radionuclides to the environment would inevitably result from either of the strategies (i.e. ‘dilute and disperse’ or ‘concentrate and retain’) and therefore an objective of no release is not feasible. Both strategies are in common use and are not mutually exclusive. Where there is a choice, the balance between the two strategies is a radiological protection issue involving, inter alia, consideration of the decay of radionuclides during the period of containment and of the associated risk of elevated exposure due to disruption by natural or human-made processes. The possibility of elevated exposures from disruptive events is an inescapable consequence of the decision to concentrate waste in a disposal facility rather than diluting or dispersing it.” [4]

The ICRP system of radiation protection governing international Safety Standards for Radioactive Waste Management is briefly described in Fig. 7. Everyone in the world is subject to a background ‘natural’ exposure, with individual doses ranging from an average of 2.4 mSv/a up to 100 mSv/a or more. Intervention with radiation protection measures is always justifiable

[3] The ICRP recommendations relating to the safety of radioactive waste management are the following: Radiological Protection Policy for the Disposal of Radioactive Waste (ICRP Publication 77); Radiological Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste (ICRP Publication 81); and Protection of the Public in Situations of Prolonged Radiation Exposure (ICRP Publication 82).

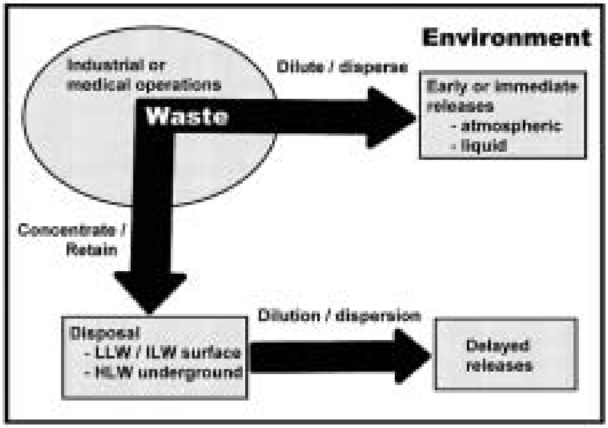

FIG. 6. The radioactive waste management approach: 'Waste disposal strategies can be divided into two conceptual approaches — 'dilute and disperse' or 'concentrate and retain'.

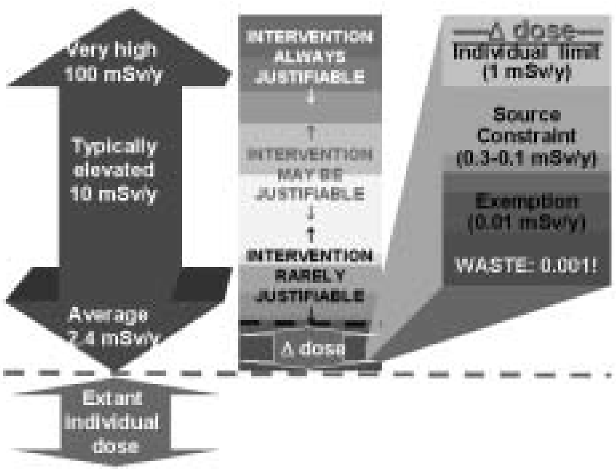

FIG. 7. The ICRP system of radiation protection, which provides the basis for the international Safety Standards for Radioactive Waste Management.

towards the high end of the range and is unlikely to be justifiable at the lower end. Above these background levels there might be additional doses attributable to practices, including radioactive waste management. These additional doses must be restricted; Fig. 7 shows the restriction levels recommended by the ICRP. In the most conservative calculations, the doses expected from radioactive waste management are far below the levels for regulatory exemption recommended by the ICRP.

5.3. Modelling

Unfortunately, since the Córdoba Conference, there have been no changes in the sometimes esoteric imaginings of modellers who, making use of the power of modern computers, like to fashion the most dramatic scenarios for the application of the international system of radiation protection. Figure 8 gives a good example of the modellers' enthusiasm; it did not appear in a journal of an anti-nuclear organization but in an official publication of OECD/NEA. It shows the modellers calculating doses up to the year 1 million! Moreover, it seems that the modellers have assumed that typical natural radiation exposures will remain the same for over a million years (in contradiction to radiogeological knowledge) and that the typical regulatory guidelines, based on now current ICRP recommendations, will be the same at the end of that preposterously long period. (Some ICRP members are present at this conference, and they may agree that there is a very low probability that, should the ICRP exist at that remote point in time, it will be sticking to its now current recommendations!). Such models — which reflect profoundly imaginative efforts and were produced with virtuous intent, perhaps to demonstrate

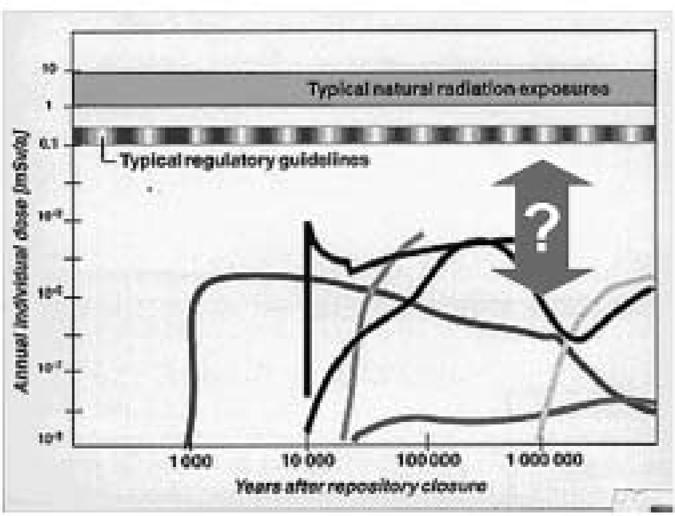

FIG. 8. Esoteric assumptions continue to be made by modellers.

how safe radioactive waste is — have probably backfired and created misperceptions on the part of decision makers and the public at large. Such calculations, unfortunately, continue to be made.

6. DEFINING RADIOACTIVE WASTE

6.1. The conceptual definition

Since the Córdoba Conference, there have been no changes in the definition globally used for 'radioactive waste'. *Conceptually*, 'radioactive waste' means all radioactive remains except those excluded or exempt from control because of their negligibility — not just the solid radioactive waste that is normally referred to as 'radioactive waste'. Thus, in international parlance, radioactive waste comprises radioactive discharges into the environment, plus solid radioactive waste 'proper' to be disposed of, plus the radioactive residues remaining after a practice is terminated and its installations decommissioned — i.e. the term covers all radioactive remains from a practice. In sum, 'radioactive waste' refers to material which will be or has been discarded as being of no further use and which has the property of being 'radioactive'. It may be surprising for many but, while scientists and regulators are in agreement on this conceptual definition, they are not yet in full agreement on what waste can quantitatively be qualified as 'radioactive'. The problem is that basically, all substances in nature contain some naturally radioactive elements — if only in trace amounts — and all waste is therefore in principle radioactive. As far as radioactivity is concerned, the qualifiers 'natural' (or 'nature-made') and 'artificial' (or 'human-made') are tricky and can cause confusion.[4]

[4] Because of the ubiquity of radiation, it is useful to deal separately with primordial and human-made radiation and radioactive materials. Two fundamental properties of matter, radiation and radioactivity, have been traditionally described as 'natural' and 'artificial' respectively, but the distinction is not precise. For instance, some radionuclides that are primordial and therefore considered 'natural' can also be produced 'artificially' (for example, technologically enhanced concentrations of radionuclides in NORM, while some that are produced by humans and therefore considered 'artificial' can also be produced by natural phenomena such as the natural fission process which took place at Oklo, in Gabon. More controversial is the application of these qualifiers to radiation sources and, in particular, to exposures.

6.2. The quantitative definition

Unfortunately, therefore, there has been no change in the ability of nuclear regulators to define 'radioactive waste' *quantitatively* since the Córdoba Conference, in spite of some strong recommendations made in Córdoba. There is no international answer yet to the obvious question: what is the minimum amount of radioactivity in materials that requires regulation for radiation safety purposes? With the huge amounts of radioactivity existing in nature, a quantitative definition of which materials have to be regulated as 'radioactive' would be extremely useful. Until now, however, there has been no international agreement on this fundamental concept for any sensible form of radiation safety regulation. As a consequence, for example, large amounts of leftover structural and other materials that are routinely released from nuclear power plants cannot be recycled into the market and have to be handled as radioactive waste, artificially enlarging the radioactive waste problem — at least in terms of volume.

Regulators have struggled with this problem since the inception of radiation safety standards. Expressions such as 'de minimis' (short for 'de minimis non curat lex': the law does not concern itself with trivia) were wrongly used for qualifying radiation exposures. 'Trivia' was taken to mean something below regulatory 'concern' rather than something not needing to be subject to regulatory 'control'. Such mistakes in communication have caused confusion and apprehension in a worried public. The current regulatory solution is twofold. On one hand, the regulatory scope 'excludes' radioactive substances causing radiation exposure of people that is unamenable to control (for example, some naturally occurring radioactive substances unmodified by humans). On the other hand, there exist regulatory provisions for 'exempting' from radiation safety requirements those radioactive substances which cannot be the cause of significant radiation exposure of people. Should certain radioactive waste be below exemption levels, it could be subject to a process of 'clearance' from regulatory requirements. Nevertheless, while there are already plenty of international standards for *exemption* and *clearance*, the issue of what is to be considered radioactive waste (or what materials should be excluded from regulation) is still a matter of great controversy among regulators and for the public at large.

The Córdoba Conference considered that the concept of 'exemption' is well established and understood. The idea of 'clearance' is becoming established, but the term continues to cause some confusion. The philosophy of clearance now needs to be converted into a practical administrative process within national regulatory systems. The application of clearance to NORM is problematic. The clearance criteria usually applied to artificially radioactive materials can correspond to levels of natural radioactivity that cannot be distinguished from background levels or that occur as natural variations in natural radioactivity levels. Radiological protection arguments can be made for applying higher dose criteria to these materials (higher than those applied in the case of artificial radionuclides), but the differences may be difficult to explain to some interested parties. If problems with the movement of radioactive materials across national borders are to be avoided, international agreement is essential on levels below which control is not required. This is an example of a situation where concerns about national sovereignty may need to be overcome in order to achieve necessary international harmonization.

7. RESTRICTING DISCHARGES

Since the Córdoba Conference, changes have occurred in how restrictions on discharges into the environment are considered, particularly in Europe. It appears that new 'political' considerations are being imposed in order to restrict discharges, leading to a demagogic, 'zero' release objective that is ideal in theory but not feasible in practice. This is a disturbing development.

The establishment of international standards for limiting radioactive discharges into the environment is a responsibility of the IAEA, which has a long history of involvement in the field of protection against radioactive materials released into the environment. In 1958, the United Nations Conference on the Law of the Sea [5] recommended assigning to the IAEA responsibility for the promulgation of standards for preventing marine pollution due to radioactive materials. In 1962, the IAEA issued the first international standards for radiation protection [6], and in 1967 it revised them with the effect of implicitly affording protection to the environment [7]. In 1974, the IAEA established a definition of high level radioactive waste unsuitable for dumping at sea and made related recommendations for the purposes of the Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter (the London Convention), one of the first international undertakings for the protection of the sea [8]. In 1976, the IAEA issued the first report on effects of ionizing radiation on aquatic organisms and ecosystems [9]. This was followed, in 1978, by the establishment of the first international standards for limiting discharges to the environment [10] and, in 1979, by the first international methodology for assessing impacts of radioactivity on aquatic systems [11]. In 1982, new international standards for radiation protection issued by the IAEA [12] introduced the concept of 'dose commitment', the use of which enables one to consider the buildup of material in the environment and take appropriate environmental protection action. In 1982, the IAEA issued the first international standards relating to generic models and parameters for assessing the environmental transfer of radionuclides [13]; in 1985, it issued the first international standards for evaluating transboundary exposure [14]; and, also in 1985, it issued the first international consensus document on K_ds in sediments and concentration factors in the marine environment [15].

A major development occurred in 1986 when the IAEA, in comprehensive standards for the limitation of discharges, described in detail the idea of limiting discharges on the basis of dose commitment [16]. In 1988, the IAEA issued a report on assessing the impact of deep sea disposal of low level radioactive waste on living marine resources [17], and four years later it issued a report on effects of ionizing radiation on plants and animals at levels implied by current radiation protection standards that reviewed the then available knowledge about the effects of ionizing radiation on species in terrestrial and freshwater aquatic environments [18]. In 1992, following the United Nations Conference on Environment and Development, the IAEA's role in this field was strengthened. In 1996, the IAEA established the first international fundamental principles for the safety of radiation sources [19], and in 1995, the first international fundamental principles of radioactive waste management [20] — which form the basis for the Joint Convention [21] — and the current international radiation safety standards, known as the Basic Safety Standards or BSS, which are co-sponsored by the Food and Agriculture Organization of the United Nations (FAO), the International Labour Organization (ILO), OECD/NEA, the Pan American Health Organization (PAHO) and WHO [22].

The Joint Convention requires each Contracting Party to take the appropriate steps to provide for effective protection of individuals, society and the environment, by applying at the national level suitable protective methods as approved by the regulatory body, in the framework of its national legislation which has due regard to internationally endorsed criteria and standards. The Joint Convention also requires each Contracting Party to take the appropriate steps to ensure that at all stages of radioactive waste management, individuals, society and the environment are adequately protected against radiological hazards. The IAEA has recently focused on the development of safety guidance for the application of the Joint Convention's principles.

In 1999, the IAEA issued its first dedicated report on issues related to the protection of the environment from the effects of ionizing radiation [23]. In 2000, it updated its standards for limiting radioactive discharges to the environment [24] and issued the first comprehensive generic models for applying the international guidance for limiting discharges in 2001 [25] (see Fig. 9).

Other elements of the IAEA's work are also of relevance to an understanding of the levels of radionuclides present in the environment, and of the practical application of international standards in an environmental context.

FIG. 9. Some of the IAEA's standards relevant to the safety of discharges of radioactive waste into the environment.

For example, the IAEA has compiled inventories of radioactive waste disposals at sea [26] and the first global inventory of 'accidents and losses' at sea involving radioactive materials [27]. Also, in carrying out its statutory function of providing for the application of international Safety Standards, the IAEA has carried out a number of extensive studies of the radiological situation in areas affected by environmental contamination, including Chernobyl [28]; the nuclear test sites at Bikini Atoll [29]; the Atolls of Mururoa and Fangataufa [30]; Semipalatinsk, in Kazakhstan [31]; and the former Soviet Union's dumping area in the Kara Sea [32]. In addition, it has organized international peer reviews — for example, an international peer review of the biosphere modelling programme of the US Department of Energy's Yucca Mountain site characterization project [33].

7.1. Radiation protection of the environment

Since the Córdoba Conference, an absolutely fresh development in the area of radioactive release limitation is the new interest in radiation protection of the environment itself. The following question is being asked: if an individual human being is well protected now and in the future, will the 'environment' (however this term is defined) also be protected? This is not a simple question to answer, as it involves ethical judgements that may not be amenable to international harmonization. With its history of strong commitment to the control of releases of radioactive materials to the environment, the IAEA is now focusing on this development and considering issues related specifically to the protection of the environment itself. In the first half of 2002, it issued the first international report on ethical considerations in protecting the environment from the effects of ionizing radiation [34].

The ICRP and the IAEA together are pursuing a potential international consensus on the issue, and the IAEA has convened a conference to be held in Stockholm in October 2003 (entitled 'International Conference on the Protection of the Environment from the Effects of Ionizing Radiation'). The IAEA's 1992 report on effects of ionizing radiation in plants and animals at levels implied by current radiation protection standards found it highly probable that a dose limit of 1 mSv/a for humans will lead to dose rates to plants and animals in the same area of less than 1 mGy/d, and that there was no convincing evidence that chronic dose rates below 1 mGy/d will harm these biota [18]. Similarly, the Preface to the BSS then declared that standards for protecting individual human beings will also ensure that no other species is threatened as a population, even if individuals of the species may be harmed. The approach based on this belief is being challenged on the grounds that, under present circumstances, it might not provide adequate protection to certain environments, e.g. environments where humans are absent. The IAEA encountered a notable example of such an environment when it assessed the former Soviet Union's dumping site in the Kara Sea, where humans appear to be afforded a higher level of protection than the environment.

Answers need to be found to the following questions:

— Is the aim to protect the human habitat or the wider environment (the present international standards implicitly relate to species in the 'human habitat' rather than to species in the 'environment')?
— Is the objective to protect individuals of a given species or the species as a whole? In other words, is it sufficient to protect non-human species as a whole (i.e. collectively), or should protection be afforded to individual members of the species?
— What are the applicable ethical principles?

7.2. Termination of practices and radioactive residues

Since the Córdoba Conference, there have also been changes in the way we consider the radioactive residues expected after current practices are terminated. Following the decommissioning of many radiation and nuclear facilities around the world, much volumetric waste will be in the form of radioactive residues. The International Symposium on Restoration of Environments with Radioactive Residues (organized by the IAEA, hosted by the US Government and held in Arlington, USA, in November and December 1999) covered issues of public health, environmental protection, social disruption, and environmental degradation [35].

The worldwide environment has been contaminated with radioactive materials of primordial and cosmogenic origin since its creation. Once humankind discovered rich underground deposits of minerals and ores, primordial radionuclides became an early cause of environmental contamination that continues to this day. It was atmospheric nuclear weapons testing, however, that aroused public concern about the potential for widespread environmental contamination. Besides sites where nuclear weapons were tested, there are sites where such weapons were developed and constructed. There are also areas with environmental contamination resulting from nuclear power plant operations and accidents, such as the environmental contamination resulting from the Chernobyl accident.

The Chernobyl accident made the public aware of the nuclear fuel cycle and the issue of the radioactive residues associated with nuclear power production. The radioactive residues, which in 1987 gave rise to the radiation accident in the Brazilian city of Goiânia, highlighted uncontrolled radioactive sources as a potential cause of widespread contamination [36]. The contamination from fallout produced by re-entering satellites seems to complete the list of causes of environmental contamination in the 20th century. The challenges associated with residues from NORM are even larger and perhaps more widespread.

Within the above control, the decommissioning of nuclear facilities being used at the moment will present a new challenge. Figure 10 presents the IAEA's preliminary estimates of nuclear power plants to be decommissioned in the future, showing a peak of investment in decommissioning between 2021 and 2025, when large amounts of residues are expected.

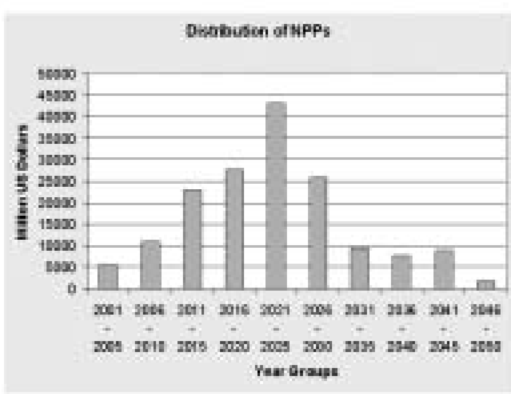

FIG. 10. The challenge posed by decommissioning.

A couple of months ago, in October 2002, the IAEA held an international conference on the safety of decommissioning of nuclear activities (entitled 'International Conference on Safe Decommissioning for Nuclear Activities: Assuring the Safe Termination of Practices Involving Radioactive Materials', in Berlin), at which some of you were present. The Conference President's summary findings, posted on the IAEA web site will be the basis of an international action plan on this issue.[5]

8. SAFETY OF TRANSPORT OF RADIOACTIVE WASTE

Another important development since the Córdoba Conference is the big change in the public perception of the safety of radioactive waste transport. Transport is the Achilles heel of radioactive waste management. Even if all other radioactive waste safety problems were resolved, should the transport of the waste from the installations generating it to the final repositories not take place for some reason, the present stagnation in the radioactive waste management field would remain. A considerable deterioration in the public perception of the safety of radioactive waste transport has occurred, as can be seen from the European news media in particular. It seems that, all over the world, public attitudes have become more critical. This has been reflected in a number of resolutions adopted by the IAEA General Conference in recent years. For example, in Resolution GC(46)/RES/9.B, adopted on 20 September 2002, the General Conference of the International Atomic Energy Agency noted "concerns about a potential accident or incident during the transport of radioactive materials by sea".

Transboundary movements of radioactive waste mean that the waste is moved from one jurisdiction (that of the country of origin) to another jurisdiction (that of the country of destination), and often that the jurisdictions of one or more countries of transit and also laws governing transport on the high seas are involved. Thus different legal regimes apply at different stages in the transboundary movement of radioactive waste, and there is consequently a need for far-reaching international harmonization in this area.

The harmonization process is quite advanced, however, as demonstrated by the international consensus on the IAEA's Regulations for the Safe Transport of Radioactive Materials (the IAEA's Transport Regulations) [37]. Article 27 (Transboundary Movement) of the Joint Convention is also significant in this regard, but there is no international consensus on what radioactive materials are and are not covered by the Joint Convention.

[5] http://www-rasanet.iaea.org/downloads/meetings/decom02.pdf.

Consistency of laws and of definitions is desirable not only at the international level but also at the national level.

As regards maritime transport, there is no general requirement under international law that coastal States should approve shipments of radioactive waste through their territorial waters if the necessary safety precautions have been taken. At present, liability is to a large extent governed by private international law, with all the uncertainties arising therefrom for potential victims. Given the role that those uncertainties play in strengthening the opposition to the international transport of radioactive waste, wider adherence to the international nuclear liability regime would assist in gaining greater acceptance for such transport.

Responsibility for the observance of international standards for the maritime transport of radioactive material lies in each case with the flag State — although the International Maritime Organization (IMO) makes observance of the IAEA's Transport Regulations mandatory. The IMO has introduced particular regimes for several waterways, such as the Panama Canal, but the movement of radioactive waste through such waterways has not caused any significant problems.

The international transport of radioactive material has an excellent safety record, but there is a very wide gap between this reality and the public's perception. A constructive, open dialogue with stakeholders about the — admittedly, somewhat complicated — regime for the international transport of radioactive material, including waste, and about the transport safety record is needed, with due consideration given to requirements regarding the physical protection of nuclear material.

The IAEA began already in 1961 to issue regulations for the safe transport of radioactive materials. The IAEA's Transport Regulations are now incorporated into United Nations recommendations on the transport of dangerous goods [39] and form part of the safety codes of all the modal organizations, the most recent being the International Maritime Dangerous Goods (IMDG) Code of the IMO issued in 2001 [39] (see Fig. 11).

An important recent development could lead to an enormous improvement in the situation as many perceive it: for the first time, countries transporting radioactive waste have agreed to undergo appraisals of how they comply with the IAEA's Transport Regulations. There are no doubts about the adequacy of the Transport Regulations, but there are doubts about compliance with them by transporting States. Now, some major transporting States have agreed that the safety of their radioactive waste transport operations should be appraised by the IAEA. An appraisal of the United Kingdom's transport operations was performed by the IAEA a few months ago [40] and represents a turning point in international co-operation in this area.

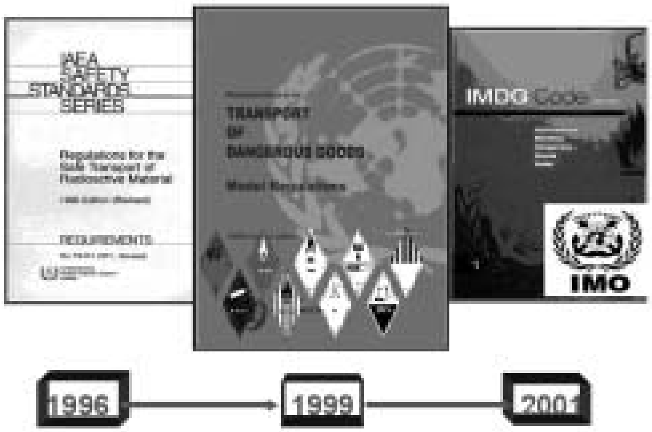

FIG. 11. The international system of standards for the safe transport of radioactive waste.

Nevertheless, the issue of perception remains. Recent newspaper reports about an accident with an oil tanker off the Galician coast of Spain have been enough to make the public nervous about the safety of the maritime transport of dangerous goods in general. The questions people may be asking include the following:

— Had the ship in question been transporting radioactive waste, what would have happened?
— What if a ship transporting radioactive waste has an accident while passing through the Panama Canal, through which many such ships pass?

These and similar questions will be discussed at the International Conference on the Safety of Transport of Radioactive Material which the IAEA is holding in Vienna in July 2003, and some of the conclusions reached here this week may be highly relevant to that conference.

9. SECURITY OF RADIOACTIVE WASTE

Another topic that has acquired new dimensions since the Córdoba Conference is nuclear security. Following the events of 11 September 2001, there has been, throughout the world, a dramatic increase in concern about securing radioactive waste storage and disposal sites and, more importantly, about securing and disposing of disused radioactive sources — an issue which was not discussed in depth at the Córdoba Conference, and which I, therefore, hope will be discussed in depth at this conference.

The increased concern about the security of radioactive waste is reflected in, for example, the following question: could unsecured radioactive waste shrouded by a conventional explosive be turned into a devastating tool for terrorists? The media in the USA promptly dubbed the new menace 'dirty bomb' — a nickname that does not alleviate public uneasiness. The possibility of such a melange being used for malevolent purposes certainly exists. However, the real issue is whether radioactive waste should be the focus of interest when hundreds of dangerous chemicals and dangerous forms of biological waste are readily available for terrorist acts. If detonated in a city, a dirty bomb would disseminate radioactive particles, but the radioactive contamination would be limited to a fairly small area: a few blocks. Although the detonation of a dirty bomb would not cause a large number of casualties, it would certainly cause terror, disruption and psychological trauma. Following the psychologial trauma caused by the terrorist attacks on New York and Washington, D.C., irresponsible statements by self-declared experts and by media sensationalists have increased public fears about the potential use of dirty bombs by terrorists.

While the fears of the public are comprehensible, the issue is not new for radiation safety professionals who, therefore, have a more balanced perspective. Long before 11 September 2001, actions for securing radioactive sources were high on the agenda of the international radiation protection community and an integral part of the radiation safety programme of the IAEA. The prevention of unauthorized possession of radioactive materials has always been an essential element of the IAEA's radiation safety activities. Already in 1996, the BSS established the international requirement that radioactive sources "be kept secure so as to prevent theft or damage…by ensuring that…control of a source not be relinquished."

Governments have gradually become aware of the international dimensions of the security threat associated with radioactive materials. In 1998, hundreds of specialists and governmental representatives met in Dijon, France, at an international conference on the safety of radiation sources and the security of radioactive materials organized jointly by the IAEA, the European Commission, Interpol and the World Customs Organization [41]. The Dijon Conference produced major findings in the light of which the IAEA Secretariat drew up an action plan for strengthening the global safety and security of radioactive sources. Implementation of this plan led to the establishment of an internationally agreed "Categorization of Radiation Sources" deemed to pose a threat [42] and of a non-binding "Code of Conduct on the Safety and Security of Radioactive Sources" [43]. In December 2000, national regulators met in

Buenos Aires at an International Conference of National Regulatory Authorities with Competence in the Safety of Radiation Sources and the Security of Radioactive Materials organized by the IAEA [44]. In the light of, inter alia, the major findings of the Buenos Aires Conference, the IAEA Secretariat drew up a revised action plan which the Board of Governors of the International Atomic Energy Agency approved on 10 September 2001 — the day before the terrorist attacks on New York and Washington, D.C.

Following 11 September 2001, the international strategy on the security of radioactive waste is being reviewed in the light of a new reality. The basic IAEA objective remains unchanged: to assist Member States in creating and strengthening national regulatory infrastructures so as to ensure that radioactive waste is registered, secured and controlled from 'cradle to grave'. The international strategy also remains essentially unchanged, but its application has to be adapted to the new reality. Before 11 September 2001, it was targeted to breaches in security caused by innocent mistakes or petty theft; now, its scope is being widened to include malevolent acts, particulary ones perpetrated by terrorists.

A number of new initiatives are being considered, for example, the following:

- Precise assessment of the global situation;
- Conversion of the non-binding Code of Conduct into a legally binding undertaking;
- An increase in the international assistance being provided to developing countries (unsecured radioactive waste anywhere can be used for malevolent purposes everywhere), including ones that are not IAEA Member States;
- The establishment of a system for appraising national compliance with international security criteria;
- The tracking, physical characterization and securing of significant radioactive waste inventories.

In this context, countries should be encouraged (and helped) to monitor border crossings for the purpose of detecting illegal movements of radioactive waste and to locate uncontrolled waste deposits; the strengthening of security during the transport of radioactive waste should become a top priority; and the international emergency response capabilities established pursuant to the Early Notification Convention and the Assistance Convention should be enhanced. An essential element in all this will be education and training, particularly through the 'train the trainers' approach.

Only last week, following a request made by some of its Member States, the IAEA agreed to convene — as a matter of urgency — an International

Conference on Security of Radioactive Sources which will take place from 10 to 13 March 2003 in Vienna, hosted by the Government of Austria, co-sponsored by the Russian Federation and the United States of America, and organized by the IAEA in co-operation with the European Commission, Europol, Interpol and the World Customs Organization. One of the main issues to be addressed at this conference will be how to dispose of radioactive sources after securing them. It is hoped that the discussions here, at the present conference, regarding the disposal of radioactive sources, will provide a significant input to the forthcoming conference on the security of radioactive sources, the findings of which are expected to lead quickly to the preparation of an international action plan.

10. FACING THE CHALLENGES

10.1. Towards the final consolidation of the international regime for the safety of radioactive waste management

The IAEA is playing a major role in the consolidation of the international regime for the safety of radioactive waste management, which has been evolving over the years. As already indicated, the regime has three key elements:

— A commitment on the part of States to legally binding international conventions;
— The establishment of globally agreed international safety standards;
— Provision for the application of those standards.

In recent years, commitments by States have come to play a crucial role in improving nuclear, radiation and waste safety. The IAEA assists the process by facilitating the conclusion of agreements and performing a range of functions for the parties once the agreements are in force, for example, it supports implementation by providing the secretariat support and rendering service to parties upon request. A prominent agreement of the kind in question is, of course, the Joint Convention.

In addition, the IAEA has, in co-operation with Member States, developed and issued more than 200 standards for radiation and nuclear safety, including Safety Standards for the Management of Radioactive Waste. The first safety standards relating specifically to radioactive waste were issued within a few years of the IAEA's creation, and by the end of the 1970s the IAEA had created a high profile series of Radioactive Waste Safety Standards (the

RADWASS document series). As already indicated, the leading document in this series, "The Principles of Radioactive Waste Management" (issued in 1995), formed the technical basis for the Joint Convention. (The Chairperson of the IAEA's Commission on Safety Standards, L.G. Williams, is represented at this conference and will talk to you about a new strategy for strengthening the IAEA's corpus of Safety Standards.)

The IAEA's strategy for providing for the application of safety standards is focused on:

— Fostering the systematic exchange of safety-related information;
— Promoting education and training in radioactive waste management;
— Supporting and co-ordinating R&D related to the safety of radioactive waste management;
— Conducting co-operation and assistance programmes in support of the application of safety standards;
— Rendering appraisal services to Member States upon request.

Appraisals have already been performed through international peer reviews. The US Department of Energy set a good example by requesting appraisals in connection with its Yucca Mountain project — an appraisal of the biosphere modelling programme, performed by the IAEA [45], and an overall appraisal, performed by the IAEA together with OECD/NEA [46]. In this area, a bridge between the developed and the developing world needs to be built through unrestricted technology transfer, for there is a great deal of radioactive waste not only in developed countries but also in developing ones. It is hoped that the IAEA's Model Projects for upgrading radiation protection infrastructure, which include activities relating to the safety of radioactive waste management (and the number of countries participating in which has now increased from 52 to 83), will lead to an unrestricted transfer of technology, and the IAEA looks forward to the Model Projects receiving still stronger support.

The participants in this conference are urged to help bring about the final consolidation of the international regime for the safety of radioactive waste management that is still evolving. The Córdoba Conference led to an action plan which the IAEA is implementing successfully and which covers, inter alia, the development of a common framework for radiation waste disposal, assessment of the safety implications of extended storage, the development of standards for geological disposal, the development of a harmonized approach to the removal of waste from regulatory control, the exploration of ways of ensuring the intergenerational transfer of information, and the consideration of the societal aspects of radioactive waste management that the Conference President mentioned — often simply referred to as ‘stakeholder involvement’. The progress being made in implementing the action plan will be described by P. Metcalf, the IAEA staff member in charge of its implementation.

The IAEA expects that this conference will produce conclusions leading to the preparation of a refined action plan which identifies what else the international community should do and what directional adjustments it should make. Hopefully, this conference will call for strengthening the emerging radioactive waste safety regime.

11. OUTLOOK

The future of radioactive waste management, and consequently of nuclear power generation, is a dominant public acceptance issue nowadays. The IAEA, which is uniquely positioned and highly respected internationally, can serve as a catalyst in the pursuit of a consensus that has long eluded the international community. But governments will play the dominant role. A major change since the Córdoba Conference is the change in the attitude of some governments from passiveness to a positive stance. A good illustration has been provided by Finland and its courageous decision in favour of the establishment of a final repository — a decision taken with top governmental and broad stakeholder involvement. The US decision in favour of establishing a final repository at Yucca Mountain could also provide some light at the end of the tunnel.

In his keynote speech at the Córdoba Conference, the then US Resident Representative to the IAEA, Ambassador John Ritch, said the following:

> “In the realm of nuclear energy, our need is for a broad discussion — in two senses. We must have a broad range of participants that includes governments, operators, industry, regulators, non-governmental organizations, respected experts, and citizens groups — indeed, any and all vessels or shapers of public opinion. We also need a broad range of subject matter, so that public dialogue is expanded beyond the narrowly contentious issue of where and how waste will be deposited. Our debate must be holistic, including a full and realistic discussion of energy alternatives — aimed, inter alia, at identifying a reasonable and accepted role for nuclear power and its by-products.”

Ambassador Ritch recalled that, in Greek mythology, an oracle stated that he who could untie the impossibly tangled Gordian knot would rule all Asia. According to legend, Alexander the Great simply cut the knot with his sword and achieved the glory that had been foretold. The retained metaphor is one of slicing through problems with quick and deft solutions. Today, as we face the challenge of extracting consensus from the bitter debate over the future of radioactive waste management and, by implication, of nuclear energy and its many beneficial by-products, no such facile answer is at hand. Ambassador Ritch said that it was not by slicing through the present impasse that we would take control of our destiny and guide ourselves rationally in meeting the urgent imperative of producing more and cleaner energy, we will not do so by slicing through the current impasse. Obstacles cannot be overrun or ignored. We must untie the Gordian knot, carefully and painstakingly, using all of our resources and democratic institutions wisely and well.

The IAEA can provide a forum — a vehicle for international standardization, communication, education and rational advance towards an urgently needed consensus among stakeholders — on a global problem that bears heavily on the very future of civilization. Today, the term ‘stakeholders’ is used so frequently that it has become a cliché. In the case of the safe management of radioactive waste and the consequent future of nuclear energy, the usage is appropriate. For all of humankind, there is a great deal at stake.

With its worldwide membership, the IAEA is well placed to provide, in co-operation with other intergovernmental organizations, a forum for international dialogue on radioactive waste management. With other organizations of the United Nations system, and also with organizations such as the OECD/NEA and the European Community, the IAEA looks forward to a consensus being reached on the safety of radioactive waste management.

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STRATEGIC DIRECTIONS IN RADIOACTIVE WASTE MANAGEMENT
The perspective of the OECD/NEA

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1. INTRODUCTION

The Organisation for Economic Co-operation and Development (OECD) was set up in 1947 to foster sustainable economic growth in countries which share common goals with regard to free trade and social values.

Within the OECD, the Nuclear Energy Agency (NEA) has the role of maintaining and further developing the bases for safe, environmentally friendly and economic uses of nuclear energy. Safe and acceptable management of radioactive waste is the key to supporting these activities, and management of these wastes poses important challenges in arriving at acceptable — and accepted — solutions.

Regarding conditioned waste, technical challenges exist because of the time frames over which many materials are hazardous, and social challenges exist because acceptable approaches are largely driven by cultural views. Thus, there is no 'one size fits all' for acceptable solutions, except that any solution must be found to be safe and secure, in order not to pose health threats to populations. The OECD/NEA does not include 'discharges' in the radioactive waste category, but in this case both technical and social concerns also exist in view of expressed desires to reduce the radiological releases.

In this context, the OECD/NEA, through its committees, contributes to the development and implementation of safe and effective practices and policies for all radioactive waste in OECD/NEA member countries. This is done by exchanging and disseminating high quality information, advancing the state-of-the-art for both technical and societal aspects, and by providing a framework for peer review. Hopefully, most of those present today will have been utilizing OECD/NEA publications at work, and found them useful. The OECD/NEA committee leading the work in this area is the Radioactive Waste Management Committee, which is a forum of senior regulators, implementers, policy specialists, and R&D specialists from OECD/NEA member countries.

2. STRATEGIC AREAS

Because situations change and evolve, the OECD/NEA examines its programmes regularly to ensure that it is focused on topics and activities most responsive to current national situations. The following outlines what may already be considered as achievements and where the challenges are.

2.1. General achievements and context

The OECD/NEA notes that in its member countries, considerable experience has been accumulated in the field of radioactive waste management over the years, particularly in the areas of:

- The handling, treatment, storage and disposal[1] of short lived low and intermediate level wastes;
- The conditioning (vitrification) of high level waste and the storage of high level waste and spent nuclear fuel;
- The minimization of waste production during plant operation;
- The management of 'historical' waste and the management of older waste facilities under changed legislative and regulatory frameworks.

It is also accepted among experts that geological disposal represents an ethical and appropriate solution to the long term management of long lived radioactive waste. Furthermore, the feasibility of geological disposal of long lived waste, including spent fuel, has been established at a technical level, and many OECD member countries are now pursuing repository development programmes. This has led to notable advances in:

- The establishment of organizational structures and regulatory frameworks to govern the construction and licensing of such facilities;
- Conceptual designs for the facilities as well as the technology required to implement the designs;
- The formulation of procedures for site selection and the technology for site characterization;
- The development and application of methods to assess the safety of the proposed repository systems;

[1] As used in this paper, 'storage' indicates the possible intention to retrieve waste and the need for continued monitoring; 'disposal' indicates the lack of intention to retrieve and a passively safe long term solution.

— The overall confidence in the design and characterization processes, and the evaluation of safety;
— The achievement of important milestones, for example, in selecting sites (Finland is the best recent example) and in further developing the existing site into a repository, which is the recent case of Yucca Mountain in the United States of America.

Lessons have also been learned from difficulties and setbacks in carrying forward waste management programmes.

In addition, the OECD/NEA notes that there is interest, and resources are being spent, in research in the partitioning and transmutation of long lived nuclides in order to reduce the amounts of long lived waste. The overall balance of financial and practical aspects of this process is, however, still debated. In particular, it is accepted that partitioning and transmutation will not diminish the need to dispose permanently of long lived waste, but it can help in optimizing the process. Some member countries also have a continuing interest in the possibility of regional, or multinational, repositories.

2.2. The OECD/NEA focus areas

Against the above background of experience, OECD/NEA member countries continue to believe that, in the field of management of solid radioactive waste, the OECD/NEA as an international organization can best serve its constituencies by focusing on the management of long lived radioactive waste and spent nuclear fuel. Some countries, such as Finland and the USA, have reached the site development phase while others are approaching critical stages, including France, Japan, Sweden, among others. Furthermore, decommissioning and the management of relatively large amounts of slightly contaminated materials are topics of great interest in OECD/NEA member countries nowadays. Given the experience gained worldwide from many decommissioning projects, the OECD/NEA finds itself at a good point in this field for stocktaking from technical, regulatory and stakeholder confidence perspectives.

Thus, the following six strategic reference areas, of general character and wide interest, have been identified at the OECD/NEA.

2.2.1. Overall waste management approaches

In terms of overall waste management approaches, there is interest in the following:

- Demonstrating that safe and environmentally acceptable strategies can be applied which respect the principle of sustainable development. This has to do with the debate on alternative management approaches such as long term guardianship versus passive safety and disposal;
- Developing further and applying the principles of retrievability and reversibility within a stepwise decision making process which gives sufficient time for social interaction to develop and be fruitful;
- Comparing the principles of radioactive and non-radioactive waste management and of the evaluation of their impacts. It is important to achieve consistency of management principles across different types of materials, including different types of radioactive materials, which has implications for intra- and intergenerational equity, and on keeping open a spectrum of energy choices in a perspective of sustainable development;
- Evaluating the impact of economic and financial pressures on waste management programmes, e.g. due to deregulation of electricity markets, as well as the impact of waste management on the continued economic sustainability of nuclear power.

2.2.2. The process of repository development for long lived radioactive wastes

Especially for the OECD/NEA, it is important to assist in the resolution of technical issues in order to promote safety and provide grounds on which to base decision making, and to help develop a common understanding between independent bodies such as implementers, regulators and policy makers on the goals to be achieved and respective responsibilities. Also important is to investigate how to develop societal confidence on how to move forward at the various stages of a repository development programme, as it is recognized that the ultimate decisions are not only technical but also societal.

2.2.3. Decommissioning and the management of slightly contaminated materials

Utilizing the experience acquired so far, it is important to assist OECD countries in preparing for the large and increasing number of decommissioning and dismantling projects that will be implemented in the coming years. Some aspects include the definition of an appropriate delicensing approach and appropriate models; identifying the major cost items; defining procedures for the release and/or reuse of sites and buildings, with a view to arriving at consensus on safe, practicable, cost effective and environmentally sound solutions.

2.2.4. Public perception and confidence

Issues of public perception and confidence apply across all topics dealing with waste management (as discussed earlier). It is important to the OECD/NEA to assist member organizations in the transition to a new culture of understanding the concerns of stakeholders and of communicating effectively. Sharing practical experiences from outreach and consultation exercises and public decision making processes, and reflecting on the lessons learned is a way to achieve that. Especially important is to build bridges to intermediaries between the public and the more technical community, for example, scientists in other fields and policy makers.

2.2.5. Implications of, and participation in, international guidance and agreements

It is important to be abreast of, and participate in, international developments. The OECD/NEA will play a forward-looking role and identify implications for waste management programmes, and make sure its committees have an input on behalf of the member countries. The new International Commission on Radiological Protection (ICRP) radiological policy considerations constitute one example, as well as the implications of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. In addition, international co-operation and co-ordination are essential to minimize duplication, and to combine the strengths of several organizations. Representatives of the European Commission and the IAEA participate in OECD/NEA meetings as well as in working parties. This conference is an example of co-operation. With both the IAEA and the European Commission, the OECD/NEA regularly co-sponsors official documents that have wide distribution and repercussions.

2.2.6. System analysis and technological advances

The back of the fuel cycle is influenced by the choices made in the front of the cycle. The choice of materials and conditioning methods also influences waste management. It is thus important to appraise the emerging waste management and disposal technologies, and to identify data needs. For instance, one recent OECD/NEA seminar identified the need to define the low and intermediate waste streams associated with partitioning and transmutation; furthermore, it was determined that if very long term storage of the waste is chosen, the materials must be adequately durable, etc.

Additionally, to return to this conference, the OECD/NEA attaches great importance to the subject of discharges for their technical and political implications. From the technical point of view, the OECD/NEA must be able to provide clear answers on the implications of different release options on such items as radiological protection of the public and workers, on the handling of waste streams, on the economics of upgrading the facilities, etc. This also has implications on the design of new generation fuel cycles.

3. SOME EXAMPLES OF ONGOING OECD/NEA INITIATIVES

3.1. Stepwise decision making

Consideration is increasingly being given, in radioactive waste management (RWM), to concepts such as 'stepwise decision making' and 'adaptive staging' in which the public, and especially the local public, are meaningfully involved in the review and planning of developments. The key feature of these concepts is development by steps or stages that are reversible, within the limits of practicability. This is designed to provide reassurance that decisions can be reversed if experience shows them to have adverse or unwanted effects. Stepwise decision making has thus come to the fore as being especially important for making progress in RWM in a societally acceptable manner. The OECD/NEA is reviewing the current developments regarding stepwise decision making in RWM with aims that include: to pinpoint where it stands, to highlight its societal dimension, to analyse its roots in social sciences, and to identify guiding principles and issues in implementation. Overall, it is observed that there is convergence between the approach taken by the practitioners of RWM and the indications received from field studies in social research, and that general guiding principles can be proposed at least as a basis for further discussion. A strong basis for dialogue across disciplines thus exists. Later in this conference, another representative of the OECD/NEA, Y. Le Bars, will introduce in more detail some of the points that are being made.

3.2. Regulatory frameworks

The involvement of both technical and non-technical stakeholders will become increasingly important as more countries move towards the siting and implementing of geological repositories. This last observation is already true in respect of other aspects of radioactive waste management such as transport, interim storage and the authorized discharge of liquid and gaseous effluents into the environment. A feature of this involvement is the increasing extent to which reference is made to procedures and standards applied internationally as well as nationally, and to comparisons between them. It is not apparent that such comparisons are always well informed. The OECD/NEA has already recognized the value of exchange and comparison of information about national practices and of having an informal, international network for discussion of issues of common concern. The opportunity for such activity is provided by the Regulators' Forum of the RWM Committee (referred to as the RWMC-RF) whose first major visible action was to compile information about the regulatory control of radioactive waste management in OECD/NEA member countries, with emphasis on waste disposal. A database of information has been created that can be downloaded from the OECD/NEA web site. The database includes factual information about national policies for radioactive waste management, institutional frameworks, legislative and regulatory frameworks, available guidance, classification and sources of waste, the status of waste management, current issues and related R&D programmes. It should, thus, provide an important source of reference for *all* stakeholders intent on learning about international practices. At the same time, the RWMC-RF is also proceeding to abstract this information into a series of higher level lessons to be learned concerning, for example, the role of regulatory agencies in decision making, the major challenges they face, the rationalization of different safety establishing criteria and procedures that reflect, to some extent, national and cultural heritages.

3.3. Peer reviews

The OECD/NEA has established itself as an important provider of independent peer reviews of national, waste disposal studies. In the past three years, it has organized, at the request of governments of member countries, the peer review of the SR 97 study in Sweden, the performance assessment of the Yucca Mountain repository in the USA (this was done in co-operation with the IAEA), the SAFIR-2 study in Belgium, the Dossier 2001 in France, and more requests are coming. These peer reviews are not, per se, stamps of approval, which can only be given by the national authorities. They are meant, rather, to help national programmes to assess themselves and to do better in the future. These peer reviews take full advantage of the wide access to expertise that is available to the OECD/NEA. Typically, a mix of specialists is utilized that represents regulators, the implementers, and R&D sensitivities. These peer reviews represent a win-win solution in that, on the one hand, the country receiving the peer review has the benefit of state-of-the-art experience from the experts conducting the review, and on the other hand, the experts carry back to their own countries a detailed understanding of other waste management approaches, safety case construction and societal decision making processes.

3.4. The safety case for geological repositories

The OECD/NEA historic strengths are in developing the technical elements of the safety case for geological disposal. In fact, the definition of 'safety case' in the waste field arises from OECD/NEA publications. Senior technical specialists, knowledgeable in construction and review of the safety case, have faced first of a kind challenges in illustrating in a defensible manner long term repository performance in the face of large spatial scales, long time frames, variability of natural systems and large uncertainties. A whole group of initiatives is dedicated to this area. Key to the success of this activity is the dialogue between researchers, regulators and implementers. The goal they have is to develop a safety case as the basis for technical and public confidence.

In this field, the OECD/NEA is reviewing, with a view to co-sponsoring, the IAEA draft safety requirements for geological disposal of radioactive waste. A brochure on the contents of a safety case is being prepared independently by the NEA. In the field of safety assessments, the OECD/NEA has just finalized the documentation of the Working Group on Integrated Performance Assessments of Deep Repositories (IPAG) series of exercises which summarized the views and experience of both reviewers and reviewees of safety studies. Other recent initiatives include a workshop on the Handling of Timescales in Assessing Post Closure Safety; a workshop on the Role of the Engineered Barrier Systems in the Context of the Entire Safety Case; and research projects dealing with the modelling of radionuclide sorption on geological media and the integration of soft and hard data for site and safety modelling purposes (the AMIGO project). Finally, two databases which constitute a reference in the field warrant a mention: the thermochemical database and the database of features, events and processes. Both databases are widely used as benchmarks in national programmes.

3.5. Decommissioning and dismantling

OECD/NEA member countries include those involved in the earliest developments of nuclear technology in the 1940s and 1950s. These countries have a wide range of plants and equipment that has now served its purpose and needs to be decommissioned and dismantled. A new range of challenges opens up as the more modern nuclear power programmes mature and large commercial nuclear power plants approach the end of their useful life by reason of age, economics or change of policy on the use of nuclear power. The scale of such challenges may be judged from the fact that over 400 nuclear power plants have now been constructed and operated worldwide, and OECD/NEA member countries account for a large proportion of these. Given an average operating life span of 30 to 40 years, and that the average age of nuclear power plants is about 15 years, the rate of withdrawal from service will peak some time after 2015.

The current situation is that much has already been done to deal with the decommissioning and dismantling, but much remains to be done. The work on earlier facilities has provided a substantial body of knowledge and experience over a wide range of complex technical issues but the requirement now is to apply the available techniques to decommission and dismantle the larger commercial facilities. In addition to technical issues, plans and procedures will need to address other major issues associated with impacts on society and the environment, regulatory arrangements and with long term funding.

The OECD/NEA has recognized the importance of the decommissioning and dismantling of nuclear facilities as far back as the early 1980s. A report has just been issued by the Working Party on Decommissioning and Dismantling (WPDD) which provides, in non-specialist terminology, a concise overview of the status of decommissioning and dismantling nuclear facilities and associated issues in OECD/NEA member countries. The report draws upon a database of fact sheets produced to a standard format by individual member countries that can be accessed online from the OECD/NEA web site. The WPDD plans to update this database regularly. The WPDD booklet is available free upon request from the OECD/NEA. Its web site (namely, the WPDD page) contains the link to the national fact sheets on decommissioning and dismantling, as well as more detailed information about the activities and publications of the group, which includes proceedings of topical sessions on the safety case, the management of materials, and others.

3.6. Stakeholder confidence

Issues of public confidence and perception are challenges shared in all areas of radioactive waste management. Lessons learned from past difficulties in progressing national radioactive waste disposal programmes indicate that any significant decisions regarding the long term management of radioactive waste will be accompanied by a comprehensive public review with involvement by a diverse range of stakeholders. These stakeholders include not just the waste generators, waste management agencies and regulatory authorities, all of whom have a primarily technical focus, but also interested or concerned parties with a non-technical focus such as local communities, elected officials, non-governmental organizations and the general public. The OECD/NEA announced the startup of activities in this field at the Cordoba Conference in 2000.

The Forum on Stakeholder Confidence (FSC) was created under a mandate from the OECD/NEA Radioactive Waste Management Committee (RWMC) to facilitate the sharing of international experience in addressing the societal dimension of radioactive waste management. It explores means of ensuring an effective dialogue with the public, and considers ways to strengthen confidence in decision making processes. The effort is also aimed at self-improvement, at giving a voice to national stakeholders, and at making the information available.

The forum involves non-institutional stakeholders through country visits involving site visits and a workshop. After a site visit, which enables direct understanding of the specific situation at hand, a wide spectrum of country stakeholders are invited to express their views on the nature of their involvement and the process by which they are involved. A highly interactive format allows FSC delegates and country stakeholders to compare experience and deepen the discussion. Thematic rapporteurs, invited by the OECD/NEA Secretariat, give feedback to the workshop participants from their own disciplinary perspective. Two workshops have been held to date, in Finland and in Canada. This is a highly valued service to member countries, as it is unusual to see so many stakeholders talking to one another under normal circumstances. The forum has thus established itself as the provider of a neutral ground for debating a specific waste management situation or issue. Member countries propose these national workshops, just as member governments request peer reviews.

4. CONCLUDING REMARKS

The present paper has provided comprehensive overviews of the strategic areas that the OECD/NEA believes are of wide interest in the management of radioactive wastes, as well some examples of actual products and initiatives at the OECD/NEA. Some of the same themes in the programme of this conference are readily recognized.

Finally, the OECD/NEA, as co-sponsors of the conference, extends its good wishes for a successful conference, and looks forward to results that will be of value and used extensively in member countries.

THE EUROPEAN COMMISSION'S PROPOSALS IN THE AREA OF NUCLEAR SAFETY AND RADIOACTIVE WASTE MANAGEMENT 'NUCLEAR PACKAGE'

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1. THE CONTEXT

The Green Paper on the security of energy supply, adopted by the European Commission in November 2000, pointed out that the European Union has little room for manoeuvre with regard to energy supply. Therefore, it concluded that renouncing the nuclear option could leave a dangerous gap in the power generation capacity of the European Union.

But the challenges that this implies should not be underestimated. It requests improved transparency and public confidence, high levels of safety and efficient long term waste management.

Under the Euratom Treaty, signed in 1957, the European Union has adopted extensive legislation on radioprotection and safeguards. In particular, the European Commission has set up a European safeguards inspectorate for nuclear installations. However, it must be noted that legislation on the safety of nuclear facilities themselves did not experience a similar development so far, although the Treaty has the objective of protecting people against the dangers of ionizing radiation.

Today, in the perspective of European Union enlargement, but also because it is a very strong concern for Europe's citizens, action must be taken as regards nuclear safety.

No major initiatives were undertaken in the area of nuclear safety until recently. In the preparation for the current enlargement of the European Union, the European Commission was asked to ensure the application of high safety standards in central and eastern Europe. The Laeken European Council in December 2001 in turn requested regular reports on nuclear safety in the European Union. It stressed the need to monitor the security and safety of nuclear power stations. It called for regular reports from member states' atomic energy experts, who will maintain close contacts with the European Commission.

2. THE NUCLEAR PACKAGE

This is why the European Commission adopted a communication containing a consistent package of complementary measures under the Euratom Treaty, aiming at the implementation of a Community approach on nuclear safety, from the design to the decommissioning of a nuclear installation and including the management of radioactive waste.

It includes two main components which are of importance in this context:

— A draft proposal for a framework directive defining basic obligations and general principles in the field of the safety of nuclear facilities.
— A draft proposal for a directive on the spent fuel and radioactive waste management.

Both draft proposals for directives were approved by the European Commission on 6 November 2002. These two texts are legally based on Chapter 3 of the Title II of the Euratom Treaty, which deals with health protection and safety. They complement the basic standards relating to the health protection of the population and of the workers against the dangers resulting from ionizing radiation. Under the terms of the Euratom Treaty, proposals in this area have to be submitted for opinion to the group of scientific experts provided for in Article 31 of the Treaty.

Thereafter, the proposals will be forwarded to the Economic and Social Committee, and then to the European Council and to the European Parliament.

Through these initiatives, the European Commission proposes to pave the way for a Community approach to issues of nuclear safety and radioactive waste management.

3. NUCLEAR SAFETY AND DECOMMISSIONING

The proposal relies on three main principles:

— Firstly, to use existing rules and principles, including those elaborated by the IAEA, and make them legally binding in the European Union. The framework directive defines basic obligations and general principles on the basis of which common safety standards will be adopted later on.

— Secondly, to create a system of independent verification. The framework directive does not create a permanent body of inspectors. Instead, the Commission will make use of safety experts maintained by national authorities to ensure a high level of nuclear safety in the Member States. These verifications will be carried out at the level of the national safety authorities, but not at the nuclear facilities themselves. The complementarity of national systems with the Community system will become the guarantee of maintaining a high level of safety in European Union nuclear facilities.
— Thirdly, to make sure that decommissioning operations are carried out at the proper time without endangering the health of persons and of the environment. The draft proposal defines Community rules to ensure radiological protection during the decommissioning operations at nuclear facilities, in particular by guaranteeing the existence and the adequacy of necessary financial resources.

In summary, this framework directive sets measures to ensure the maintenance of a high level of nuclear safety, not only during the operation of a nuclear facility but also during its decommissioning.

4. RADIOACTIVE WASTE MANAGEMENT

The problem of radioactive waste resulting from nuclear activities calls for effective solutions which do not yet exist at a satisfactory level today.

There is a broad international scientific consensus that deep geological disposal is the best option. Nevertheless, this fact should not prevent the continuation of research into new technologies which could reduce levels of radioactivity in nuclear waste. This is the reason why such an initiative is supplemented by strong incentives in terms of research.

Two concrete measures are the following:

— The directive stipulates that Member States adopt a timetable to dispose of radioactive waste. Member States will have to adopt, according to a pre-established timetable, national waste disposal programmes. They will be required to make the decisions on the choice of a site by 2008, and to make the site operational by 2018. For low level radioactive waste, disposal has to be carried out by 2013 at the latest. The proposal also leaves open the possibility to the Member States of agreeing for the creation of a regional site within the European Union, or in a non-member country.

— An increased effort as regards research. On the subject of nuclear waste management, research is crucial. The European Commission is indeed aware that waste disposal, which represents the best technical solution in the current state of knowledge, must not close the door to research activities that deserve to be continued and supported. The efforts, as regards research, have to be increased. Financial commitments have to be maintained or even increased in certain States and more effective co-operation is necessary between the various Community and national programmes, within the framework of the financial prospects for the sixth framework programme on Community research activities.

At a later stage, the European Commission could also propose the creation of a Joint Undertaking, as foreseen by Chapter 5 of the Euratom Treaty, to manage and direct the research funds intended for waste management.

In conclusion, the package on nuclear safety and radioactive waste management aims to give a consistent and balanced overall framework which provides for a Community solution to the various issues mentioned before. With these proposals, the European Commission is seeking to fulfil its responsibilities by endowing the European Union with greater safety, within a framework of enhanced transparency.

PREPARING FOR THE NUCLEAR CENTURY
The roles of science and public policy in resolving the issue of nuclear waste

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1. INTRODUCTION

For the half century of Cold War that ended just a dozen years ago, geostrategic conflict was the consuming focus of world politics. Today, having emerged from that dangerous era, the world's nations have begun to refocus. Rising ever higher on our agenda are critical global problems long deferred, potentially even more threatening and now too urgent to ignore.

These problems do not arise from a clash of armed nations or rival ideologies, but rather from the vigour of peaceful human activity and from an explosive rise in human numbers.

Today, and for the foreseeable future, the fundamental question facing humanity is whether we can reconcile the imperative of fulfilling human needs and aspirations with the imperative of preserving the very environment that enabled civilization to evolve.

Dominant in today's headlines is the challenge of preventing the use of weapons of mass destruction for aggression or terror. But no less urgent is the need to act now to prevent the larger, more pervasive dangers that will eventually overwhelm us if we fail to deal with the sweeping challenge of achieving global sustainable development.

It is far from alarmist to warn that the air we breathe and the climate on which we depend could each become, during the century ahead, instruments of mass destruction that far exceed the lethality of human-made weapons.

Nor is it alarmist to state what is no more than a fact: that world population, which will increase from six to nine billion in the next 50 years, is expanding far more rapidly than our ability to meet basic human needs. In the coming half century, global energy demand will double, and humankind will consume more energy than the total used in all previous eras. In just the next 20 years, we will be hard pressed to avoid a global catastrophe arising from the severe shortage of clean water.

These trends are dire and make inevitable a future of radical change. Either we will achieve radical transformation in the global economy, or we will experience a radical surge in human suffering and a radical alteration in the global environment.

No aspect of sustainable development is more elemental than the need to accomplish a massive worldwide shift to clean energy technologies — to be used both by economies that are already industrialized and also to meet an expanding global demand.

It is an irony of our age, and it is fast becoming a tragic irony, that so many citizens and organizations most concerned about the clean energy problem are fixated on myths, dogmas and sheer fantasies regarding the solution.

In the realm of hard reality, projections by the International Energy Agency (in the public sector) and the World Energy Council (in the private sector) point unambiguously to the same conclusion: that our need for clean energy on a colossal scale cannot conceivably be met without a sharply increased use of nuclear power.

Those who persist in opposing nuclear power in the name of environmental preservation will surely earn the scorn of history and of future generations. Fortunately, the world is coming to recognize the profound reality that sustainability requires nuclear energy.

The world's environmentalists, who have performed many valuable services, can now provide their fellow citizens no greater service than to discard the fiction that conservation, solar panels and windmills alone can meet human needs. The path of sound environmentalism today is to embrace — and fight for — a future in which nuclear power and 'new renewables' function as clean energy partners in a transformed global economy.

2. FOUNDATIONS FOR A 'NUCLEAR CENTURY'

In the decades ahead, the world will come to recognize its debt to the scientists and diplomats of the last half century who worked to build nuclear power into a vibrant and mature technology supported by an international structure to ensure its peaceful uses.

This combined effort has paved the way for a nuclear century in which the power of the atom, rather than posing a threat to human existence, will be indispensable to human welfare:

— First, we have met the challenge of proliferation. The global regime founded on the Treaty of the Non-Proliferation of Nuclear Weapons, and the safeguards system that supports it, constitutes one of the great diplomatic achievements in history. We cannot erase the danger of illicit activity arising from nuclear knowledge, but we have taken enormous strides to fulfil the pertinent goal, which is to ensure that valuable use of nuclear technology does not abet illicit activity.

— Second, we have met the challenge of safety with technological advance, with high standards promulgated by the IAEA and with a new institution: the World Association of Nuclear Operators (WANO), which represents an extraordinary achievement in private sector diplomacy. Today, WANO's network of technical co-operation and peer review encompasses every power reactor worldwide, and WANO has joined the IAEA as an essential asset for a widening global industry.
— Third, in lowering costs, we have made steady progress through improved designs and operational efficiency, and we can look to a future in which nuclear power will emerge as a clear winner on the field of cost competition. Standardized and simplified reactor designs will lower capital expenditure, capacity factors will continue to inch upward and uranium fuel will remain affordable and bestow energy independence. Meanwhile, fossil fuels will offer uncertain prices, unreliability of supply, increasing shortages and rising penalties for use, through carbon taxes or emissions trading.
— Finally, in the critical area of waste disposal, we have made enormous progress, both technically and politically. It is the topic of this conference to survey the steps now to be taken as we move to build a functioning worldwide system for the long term disposition of nuclear waste.

It is ironic that some environmentalists oppose nuclear energy. The irony is compounded when it is opposed on the grounds that waste is the insoluble problem of nuclear power. In truth, waste is the greatest comparative *asset* of nuclear power.

Compared with the 25 billion tonnes of carbon dioxide now spewing into the biosphere each year from the use of fossil fuel, nuclear power creates a tiny volume of waste that can be safely managed — and disposed of — without damage to people or the environment.

It is precisely this asset, that is, the ability to extract enormous energy from the atom with a minimum of waste, that constitutes Nature's great blessing to humanity as we seek to meet expanding human needs in a biosphere that is both resilient and fragile.

In the years just ahead, the advantages of nuclear power will be multiplied by another atomic marvel: the ability to unite hydrogen and oxygen to make electricity. Hydrogen offers a means of storing electricity on a vast scale, for use in cleanly powered transportation and in the full range of traditional uses of electricity for home and industry.

Hydrogen's environmental value requires, however, that it be made cleanly, that is, using the clean primary energy that only nuclear power can provide on a vast scale. Hydrogen provides the bridge by which nuclear power can expand its clean energy contribution from the narrow realm of providing baseload electricity to the entire spectrum of energy use. With this bridge, it is now possible for the first time to envisage a thriving, large-scale, emissions-free industrial economy, with nuclear power and renewables providing clean primary energy for direct electricity and for electricity storage via hydrogen.

The father of the hydrogen fuel cell, Geoff Ballard, describes this as an economy operating on 'hydricity'. 'Hydricity' is an exciting prospect not only because it offers technological hope, but also because it can inspire action in the realm of climate change diplomacy. The Kyoto Protocol, even with its meagre cuts and incomplete participation, has introduced the valuable concept of emissions trading. Our need now is for a comprehensive treaty regime in which all the nations of the world — developed and developing — undertake a binding commitment to use emissions trading as the economic incentive for a long term evolution to a global clean energy economy.

It is possible to envisage a global trading system in which all nations find advantage. Our failure thus far indicates a lack of vision as to how a collective commitment to deep emissions cuts might realistically be fulfilled. The emergence of a feasible and widely understood clean energy vision could break this logjam, stimulating nations to undertake the commitments that will accelerate the vision's fulfilment.

Because 'hydricity', powered by nuclear energy and renewables, promises to provide that vision, it is extremely important that we continue our progress in developing regimes governing nuclear energy which are conducive to building ever stronger public support. In no aspect of nuclear power is such progress more important than in the management of waste.

Our progress to date on waste disposal has been both scientific and political. In both areas — science and public policy — it is pertinent today to ask two questions: first, where do we stand? and second, what further progress is feasible and how should we seek to achieve it?

3. PROGRESS AND PROSPECTS IN THE SCIENTIFIC REALM

As to where we stand on the scientific front, it is fair to say that our work is, in principle, complete, insofar as the scientific community has achieved consensus that a well-chosen, well-engineered geological repository is a responsible and feasible means of achieving safe, long term storage and disposal.

This consensus was reflected in a 1999 report of the OECD/NEA Radioactive Waste Management Committee, which concluded as follows: “Although refinements are still being made, deep geological disposal is effectively a technology that is mature enough for deployment.”

For its part, the ICRP has affirmed repeatedly that the radiological impact from the disposal of radwaste, using techniques that are now accepted, will be negligible.

To assert this is not to dismiss the possibility and desirability of scientific progress in reducing the quantity of waste generated by a given amount of nuclear power or in shortening the time required for decay.

Last month, while in the United States of America, I visited the Argonne National Laboratory, which will soon become the newest member of the World Nuclear Association (WNA). Researchers there are now participating with other laboratories in the USA to promote an initiative of the US Department of Energy (USDOE), the new Advanced Fuel Cycle Initiative. It was launched in October 2002 and focuses on achieving progress in the partitioning and transmutation of waste into short lived or non-radioactive material. A specific objective is to obviate the need for a high level waste repository in the USA, in addition to the existing one at Yucca Mountain.

The USDOE Advanced Fuel Cycle Initiative and the leadership of the USA in a multilateral partnership pursuing the development of Generation IV advanced nuclear reactor designs are much to be welcomed, for the scientific progress they will engender and equally because they demonstrate a revitalized commitment on the part of the USA to nuclear power that will have a valuable ripple effect around the world.

Our goal should be to harmonize to the highest degree possible these USA-led efforts, as well as parallel research under way in France, in Japan, in the Russian Federation, in the European Organisation for Nuclear Research, in the IAEA’s International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO), and elsewhere — to the maximum degree possible. It is a fundamental goal of the WNA, as it is of the IAEA, to promote transnational co-operation within the world nuclear community.

As we pursue this collective research, however, we must take great care to place it in an accurate context. We must not allow the prospect of further progress in the fuel cycle or in the science of nuclear waste to become an obstacle to our proceeding with deliberate speed to implement, on the broadest possible front, the concept of geological storage and disposal.

Even with revolutionary progress in reactors and the nuclear fuel cycle, there will still be waste requiring geological disposal.

As the OECD/NEA Radioactive Waste Management Committee concluded in 1999, partitioning and transmutation is not an alternative to disposal: “At best it reduces the volume, or changes the isotope distribution, of wastes requiring disposal.”

In addition, the Radioactive Waste Management Committee warned against regarding “extended or indefinite surface storage as a real alternative to disposal”. Indeed, I would sharpen this point by noting that the most vocal advocates of indefinite surface storage of waste are the truly dedicated opponents of nuclear energy, who are keenly concerned to keep the waste issue alive — and indefinitely unresolved.

In short, new and ongoing research efforts on waste minimization and waste disposal can be a great asset as we continue to perfect nuclear technology for the new millennium. But these efforts can pose a liability if and as we allow research to be misconstrued as implying a need to wait.

Research now should be seen as a process of optimizing technologies, for power production and waste disposal, which are already mature and eminently sound.

4. PROGRESS AND PROSPECTS IN PUBLIC POLICY

Turning now to the public policy front, where do we stand and where do we go from here?

Nearly three years ago, representing the USA at the International Conference on the Safety of Radioactive Waste Management in Cordoba, I analogized the policy aspects of waste management to a Gordian knot. Unlike the Alexander of antiquity, who achieved greatness by slicing through a hopelessly tangled knot, our path to success requires patience and step by step success.

Today we can take encouragement that our progress in untying the knot of long term waste management has, in recent years, been considerable.

On the national policy front, we have seen hard fought and well earned victories for reason in both Finland and the USA. Symbolically, these successes are synergistic because they combine Nordic moral authority with the technological leadership of the USA. Parallel political progress is under way in Sweden and the Russian Federation and, to various degrees, elsewhere.

Meanwhile, on the international front, we have achieved equally historic progress in three key areas: standards, obligations and peer review to demonstrate compliance. This progress constitutes a giant step toward a fully functioning, internationally sanctioned system. The key areas are outlined as follows:

(a) *Standard setting:* First, we are about to achieve comprehensive international agreement on standards for waste safety.

Through the IAEA, the international community has built a sophisticated, nearly complete corpus of global safety standards. These are embodied in a series of IAEA publications covering all aspects of safe operation and various aspects of waste management.

Heretofore, one key element of the mosaic was missing. Very recently, technical officers from national regulators met to consider and finalize the last draft of the IAEA's Safety Standards for Geological Repositories.

According to current plans, publication after approval by the Board of Governors of the International Atomic Energy Agency is scheduled for 2004. In the meantime, an extensive effort will be undertaken to achieve maximum institutional and national 'buy-in'.

When achieved, this success will constitute a historic landmark, for it will expand the coverage of internationally agreed safety standards to the nuclear fuel cycle in its entirety.

(b) *Obligations:* Second, we have brought into force the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, with the first meeting of the parties to occur later in 2003.

Establishment of the Joint Convention also represents an historic step, for it raises the commitment to safe disposal according to global standards from a catechism to an international, legally binding obligation.

A remaining task is to bring in three major players who are not yet in the regime: the USA, the Russian Federation and Japan.

(c) *Peer review:* Finally, we have established a track record for the immensely important process of IAEA-led peer review, more formally known as appraisal of compliance, with regard to geological disposal.

Two such reviews have occurred, both in connection with Yucca Mountain. The first concerned only an evaluation of the biospheric modelling programme. The second was an all-encompassing review of the entire Yucca Mountain project.

> This step is historic because it has demonstrated, in a case holding importance for the future of the entire global industry, the valuable domestic impact of validated compliance with international standards.
>
> In the Bush Administration's effort to assemble a majority in Congress to support Yucca Mountain, the fact that the project had passed the test of an objective international evaluation proved to be an immense asset.
>
> Traditionally, governments and industry have been instinctively averse to the intrusion of appraisal by external bodies. But this precedent — of outside peer review serving as a crucial *asset* in national decisions — offers a lesson for all nations, and not only on matters of geological disposal.
>
> This lesson is now taking hold. Recently, for example, the United Kingdom chose to obtain an IAEA peer review on transport. Following suit, France has now requested the same evaluation for the same reason: the persuasive effect of a neutral evaluator applying a globally approved standard.

The topic of international standards for geological disposal inevitably points us towards the question of international repositories. It is widely recognized that for some countries, especially small ones, this concept will eventually hold great value because of challenging geological conditions, limited siting options or cost.

Earlier this year, a small group of organizations from five European countries launched a new association, the Association for Regional and International Underground Storage (ARIUS), to support the concept of shared facilities for storage and disposal. The WNA intends to work closely with ARIUS and its members to explore this concept.

In so doing, however, we share with ARIUS a keen awareness of the sensitivities attendant to this subject. It is absolutely imperative that any consideration of the eventual use of shared facilities not impede progress in those countries that are in the process of demonstrating leadership by acting to fulfil their responsibilities through national sites.

Indeed, it is fundamental to the future of geological disposal that we achieve a track record of successful national disposal. Such progress should deserve to dispel the phobias and taboos that currently surround this topic, so that nations can eventually make decisions, whether for national or shared sites, based on rational calculation rather than on fear and procrastination.

5. A PARTNERSHIP FOR NUCLEAR PROGRESS

In closing, let me express on behalf of the nuclear industry, gratitude for the contribution of the IAEA in pushing forward towards the achievement of a worldwide system of nuclear waste disposal based on high, legally binding standards overseen by a process of peer review.

Two years after creating the WNA on the foundations of the previous Uranium Institute, we are well advanced in the building of a truly global organization of the companies and organizations that conduct the actual business of operating the nuclear fuel cycle, and generating nuclear electricity, worldwide.

In building this professional community, our aim is to work, without inhibition, to win support for nuclear power among citizens and policy makers worldwide.

In so doing, we recognize that the functioning of our industry — and the task of winning public support — depend crucially on the functions provided by the IAEA, this great agency.

The WNA's Charter of Ethics dedicates us to full support of the IAEA and of the WANO.

Our goal is to work in close co-operation with both WANO and the IAEA — in a partnership that enables nuclear technology to make the crucial worldwide contribution that will be so desperately needed by all of humankind in the coming century.

INTERNATIONAL OVERVIEW

(Session 1)

Chairperson

A.J. BAER
Switzerland

THE PRESENT SITUATION IN RADIOACTIVE WASTE MANAGEMENT
An EDRAM perspective

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1. THE PRESENT SITUATION

What is the present situation in the radioactive waste management area? Perhaps the most important points are that every country with a nuclear power programme has a radioactive waste management programme, that most of the national radioactive waste management programmes (which are research intensive) are well advanced, that all of the countries in question consider geological disposal to be the preferred option for dealing with the radioactive waste from their nuclear power programmes, and that there is extensive international co-operation relating to radioactive waste management.

In discussions regarding geological disposal in the countries where the radioactive waste was produced, various alternatives have been proposed. However, exportation of the waste is not a realistic alternative, as most countries have laws regulating the exportation and — more importantly — the importation of radioactive waste. Separation and transmutation would reduce the waste volumes, but geological disposal of the residues would still be necessary, and technical implementation is still a long way off. Disposal in space is a high risk alternative and disposal under the sea-bed has been prohibited by international conventions.

As the International Association for Environmentally Safe Disposal of Radioactive Material (EDRAM) sees it, in all national radioactive waste management programmes, a common strategy is being pursued for ensuring the long term safety of a system for disposing of high level waste.

At the international level, the IAEA, the OECD/NEA and the European Commission are doing very useful work in co-ordinating international co-operation, and networks — such as EDRAM for implementers — have been set up to promote research.

EDRAM member countries are ENRESA (Spain), ANDRA (France), ONDRAF (Belgium), NAGRA (Switzerland), Ontario Power (Canada), OCRWM (USA), POSIVA (Finland), Nirex (UK), DBE and BfS (Germany), NUMO (Japan) and SKB (Sweden). EDRAM organizes international conferences and seminars, promotes information exchange and exchanges of research workers, arranges for members to review one another's radioactive waste management programmes and for joint activities in members' underground rock laboratories (URLs), and facilitates the commercial transfer of know-how.

2. URLs

There are URLs in the following EDRAM member countries: Belgium, Canada, Finland, France, Germany, Japan, Sweden, Switzerland and the United States of America. At these URLs, research is under way on different kinds of geological formation, for example, clay, salt and crystalline minerals.

Finland provides a good example of a radioactive waste management programme that is well advanced: site investigations have been carried out and the environmental impact assessment process has been completed; the system and the site for a deep geological repository have been chosen; and — perhaps most important of all — the Finnish Parliament has given its blessing.

In the USA there is a deep repository for high level waste in operation, the Waste Isolation Pilot Plant (WIPP) in New Mexico, but it accepts waste only from the military sector. High level waste from the civilian sector will probably be disposed of at Yucca Mountain, as the Yucca Mountain site has now been recommended by the US President with the backing of the US Congress.

In Sweden, two site investigations are under way, at Östhammar and Oskarshamn. A URL is in operation and the environmental impact assessment process is under way. It is expected that the site for Sweden's deep geological repository will be selected in 2007 and that the repository will go into operation in 2015.

In France, a URL is under construction and in Switzerland, in Belgium and in Canada, a URL is in operation. In all four countries, extensive research activities are taking place, as in Spain, Japan, the United Kingdom and Germany.

3. IMPORTANT FEATURES OF A NATIONAL RADIOACTIVE WASTE MANAGEMENT PROGRAMME

With the remaining obstacles being political rather than technical, what are the most important desirable features of a national radioactive waste management programme? I would say that they are the following:

— A stepwise implementation process, with stakeholder involvement in each step;
— A clear definition of the responsibilities of the different participants — regulators, implementers, governmental agencies and so on;
— Transparency;
— Well focused scientific backing;
— Reliably operating storage facilities — especially ones which members of the general public can visit;
— Active national and local politicians, decision makers and opinion formers — as in Finland and Sweden, for example;
— Well developed arrangements for dialogue with all stakeholders, the term 'stakeholder' being interpreted very generously;
— Close international co-operation, as it is possible to learn a lot from one another;
— Personnel engaged in the programme at all levels who are dedicated and able to communicate positively with ordinary local people.

I would also say that the national radioactive waste management programmes of the EDRAM member countries have become more transparent, with increasing stakeholder involvement and dialogue. In my view, that is a very welcome development.

Another welcome development has been the increase in international co-operation, for example, in bilateral and multilateral joint efforts at URLs.

4. MAIN CHALLENGES FOR THE FUTURE

As EDRAM sees it, the main challenges for the future relate to the siting process, since each member country has its own distinct laws, regulations and practices, and the interests of stakeholders and the nature of stakeholder involvement differ from country to country — as do communication procedures, and national and local decision making processes. On the technical side, each country must optimize its repository system in the light of the geological environment at the selected site. Also, there must be co-operation in finding solutions that are good from the technical and societal points of view, but each programme must progress in its own way.

In radioactive waste management, high ethical standards are important — if only because groups hostile to nuclear power generation are closely following the activities of those working in that field. Also, it is important not to leave problems to future generations, and today's problems must be solved democratically and interactively. Moreover, each country must make plans for the disposal of its own waste while at the same time co-operating internationally in efforts to find solutions.

5. WHAT HAS BEEN ACHIEVED?

In EDRAM's view, a lot has been achieved, especially on the technical side, but much remains to be done. Good repository plans have been prepared, and dedicated people stand ready to implement them.

EDRAM believes that there is a need to develop new ways of communicating with the public on important issues in order to build trust, which takes a long time to build but can be lost within an instant — never to be regained. There is also a need for still greater involvement of stakeholders, including the general public, politicians and other decision makers, municipalities, the mass media and so on. In addition, there is a need for optimum site specific technical solutions.

There have recently been breakthroughs in two EDRAM member countries, and EDRAM believes that there will be breakthroughs in some other member countries within the next few years.

REGULATORY CHALLENGES IN RADIOACTIVE WASTE MANAGEMENT ON NUCLEAR SITES

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1. INTRODUCTION

Countries that have run major military and civil nuclear development programmes now share a common legacy: the large quantities of radioactive waste currently accumulated on their nuclear sites. In some instances, especially on older sites, this material may be stored within a redundant and decaying building infrastructure. Internationally, the focus of the nuclear industry's effort is turning to decommissioning these facilities and managing the radioactive waste in a safe manner. Further radioactive waste generated by operational facilities continues to add to the overall inventory, but in general it has been better managed.

Although much of the radioactive waste exists as a result of the actions of the past, the responsibility for managing it has fallen on today's generation. There are a number of reasons why this is so. Firstly, in earlier times, priorities were very different from those that apply today, and less thought was given to how the by-products of the nuclear programmes should be managed. Secondly, for the last 20 years or more, there has been a preference not to foreclose future options, which encouraged a wait and see approach. The main reason behind not foreclosing future options was the anticipation that the radioactive waste would be able to be disposed of within a reasonable timescale. However, in the last few years, the lack of progress in the construction of disposal facilities in most countries has made it clear that it cannot be assumed that this solution will be available in the near future.

The circumstances described above present a range of challenges to the authorities responsible for the regulation of the safe management of radioactive waste. From the perspective of the Nuclear Installations Inspectorate (NII), the regulator for safety and radioactive waste management on nuclear sites in the United Kingdom, the aim of the present paper is to describe the nature of those challenges. The situation in the UK will be used to illustrate many of the points. Managing radioactive waste has become an intergenerational issue and regulators must carry out their duty in a manner which best contributes towards the common goal of making the nuclear sites safe for future generations.

2. NATIONAL POLICIES AND REGULATORY FRAMEWORKS

Governments set legislation and define national policies, and in general they all recognize the need to put in place a framework that will ensure the safe management of radioactive waste both now and in the future. In most countries, underground disposal is the favoured long term solution but progress is slow because of the difficult issues surrounding site selection and public acceptance of a repository. Involvement of stakeholders and especially the general public in the process is seen as a key means of moving forward. In the UK, the Government is reviewing its policy on radioactive waste management with the aim of developing consensus on the long term solution. As a first step, it has consulted on a programme for reviewing the options, and the nature of a decision making process that can promote public confidence [1]. This is likely to lead on to a programme of research and public discussion which will take several years before the preferred solution is chosen. The timescale for the implementation of that solution cannot be defined as yet.

This environment of uncertainty over future policy, which could persist for several decades, presents a real challenge to the nuclear operators who are responsible for managing the radioactive waste on the nuclear sites, and the regulators that are responsible for enforcing the legislation. In the UK the NII, the safety regulator, seeks to adapt its regulatory approach to match the circumstances, and in making decisions it takes into account both short term and long term requirements. Wherever possible, it wishes to see a degree of robustness and flexibility for the future incorporated in the management of radioactive waste and it is fortunate that the UK's non-prescriptive legislation provides the opportunity to do this. The NII strives to be aware of the needs and views of its stakeholders, including the public, and to be open in its regulatory work. Wherever possible, important outcomes or decisions in its work are published, either as reports, or by placing documents on the Internet. Increasingly, the NII is seeking to place the guidance produced for its inspectors on the Internet, so that anyone who wishes to can better understand the NII's expectations. Specific guidance on decommissioning, radioactive waste management, and safety cases [2, 3, 4] has been at the forefront of this initiative.

The NII works closely with the other regulators in the UK, who have the responsibility for the protection of the environment and security. Where radioactive waste management issues fall within the responsibilities of more than one regulator, it presents them with the challenge of providing co-ordinated regulation. An example of an area where this co-ordination is necessary is the implementation of the OSPAR Commission recommendations. In the UK, the Government's strategy [5], drawn up in response to OSPAR, requires progressive and substantial reductions in the level of radioactivity in discharges from nuclear sites. However, in some cases this can only be achieved by producing further solid radioactive waste. There is a challenge to the regulators to find the right balance between the need to reduce discharges and the safety implications of accumulating additional solid radioactive waste on the nuclear sites.

Currently, there are a number of different systems for classifying radioactive waste, including systems proposed by the IAEA, the European Union and individual countries. Ultimately, the aim of all these systems is to group wastes in a way that will help their management in the future. Activity content, heat generation, half-life and radiotoxicity are all parameters that in some way determine the method by which waste needs to be packaged and stored, and how such waste can be disposed of. A number of countries that classify radioactive waste by half-life have been able to provide relatively simple disposal facilities designed to retain waste until the radioactivity has disappeared, after a few hundred years. The classification of spent fuel and other fissile material is also uncertain in many countries. Whatever the outcome of the debate as to whether this material will be reused at some time or not, in the meantime the material will need to be managed safely, taking into account the probability that some of it will become radioactive waste in the future. The challenge for the regulators is to encourage nuclear operators to characterize radioactive waste in terms of the information that will be required to support its future management and to segregate it effectively such that the most appropriate means can be employed for storage and disposal.

3. RADIOACTIVE WASTE MANAGEMENT STRATEGIES

It has become very clear that decommissioning and radioactive waste management are interrelated activities that must be co-ordinated, and that both need careful strategic planning if projects are to be taken forward successfully. With no prospect of a long term management solution becoming available for most of the radioactive waste in the foreseeable future in the UK, the approach is to place the waste into a passively safe state suitable for an extended period of interim storage. Some of the radioactive waste has been treated and packaged but a considerable amount is accumulated in a raw form in facilities which are likely to deteriorate with time. In 1998, the NII published a review of the state of radioactive waste storage conditions across the nuclear sites in the UK [6]. It concluded that “although the current situation was adequately safe and areas of immediate concern were being dealt with, many of the stores did not meet modern standards, and have limited lives” and that in the future “a programme of retrieval and processing of radioactive waste and replacement, or refurbishment, of the stores will be required to ensure ongoing safe storage”. As a result, NII expects the nuclear operators to have programmes to improve the storage conditions of their waste, and it monitors progress as part of its regulatory activity.

In the UK, the greatest quantities of radioactive waste reside on the Sellafield site, operated by British Nuclear Fuels plc (BNFL), and the Dounreay site, operated by the United Kingdom Atomic Energy Authority (UKAEA). The development of strategies and planning for decommissioning and radioactive waste management on these sites has proved to be a complex task. In addition to the removal of the old facilities, new facilities need to be designed and constructed to carry through the programme of waste retrieval, processing and storage. One of the major challenges has been to understand and take account of the interactions between individual facilities, both existing and planned, some of which cannot be shut down while they are required to support other parts of the programme. In some areas, the safe retrieval of radioactive waste poses difficult technical challenges and it may be unavoidable that the work will lead to temporary increases in risk. The NII is prepared to sanction these temporary increases in risk, as long as they are adequately controlled, if the completion of the work will lead to a reduction of the hazard and lower risks in the longer term.

The programmes of work for waste retrieval on the Sellafield and Dounreay sites will last for more than 50 years and the storage of radioactive waste will require ongoing management for much longer than that. There are currently 40 licensed nuclear sites in the UK and similar programmes of radioactive management will be needed on those sites even if they are not always on the same scale as the work described above. On other sites, for example, the decommissioning of shut down nuclear reactors has begun with the treatment of mobile wastes, construction of long term stores and the preparation of the remaining reactor structures for periods of care and maintenance. This means that radioactive waste management will continue on those sites for many decades.

The very long timescales embodied in the management of radioactive waste present another challenge to the regulators, and reinforce the need for robust strategies that cover the overall period. The NII has been assessing the operators’ strategies and plans for some years now, and it will continue to monitor progress, challenge priorities and ask for programme dates to be shortened where there are significant safety concerns. Furthermore, the NII is aware of the extent of organizational change in the nuclear industry, and the effect it may have on safety, especially where long timescales are involved. The operator, who is the licensee for a nuclear site, should remain in control of operations at all times, and to do so it must retain the necessary resources and competence to understand the hazards and how to manage them. The NII expects licensees to have well defined processes for controlling the impact of changes within their organizations and, as the regulator, the NII will continue to monitor and assess their proposals.

4. LOW LEVEL WASTES

Experience shows that decommissioning projects can be delayed if a route has not been established for managing all the radioactive waste that is produced. A good example is the large volume of concrete and rubble produced from the demolition of buildings, which is often contaminated with very low levels of radioactivity. In the UK, conventional low level radioactive wastes are disposed of to the Drigg disposal site near Sellafield and the NII encourages this, but it is generally accepted that large volumes of low activity material should not be sent there because it does not make best use of the capacity that is intended for more hazardous wastes. That leaves the question of what should be done with this material. Clearly, the first aim should be to segregate as much as possible of the uncontaminated material so that it can be released from regulatory control. The regulator is encouraging operators to develop the means of managing remaining low level waste which are commensurate with the hazard it presents. Such means could include burial or storage in simple engineered facilities, such as the clay pits at the Centre de l'Aube in France, or recycling and reuse, however, work is still required to establish these options in the UK.

5. INTERIM STORAGE OF HIGHER ACTIVITY WASTES

The NII believes it is prudent for the nuclear operators to plan for periods of interim storage of at least 100 years. To reduce the hazard it presents, radioactive waste that is in a mobile form needs to be retrieved and processed into a passively safe form. While there is general agreement on the concept of passive safety, there is less information as to how it can be achieved in practice [7]. The NII has prepared guidance [4] for its inspectors, containing a set of principles for passive safety (listed below) against which they can assess the proposals of nuclear operators. In line with the flexible regulatory system in the

UK, these principles represent expectations which should be met as far as is reasonably practicable.

- *Multiple barriers against release:* Passive safe storage will be achieved by a suitable combination of the radioactive wasteform, a package and building, which should be designed to provide effective containment and prevent leakage of radioactivity to the environment.
- *Wasteform:* The wasteform should be physically and chemically stable and resistant to any significant deterioration over the storage period. In many cases, the raw waste (such as gases, liquids and powders) will require processing into a passively safe form to immobilize the radioactivity; other raw wastes may already be in a suitable form. Stored potential energy, which can exist in a number of forms should, as far as possible, have been removed from the waste. The wasteform should have low chemical reactivity and be resistant to degradation.
- *Waste package:* The waste package should be compatible with the wasteform. It should be resistant to degradation over the period of storage and to the range of foreseeable internal or external hazards, and designed to facilitate the future retrieval and transport of the radioactive waste. In the UK, Nirex has developed and approved the design of a number of standard packages, to assist waste producers who are managing waste.
- *Storage building:* The role of the storage building is to provide protection from the elements, radiation shielding and to present a boundary against unauthorized intrusion. Structures should be designed to be fit for purpose for the whole period of waste storage. However, structures with a shorter life may be appropriate if they are designed with the capability for refurbishment or replacement in the future.
- *Safety systems:* The dependence on active systems, maintenance, monitoring and human intervention to ensure safety should be minimized; any systems that are required should be straightforward, robust and long-lived.
- *Retrieval:* The design of the building should take into account the future need to retrieve and transfer the radioactive waste at the end of the period of passively safe storage or at an earlier time should waste management strategies change.
- *Inspection:* The facilities should be designed so that it is practicable to retrieve and inspect any of the radioactive waste packages in the store, and include provision to undertake remedial action if necessary.
- *Records:* All the information that may be required in the future to continue the safe management of the radioactive waste should be recorded and preserved.

Most countries recognize the need for a system which gives confidence that waste packages produced today are likely to be acceptable for disposal in the future. It is difficult to predict with certainty the acceptance requirements of future disposal facilities but it is possible to define generic specifications which should reduce the risk that waste packages will need to be reworked in the future; a step that would place an unnecessary burden on future generations and their resources. Again there is a challenge to the regulators to take account of these very long term risks and the uncertainty of the future within their scrutiny of the waste management practices. In the UK the NII, which regulates the storage of radioactive waste on nuclear sites, and the environment agencies, which regulate the disposal of radioactive waste, are working together to jointly define the way these issues are covered within the regulatory framework.

The need to balance short and long term risks in radioactive waste management presents a further challenge to the regulators. In some cases, judgements may need to be made as to whether the demands to secure immediate safety improvements may override the longer term safety goals of ensuring compatibility with disposal requirements. However, these cases should be the exception and will require careful justification.

6. CONCLUSIONS

The present paper offers a summary of some important challenges that radioactive waste management on nuclear sites present to regulators. The main points have been illustrated with descriptions of the situation in the UK, but the issues appear to be common to those countries which have had large-scale nuclear development programmes. The burden of managing radioactive waste falls on today's generation and doing nothing is not an option. Regulators must respond in a manner which contributes towards the common goal of making the nuclear sites safe for future generations.

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RADIOACTIVE WASTE MANAGEMENT
A Greenpeace perspective

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Greenpeace International is a relatively large non-governmental organization, with presences in 40 countries. It does not accept money from governments or from business corporations. Most (90% or more) of its money comes from private individuals. For some projects, it accepts money from foundations, but only if there are no strings attached.

Greenpeace has been accused from time to time of being 'non-scientific' or even 'anti-science'. In my opinion, however, Greenpeace has access to and understands the high quality scientific information necessary in order to tackle environmental issues.

I shall describe briefly how Greenpeace came to concern itself with radioactive waste management.

When it was established in 1971 in Canada, the issue on which Greenpeace focused was nuclear weapons testing. Soon afterwards, it started to focus on marine pollution, and in that context it regarded radioactive contaminants in the same way as it regarded other environmental contaminants such as lead, mercury, dioxins and so on. The approaches adopted by it for dealing with non-radioactive hazardous substances have proved useful in dealing with radioactive ones.

Our main concern in dealing with radioactive and other contaminants has been that harm should be prevented. Of course, there are cases where the harm has already been done, sometimes a long time ago; in such cases, however, we draw attention to the problem. We also draw attention to problems which we know to be imminent even if we cannot yet provide the scientific proof that they are imminent.

We believe that the primary responsibility for managing radioactive waste lies with those countries which produce the waste, and that their responsibility ends only when the potential for harm due to the waste ceases to exist. We also believe that the costs of dealing with radioactive waste should be fully factored into the costs of the activities giving rise to the waste, be it nuclear power generation, the medical or industrial use of radioisotopes, or whatever.

In the conference programme, under the heading International Overview, the question posed is this: "What has been achieved so far and what remains to be done?"

When Greenpeace started to focus on marine pollution, it did so in the context of work on the London Convention 1972, which was being developed for the purpose of regulating the disposal of packaged waste at sea; originally, this legal instrument was referred to as the London Dumping Convention 1972. Fortunately, the London Dumping Convention was in due course amended, becoming a legal instrument that prohibits — rather than regulates — the dumping of waste at sea. Its geographical scope was extended with the entry into force of the United Nations Convention on the Law of the Sea, and there is now a global ban on radioactive waste dumping at sea—with one exception, about which I will simply say that Greenpeace hopes that the country in question will in due course withdraw its reservations regarding the global ban.

There have been similar positive developments in the OSPAR context, thanks in part to pressure exerted by Greenpeace. The challenge now is to implement the new regime in an effective manner.

I believe that the discussions about radioactive waste management in which Greenpeace has participated over the years have led, in some countries, to changes in the way in which national radioactive waste management programmes are regarded; to a greater awareness that mistakes were made in the past and that transparency is essential; and to a willingness to question long-standing assumptions and really engage with the stakeholders. The United Kingdom is a particularly striking example. In many countries, however, much more still needs to be done.

A major challenge is going to be ensuring that the financial resources necessary for decommissioning and long term radioactive waste management are available. Only a few countries have already set up arrangements whereby they will not have to make compromises owing to a shortage of financial resources.

As regards international standards and international legal instruments, Greenpeace would like to see an extensive debate on whether such standards should provide merely for basic minima with which everyone can agree, or set goals which result in better national practices.

From involvement in an ICRP task group looking into questions of environmental protection, I have concluded that the nuclear community, including the radioactive waste management community, could learn a lot from what has been done to protect the environment from non-radioactive pollutants.

We are pleased with what has been done in recent years in trying to deal with the legacies from past mistakes but believe that more needs to be done, and that more resources need to be devoted to the task in order that it may be accomplished in a timely fashion.

We have concerns about the advocacy of international repositories, which we consider to be prompted largely by a desire to save money (a desire for economic efficiency) and by a desire to avoid domestic political difficulties. In our view, exporting radioactive waste for disposal in international repositories would simply be a form of waste dumping. In that connection, we do not believe that the shipping of spent fuel or radioactive waste to the Russian Federation for reprocessing or storage would be consistent with Article 27 (Transboundary movement) of the Joint Convention which, moreover, is silent about what should happen if the State of destination is not a Contracting Party to the Joint Convention.

Preambular paragraph (xi) of the Joint Convention contains the general principle, with which we agree, that radioactive waste should be disposed of in the State in which it was generated. However, it goes on to talk about the sharing of facilities by Contracting Parties, without referring to the situation of States which are not Contracting Parties. Moreover, it talks about "safe and efficient management of spent fuel and radioactive waste", without making it clear what 'efficient' means. If 'efficient' means just 'economically efficient', Greenpeace has good reason to be sceptical.

A country which embarks on nuclear power generation must be able to manage the resulting waste safely. The cost of managing that waste safely is part of the cost of 'doing business'. If the country cannot afford to manage the waste safely, it should not be in 'the business'.

What I have learned about non-radioactive hazardous waste exports (for example, in working on the Basel Convention) suggests that waste follows the path of least resistance to countries with low prices and low health and safety standards, not to countries with safe disposal sites.

A number of countries have by now been producing spent fuel and radioactive waste for about 50 years, but they still have no solution to their disposal problems. What does that say about the nuclear power community in those countries?

When talking about Greenpeace, some people imply that it has a hidden agenda. I would suggest that it simply has different values and perspectives, and makes different assumptions. It did not start out with a platform opposed to nuclear power generation, but it soon asked the following question: "Is nuclear power generation a sustainable energy production option?" And it concluded that the answer was "No!"

So, is the aim of the radioactive waste management community in engaging stakeholders — including international stakeholders such as Greenpeace — simply to continue with 'business as usual' but on the basis of better and more comprehensible technical explanations? Or is it rather to elicit new questions from people who do not share its values and perspectives?

Discussion following paper by S. Carroll

Y. Le BARS (France): I am fairly new to the radioactive waste management business, and I am finding it difficult to compare the problems relating to radioactive waste, on one hand, with those relating to nuclear power plants, on the other. What do you consider to be the problems relating to radioactive waste?

S. CARROLL (Greenpeace International): In my view, there are not only problems relating to solid radioactive waste in storage or in a repository, which are problems of long term management, but also problems relating to radioactive waste released into the environment. My concerns go further, however, and relate in addition to the reasons why radioactive waste is produced.

There have been accidents and incidents involving radioactive waste, and some of them are well documented, but I am unaware of a database covering them all. It might be worth checking with the IAEA's International Nuclear Information System (INIS).

H. FERNANDES (Brazil): In my country, Greenpeace has come out strongly against nuclear power generation, including the construction of a third nuclear power reactor. I should have thought that in Brazil, which has so many pressing problems, such as those arising out of its commitments. vis-à-vis the World Bank and the International Monetary Fund, Greenpeace would not focus so much on nuclear power generation. How are the Greenpeace priorities for different countries set?

S. CARROLL (Greenpeace International): Greenpeace is organized at the international level, the regional level and the national level. National priorities are set almost exclusively by the national offices. As regards the issue of nuclear power generation in Brazil, Greenpeace International collaborates with Greenpeace's Brazil Office on particular aspects, but the other work done by Greenpeace in Brazil reflects the priorities of the Brazil Office.

Having said that, I would emphasize that Greenpeace is just one among thousands of non-governmental organizations working on different issues at different levels. It co-operates with other non-governmental organizations in areas of common interest, and there are areas which it does not touch, as it feels that it could not add much to what other non-governmental organizations are doing. Greenpeace does not believe that it has the answer to every question.

A.-C. LACOSTE (France): I should have liked to see at this conference — besides specialists in radioactive waste management and other representatives of the nuclear industry — specialists in non-radioactive waste management and more stakeholder representatives such as S. Carroll.

J. GREEVES (USA): S. Carroll is here and K. Sullivan is here, and both have made presentations. That represents an improvement over the situation which normally existed a few years ago. I think that we are moving in the right direction.

A.-C. LACOSTE (France): Yes, but we are moving slowly.

Y. Le BARS (France): I believe that stakeholders will be able to achieve a real impact through initiatives like the OECD/NEA Forum on Stakeholder Confidence and, at the European level, the COWAM Project.

Regarding A.-C. Lacoste's comment about specialists in non-radioactive waste management, meetings have been held within the OECD/NEA framework for the purpose of seeing what could be learned from the chemical industry. The problem was that the chemical industry has rather less stringent requirements than the nuclear industry.

A.-C. LACOSTE (France): As far as I know, the waste disposal siting issue is almost as difficult for the chemical industry as for the nuclear industry.

S. CARROLL (Greenpeace International): Regarding what J. Greeves just said, I have seen the IAEA's attitude towards Greenpeace evolve over the years. The first time I attended an IAEA meeting, I was not made very welcome. Now, if I am unable to attend some IAEA meetings, the IAEA calls me to ask why.

However, the IAEA has been slow to change and still has a long way to go in liaising with stakeholder non-governmental organizations. It is at the stage of saying "we would like someone from your NGO present at this meeting in order to say such-and-such" rather than being open to approaches by non-governmental organizations saying "we have something to say which we think you should listen to".

As regards the IAEA's Safety Standards in their present form, I do not think that Greenpeace has much to contribute in a forum like this. It could perhaps help to address the underlying issues in a broader sense, but outside the IAEA context.

Many organizations tend to 'talk to themselves', believing that they are thereby doing a good job. For example, the International Maritime Organization, with which I have quite a lot to do, thinks that it manages risk very effectively, until a marine disaster like the sinking of the oil tanker *Prestige* off the coast of Spain forces it to re-examine its safety standards. Such organizations need to open themselves up to more contributions from outside.

A.V. GIL (USA): I used to be a member of Greenpeace, and I feel very strongly about stakeholder involvement. However, I caution everyone to be careful about describing themselves as 'stakeholder representatives'. In

Nevada, some of the very few people regularly attending meetings about the Yucca Mountain project have described themselves as ‘stakeholder representatives’, but I doubt whether they have been given a mandate by stakeholders to represent them. Many stakeholders not attending such meetings, for whatever reason, have sent in written comments — they have represented themselves.

DISCUSSION

International Overview

Session 1

M.V. FEDERLINE (USA): How can we take advantage of the experience of those countries which are making progress without reducing flexibility for those countries which, because of cultural differences, want to pursue different approaches?

P. NYGÅRDS (Sweden — EDRAM): National and local politicians tend to focus on their own countries and are generally not aware of what is happening in other countries. Technical people from different countries meet at conferences like this one and exchange information about one another's programmes, and in my view it is necessary to bring together politicians from different countries, in addition to technical people, so that the politicians of one country can learn about the programmes under way in other countries.

A. NIES (Germany): From the presentation of P. Nygårds, I understood that in his view all countries consider disposal to be the preferred option. I should like to know whether that is L.G. Williams's view.

L.G. WILLIAMS (United Kingdom — INRA): There is a general consensus that most countries consider deep underground disposal to be perhaps the only solution. As far as the United Kingdom is concerned, we shall have to await the outcome of the Government's current consultations on what the preferred solutions for that country might be.

CONTROLLING DISCHARGES OF RADIOACTIVE EFFLUENTS TO THE ENVIRONMENT

Policies and trends

(Session 2)

Chairperson

R.G. HOLMES
United Kingdom

NEW INTERNATIONAL LEGAL INSTRUMENTS INFLUENCING THE CONTROL OF RADIOACTIVE DISCHARGES TO THE ENVIRONMENT

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Abstract

The paper reviews the development, since the 1970s, of international legal instruments related to protecting the marine environment from pollution due to radioactive and other materials. It explains the basis for, and the requirements of, the strategy of the OSPAR Convention with regard to hazardous substances and, in particular, it discusses the requirements for the control of radioactive discharges from land-based sources.

1. INTRODUCTION

The year 2002 marks the 30th anniversary of the first major international agreements on the control of the disposal of waste into the marine environment — the Oslo Convention [1] and the London Convention [2].[2] These conventions were part of a burst of international policy making on the marine environment, largely triggered by the wreck in 1967 of the *Torrey Canyon* on the Seven Stones Reef in the Atlantic Ocean to the west of the Isles of Scilly in the United Kingdom, and by the (fortunately unsuccessful) attempts in 1971 to dump 600 t of toxic chlorinated waste from the *Stella Maris* in the North Sea or the Atlantic Ocean.

These events were followed by regional agreements on co-operation on marine disasters, on the rights of States to intervene on the high seas beyond their jurisdiction to protect themselves from pollution, by the Oslo Convention and the London Convention, and by the inclusion of two of the principles

[1] The views in the present paper are those of the author and should not be regarded as the views of the OSPAR Commission, its Contracting Parties or the OSPAR Secretariat.

[2] This was originally referred to as the London Dumping Convention, but 'Dumping' was dropped when the main thrust of the Convention became a ban on dumping, rather than regulation of dumping.

adopted by the United Nations Conference on the Human Environment held in Stockholm in 1972, and known as the Stockholm Principles.

From the Stockholm Principles, the two referred to are:

- Principle 7: "States shall take all possible steps to prevent pollution of the seas by substances that are liable to create hazards to human health, to harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the sea."
- Principle 21: "States have, in accordance with the Charter of the United Nations and the principles of international law,
  - the sovereign right to exploit their own resources pursuant to their own environmental policies, and
  - the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction."

This initial group of agreements was quickly followed by regional agreements on land-based discharges for the North East Atlantic Ocean and the Baltic Sea and a series of agreements under the newly founded United Nations Environment Programme (UNEP), constituting the Regional Seas Programme. Such agreements provide one important means of striking a balance in relation to the marine environment between national interests and wider considerations. The present paper reviews the developments in this field over the past 30 years, concentrating particularly on the last decade.

To contextualize the role of OSPAR in the present discussion, the OSPAR Commission was created by the 1992 OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic, by merging the Oslo Commission and the Paris Commission.[3]

2. EARLY STEPS IN PROTECTING THE MARINE ENVIRONMENT FROM ANTHROPOGENIC RADIOACTIVITY

The burst of international activity in the early 1970s was against a background of the 1958 United Nations Convention on the High Seas, which codified much of the law of the sea. The convention emphasized the duties of

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[3] The Contracting Parties to the OSPAR Convention are Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom, together with the European Community.

States to protect the seas against pollution, especially from pollution from radioactive materials [3].

Two separate aspects of dumping (disposing of waste from a ship or, theoretically, an aircraft) and land-based discharges (liquid discharges direct by pipeline into the sea or indirect through a river) have been handled generally by separate arrangements.

Under both aspects, however, the approach has usually been to concentrate on obligations to avoid pollution. Pollution has been defined, since at least the 1974 Paris Convention [4] in terms of harm and likely harm to a wide range of possible interests. The version of this definition which is now the locus classicus is that the United Nations Convention on the Law of the Sea (UNCLOS) [5] states that pollution is "the introduction by man, directly or indirectly, of substances or energy into the maritime area which results, or is likely to result, in hazards to human health, harm to living resources and marine ecosystems, damage to amenities or interference with other legitimate uses of the sea." The essential point to note is that there is a threshold (of contamination resulting in, or likely to result in, some form of harm) which must be crossed, or be likely to be crossed, before anti-pollution commitments are engaged.

The Oslo Convention and the London Convention shared a common approach to regulating dumping. The main features of the initial versions of these conventions were:

— A ban on dumping 'black list' substances (those listed in Annex I to the conventions);
— A licensing requirement for dumping 'grey list' substances (those listed in Annex II to the conventions);
— A pledge to promote, in the competent international agency, measures on radioactive substances;
— Internal waters were not covered in the conventions (that is, those waters within the baselines from which the breadth of territorial sea is measured);
— Importantly, an item was added to the 'black list' in the London Convention covering "high-level radioactive wastes or other high-level radioactive matter defined on public health, biological or other grounds by the competent international body".

Similar approaches were applied to land-based discharges. The Paris Convention, for example, provided for commitments to:

— Eliminate pollution from 'black list' substances (those listed in Part I of Annex A to the convention);

- Limit strictly pollution from ‘grey list’ substances (those listed in Part II of Annex A to the convention) by regulation or by permitting the discharges of such substances;
- Forestall and, as appropriate, eliminate pollution from radioactive substances, taking into account the recommendations of appropriate international organizations and agencies;
- Cover all marine waters, up to the freshwater limit.

The Regional Seas Conventions, negotiated under the aegis of the UNEP,[4] adopted an approach based on an umbrella convention, with the substantive measures set out in Protocols to that convention. This permitted a mix and match approach, under which States had greater freedom to choose which measures to accept, since each Protocol required separate signature and ratification, as compared with the approach of the Helsinki Convention [6], where the different aspects were dealt with in annexes to a single convention — the model also applied to the consolidated and updated OSPAR Convention in 1992. In the Regional Seas Conventions, the approach adopted for radioactive materials was, however, similar to that of the Oslo Convention and the Paris Convention. For example, the 1980 Protocol on Land-based Sources to the Barcelona Convention [7] contained a commitment to the elimination of pollution from radioactive discharges which does not meet the requirements of the competent specialized agency.

Specific measures on the dumping of radioactive wastes and the control of radioactive discharges therefore rested on progress in specialized international forums — especially the IAEA, which was seen by most States as *the* specialized forum in this field.

3. DEVELOPMENTS 1972–1992

The IAEA quickly took up the London Convention’s invitation to define high level radioactive material, including waste, the dumping of which was to be

[4] Many conventions fall under the title of Regional Seas Conventions, and include the following: the Convention for the Protection of the Mediterranean Sea against Pollution, the Kuwait Regional Convention for Co-operation on the Protection of the Marine Environment from Pollution, the Convention for the Protection of the Marine Environment and Coastal Area of the South-East Pacific, the Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment, the Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region and the Convention for the Protection of the Natural Resources and Environment of the South Pacific Region.

banned. The definition and accompanying recommendation was approved in 1978 [8] and adopted by the Consultative Meeting of the Contracting Parties to the London Convention.

Discussion on the issue continued and in 1983, the London Convention adopted a voluntary 25-year moratorium on all dumping of radioactive waste, while studies of the issue were carried out.

Under some of the regional agreements, progress was also made. For example, the Paris Commission, operating under the Paris Convention, adopted recommendations from 1988 onwards to guide implementation of the Convention in the field of radioactivity. Under the Paris Convention, recommendations are instruments which are not binding in international law but which, in practice, Contracting Parties have honoured in a manner consistent with their understanding of what is required. These recommendations were consolidated in 1991. The resulting Recommendation committed the Contracting Parties to:

— Respect the relevant recommendations of the competent international organizations;
— Apply the best available technology to minimize and, as appropriate, eliminate any pollution caused by radioactive discharges from all nuclear industries, including research reactors and reprocessing plants, into the marine environment;
— Present a statement on progress made in applying such technology every four years for each facility.

4. INTERNATIONAL LEGAL DEVELOPMENTS

In considering recent developments in international instruments, it is essential to bear in mind the spectrum of instruments that are available. This spectrum has, at one end, the binding requirements of international treaties and conventions and, at the other, policy commitments given in an international context by State representatives in an informal way. It is often the case that there is progress from the informal to the formal ends of this spectrum in the course of resolving an issue. This is commonly because of the corresponding spectrum of attitudes to international commitments: there may be some embarrassment in failing to deliver an informal policy commitment — there are much more serious consequences for breaching a binding international obligation. Accepting an initial informal commitment allows time to get used to living with it, to find out how difficult it is to do so and what the risks are of failing to deliver. As such, an informal commitment becomes something understood and accepted, and confidence is developed in order to progress to a more formal commitment.

Rosalyn Higgins, the first female member of the International Court of Justice, has argued that it is helpful to view international law as a discipline in terms of a process of resolving disputes, rather than in the more traditional terms of establishing norms and classifying factual situations against those norms [9]. This seems particularly relevant to processes under way in international forums for reaching agreement on the handling of radioactive waste and agreeing a balance in relation to the marine environment between the rights of individual States to pursue their own policies within their own jurisdictions and international concerns about the protection of the marine environment for sustainable use.

4.1. Five varieties of argument

An awareness of the different types of reasoning that have been deployed by negotiators in these processes also helps the developments to be understood. Without such an awareness, there is a real risk that the forces behind policy developments appear irrational. In policy making with respect to the environment, at least five varieties of argument, listed below, can be distinguished.

4.1.1. Prudential calculus

Prudential calculus is the predominant type of argument, used generally in most policy making as well as in disciplines such as engineering, finance and economics. The central core, of course, has to be the establishment of causal links, which are applied through marginal analysis, examining the effects of changes at the margin in inputs and outputs on the function under discussion. This will naturally include assessment of the probabilities of different risks. The calculus will try to assimilate all factors that are seen as relevant, bringing them into account in a variety of ways — often by stating them in terms of a single factor, such as money.

4.1.2. Moral imperatives

A ‘moral imperative’ argument is deployed as a kind of ‘trump’ — to borrow a term from card games. Whatever the conclusions of the prudential calculus on a problem, accepting a moral imperative can set those aside. A good example in the field of the marine environment arose in 1995 in the debate on the *Brent Spar* (whether to permit the dumping at sea of a disused offshore installation): the European Commission member responsible said that right-thinking persons would not let their children drop drink cans in the street, and the same imperative applied to firms disposing of other disused metal objects [10]. This argument was put forward to override any arguments based on the prudential calculus about the costs, benefits and disadvantages of the various possible courses of action.

4.1.3. Absolute values

Absolute values are similar to moral imperatives, but deal with values other than ethics. Certain values are seen as incommensurable with other values used in a prudential calculus. One important value of this kind that arises in environmental policy is the value of the pristine natural state. Like the loss of virginity, once an environment ceases to be pristine, it can never recover that quality. This argument has played a substantial role in the creation of natural parks [11], since the preservation of the primeval wilderness was given a trump status. The argument also plays a significant, if often implicit, role in debates on the marine environment, since marine ecosystems are often seen as the last wilderness.

4.1.4. Intergenerational equity

Intergenerational equity can be seen, perhaps, as one kind of moral imperative or absolute value. The Brundtland Commission defined sustainable development, the concept that underlies all current environmental policy, in terms of intergenerational equity: “development meeting the needs of this generation while compromising the ability of future generations to meet their own needs” [12]. When dealing with issues that have a very long run-off period (such as the creation and disposal of some radioactive isotopes), the impact of that run-off on future generations’ scope for action may be very important.

4.1.5. Risk perception

Risk perception is a different sort of argumentation. Political decisions have to take account of public opinion. The assessment of likely public reaction to a policy is an important phase in policy making. Public reactions will be driven at least as much by the subjective way in which the risks are perceived as by their objective analysis under the prudential calculus. The UK Department of Health [13] has examined this in some detail, and analysed the problem of managing the public’s reaction to risks in terms of a list of ‘fright factors’. Under this analysis, risks are seen as generally more worrying (and therefore less acceptable) if perceived in the following ways:

— To be involuntary (e.g. exposure to pollution) rather than voluntary (e.g. dangerous sports or smoking);
— As inequitably distributed (some benefit while others suffer the consequences);
— As inescapable by taking personal precautions;
— To arise from an unfamiliar or novel source;
— To result from human-made rather than natural sources;
— To cause hidden and irreversible damage (e.g. through the onset of illness many years after exposure);
— To pose some particular danger to small children or pregnant women or more generally to future generations;
— To threaten a form of death (or illness/injury) which gives rise to a sense of particular dread (such as cancer);
— To damage identifiable rather than anonymous victims;
— To be poorly understood by science;
— As subject to contradictory statements from responsible sources (or, even worse, from the same source).

It is important to note that radioactivity can be seen as scoring high under a large proportion of these factors. The effects of these 'fright factors' on public opinion are modified by at least two forms of amplification. First, since public perception will be based largely on reports through the media, it is necessary to consider the triggers which will lead to the media amplifying coverage and making a major story out of an issue and which will condition their approaches. At least nine such media amplification triggers can be identified:

(1) Questions of blame.
(2) Alleged secrets and attempted cover-ups.
(3) 'Human interest' through identifiable heroes, villains, dupes, etc. (as well as victims).
(4) Links with existing high-profile issues or personalities.
(5) Conflict (whether already existing, or capable of being generated by the media coverage).
(6) Signal value: the story as a portent of further ills (e.g. 'What next?').
(7) Many people exposed to the risk, even if at low levels (e.g. 'It could be you!').
(8) Strong visual impact (e.g. pictures of suffering, even if not scientifically justified).
(9) Links to sex and/or crime, ranging from the possibility of finding someone to blame who can be sued or prosecuted to links to sex (a perennial media interest).

TABLE I. PROPORTION OF GDP FROM AGRICULTURE, HUNTING, FISHERIES AND FORESTRY

Non-nuclear States (%)		Nuclear States (%)	
Iceland	8.0	France	2.5
Ireland	4.1	Germany	1.2
Denmark	3.8	United Kingdom	1.2
Norway	1.9		

Source: Europa Year-Book 2001

A second form of amplification comes from factors specific to one area or locality. These are often economic, but other types of factor (such as cultural) can also be significant. Economic factors often involve primary food and drink production and tourism. In both of these fields, there is the possibility of a major consumer switch in purchasing patterns as a result of the impact of 'fright factors'. For radioactive substances, this risk was identified, for example, in Chapter 5, Section C1, para. 109 of the 1995 Global Programme of Action for the Protection of the Marine Environment from Land-based Activities [14]. The seriousness of this kind of amplification trigger is underlined by the catastrophic effect on the marketing of beef in Europe following the crisis over bovine spongiform encephalopathy (BSE, known informally as 'mad cow disease'). 'Fright factors' and local amplification triggers can be seen as underlying differences in approach between neighbouring nuclear and non-nuclear States. For example, the degree of economic reliance on the primary food and drink production varies interestingly between States in Western Europe, which are strongly opposed to radioactive discharges into the sea, and other States in the same region (though it is not sufficient to explain wholly the difference in attitudes). Table I illustrates this.

5. DEVELOPMENTS SINCE 1972

The background provided in the preceding section gives the starting point and some of the reasoning underlying developments in the last decade. Twenty years after the United Nations Conference on the Human Environment in Stockholm, the United Nations Conference on Environment and Development (UNCED), which has come to be known as the Earth Summit, took place in Rio de Janeiro, in June 1992. The change in the name of the conference, of course, represented an important change in approach by the world community, with emphasis on the need for sustainable development, rather than simply protection of the environment. For present purposes, more importance lay in the emphasis on a holistic approach to the marine environment contained in Agenda 21, the document that set out the conclusions of UNCED on the way forward in particular fields. The emphasis had moved from protective measures dealing with specific marine contaminants in isolation to an approach to the conservation of the marine environment as a whole. Radioactivity was still seen as a separate issue, but increasingly it was being looked at against a background of the sustainable use of the seas and marine resources, viewed as a whole.

Parallel to the UNCED process was a wish to take stock of developments in relation to specific instruments from the 1970s. Twenty years represented a good point at which to review what had been achieved and to update the instruments. This movement led to the 1992 OSPAR Convention [15] (combining and updating the Oslo Convention and the Paris Convention), the revision in 1992 of the Helsinki Convention and amendments in 1995 to the Barcelona Convention.

Since the issue of radioactivity was prominent in the negotiations on the OSPAR Convention, this can be taken as a marker of these developments, although developments in the other regional marine conventions around Europe shared many of the same features.

6. DUMPING

Negotiation of the OSPAR Convention was largely dominated by the issue of dumping radioactive material, including wastes, in the sea. The general background to this particular set of issues was agreement emerging in the consolidation and updating of the Oslo Convention and the Paris Convention on the need for, and text of:

— A general obligation to take all possible steps to prevent and eliminate pollution and to protect the North East Atlantic Ocean against the adverse effects of human activities;
— An obligation to apply the precautionary 'polluter pays' principle, the 'best available techniques' (BAT) and the 'best environmental practices' (BEP), to be defined on the basis of a prescribed set of criteria. The definition of the precautionary principle was negotiated in parallel with that adopted by UNCED, but took a rather different approach. The UNCED approach was negative: action is not to be postponed on the basis that scientific proof is not available. The OSPAR Convention adopted a positive approach [16]:

"preventive measures are to be taken when there are reasonable grounds for concern that substances or energy introduced, directly or indirectly, into the marine environment may bring about hazards to human health, harm living resources and marine ecosystems, damage amenities or interfere with other legitimate uses of the sea, even when there is no conclusive evidence of a causal relationship between the inputs and the effects."

The obligations to apply BAT and BEP, taken with the precautionary principle, imply obligations to act, where economically feasible, to reduce discharges of commitments, even if pollution (in the sense of actual or likely harm) is not immediately in prospect;

— Provision for the adoption of further binding decisions. In effect, this permitted the development of the obligations of the convention within its general framework without requiring the time consuming process of negotiating and ratifying new protocols;
— Provision for extending the scope of the convention by the adoption of new annexes (subject to ratification). This represented a compromise between States that wanted to extend the scope of the revised convention substantially, and those that wanted to retain the scope of the existing Oslo Convention and Paris Convention. In 1998, this provision was used to extend the scope to permit the adoption of programmes and measures under the convention (other than on fisheries management) to regulate all human activities that may affect adversely the marine environment;
— Provision for reporting and assessing compliance by the Contracting Parties with their obligations under the convention, participation by international non-governmental organizations and rights of public access to information.

On the issue of sea dumping of radioactive material, the division was between France and the UK, on the one hand, who wanted to retain the option of dumping bulky low level and intermediate level waste (particularly that resulting from decommissioning power stations) and, on the other hand, the remaining 13 States that shared a strong wish to end all dumping of radioactive material. The reasons for this strong wish can be seen as both:

— A wish to make the same sort of progress on radioactive dumping as had been made over the previous 20 years in relation to other kinds of dumping (effectively, agreement had been reached to ban all forms of dumping industrial waste);

— Disappointment that the competent agency at the global level had not made this kind of progress, and a consequent feeling that progress would have to be made at the regional level.

The result of the 1992 OSPAR negotiations was a clear starting point: a ban on all dumping of low level and intermediate level radioactive substances, including waste (high level radioactive waste was, of course, already covered by the combination of the London Convention and the IAEA Definition and Recommendation). This applied to all the maritime area, including internal waters. The special interests of France and the UK were accommodated by a complex text. A large part of the complexity was due to a requirement of many Contracting Parties to avoid wording which clearly granted an exemption to France and the UK. Those wanting to retain the "option of an exception" were to report in 1997 and regularly thereafter about the progress in establishing alternative land-based options and on the results of scientific studies which show that any potential dumping operations would not result in hazards to human health, harm to living resources or marine ecosystems, damage to amenities or interference with other legitimate uses of the sea. The ban was to apply until 2008 (the end of the 25-year moratorium agreed by the Consultative Meeting of the London Convention) to all Contracting Parties. At that point, there was to be a meeting of the OSPAR Commission (the international body responsible for implementing the Convention) at ministerial level to resolve what should be done, unless a unanimous agreement on the issue came about earlier. The text was sufficiently obscure that the UK felt the need to emphasize in a declaration on signature that it was not bound by the ban on dumping radioactive waste after 2008.

This regional development helped to clear the way for progress at the global level. In 1993, the Consultative Meeting of the Contracting Parties to the London Convention considered the report on the studies that had been put in hand when the moratorium was agreed. In consequence, the meeting amended Annex I to the Convention (the 'black list' to include low level and intermediate level radioactive waste, as well as the existing entry for high level waste, subject to review in 25 years' time.[5] This amendment took effect in 1994 in

[5] London Convention, Annex I [substances which are prohibited from ocean disposal], amended para. 6: "Radioactive wastes or other radioactive matter", and new para. 12: "Within 25 years from the date on which the amendment to paragraph 6 enters into force and at each 25 year interval thereafter, the Contracting Parties shall complete a scientific study relating to all radioactive wastes and other radioactive matter other than high level wastes or matter, taking into account such other factors as the Contracting Parties consider appropriate, and shall review the position of such substances on Annex I in accordance with the procedures set forth in Article XV."

accordance with the Convention at the expiry of 200 days from the meeting, and covered all but one Contracting Party, who entered a dissent.

In light of the developments in the London Convention, it proved possible to unscramble the complex arrangements in the OSPAR Convention. At the first Ministerial Meeting of the OSPAR Commission at Sintra, Portugal, on 22 and 23 July 1998, agreement was reached on a unanimous decision, that terminated the "option of an exception" [17]. As a result, the OSPAR Convention provides for a complete and permanent ban on the dumping in the maritime area of radioactive substances, including wastes — without the review for which the London Convention provides. This agreement undoubtedly was helped by the fact that the Deputy Prime Minister of the UK in 1998 (who led the UK delegation at Sintra) had in the past swum down the River Thames in London to protest the refusal of the UK to accept a ban on dumping radioactive waste, as well as by the election in France of a government which included a Minister for the Environment (who led the French delegation) from an explicitly Green political party.

7. LAND-BASED DISCHARGES

The general background to the specific features related to land-based discharges was, of course, the same as that for the dumping provisions (referred to in Section 6 above). In the negotiation of the OSPAR Convention, Annex I (on land-based sources), the emphasis on the holistic approach led to ending any special emphasis to a single approach. Radioactivity, for example, was made one of the criteria for setting priorities, assessing the nature and extent of the programmes and measures, and their timescales, rather than being treated in a separate article from those covering other hazardous substances. The requirement was, however, that recommendations and monitoring of the other appropriate international organizations and agencies should be taken into account for radioactive discharges. This development integrated the approaches to radioactive substances and other hazardous substances, while maintaining some special features. There was no immediate action, however, to adopt any new programmes or measures.

The UNCED Agenda 21 contained an invitation to UNEP to hold a conference addressing the development of a global programme of action on land-based sources of marine pollution [18]. As a consequence, and after preparatory meetings in Nairobi, Montreal (Canada) and Reykjavik, a conference was held in Washington, D.C., in October and November 1995. As a result, 108 States joined to adopt the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities [14].

The Global Programme of Action (often referred to as the GPA) continues to recognize radioactive substances as a ‘source category’ separate from hazardous substances — although the division of the category of hazardous substances into persistent organic pollutants, heavy metals and oils (hydrocarbons) reduces somewhat the force of this separate status. The GPA sets the objective of reducing and/or eliminating radioactive emissions and discharges of radioactive substances in order to prevent, reduce and eliminate pollution of the marine and coastal environment of human-enhanced levels of radioactive substances. The actions recommended can be grouped into levels and summarized as follows:

— *At the national level:* To minimize and limit the generation of radioactive waste; to ensure safe storage transport and disposal; to ensure proper management of radioactive waste; and to use the BATs to avoid marine inputs of radioactive substances.
— *At the regional level:* To monitor marine radioactivity; to agree criteria for assessment of the application of the BATs; and to prepare comprehensive assessments of the impact of radioactive substances.
— *At the global level:* To support the IAEA development of radioactive waste management safety standards; to support countries in need of assistance; to maintain international quality assurance; and to provide international expert assistance (see Chapter 5, Section C, paras 107–113 in [14]).

The approach of the GPA to radioactive substances has been incorporated into the recently adopted Protocol Concerning Pollution from Land-based Sources and Activities, for the Caribbean [19].

8. FURTHER OSPAR DEVELOPMENTS

The OSPAR Convention came into force on 25 March 1998, one month after the completion of ratification, approval or acceptance by all the Contracting Parties to both the Oslo Convention and the Paris Convention. It was decided to mark this by arranging that the first meeting of the OSPAR Commission would be at ministerial level in Sintra, Portugal.[6] It was also

[6] The special provisions in the Convention on dumping radioactive waste had foreseen a ministerial meeting in 1997. Ratification, however, was not complete by the end of 1997, and therefore this specific provision became spent. The provision for biennial ministerial meetings thereafter was superseded by the unanimous decision terminating these special provisions.

decided to set up strategy statements on the work of the Commission in the following different fields:[7]

— Protection of marine ecosystems and biodiversity (under the new provisions for the scope of the Convention agreed at the meeting in Sintra, Portugal);
— Hazardous substances;
— Radioactive substances;
— Eutrophication (that is, the problems caused by the introduction of excessive amounts of nutrients, especially nitrogen and phosphorus, into parts of the marine environment);
— The offshore oil and gas industry (not adopted until 1999, in view of the major debate at the 1998 Ministerial Meeting on the *Brent Spar* issue, namely, the disposal of disused offshore installations).

These five strategies were to be complemented by the ongoing Joint Environmental Assessment and Monitoring Programme, which was to be revised after the completion of the Quality Status Report on the marine environment of the North East Atlantic Ocean in 2000.

The status of the strategies was that they were adopted formally to guide the future work of the OSPAR Commission. They, therefore, clearly constituted aspirational goals for what the Commission should aim to achieve, rather than commitments or undertakings by the Contracting Parties. Nevertheless, the expectation was that the Contracting Parties would work together to achieve these objectives.

The decisions with respect to the fields for which to establish strategy statements did not result from predetermined ideas on the logical divisions between the subject matter. They were, rather, pragmatic responses to the fact that the Contracting Parties tended to send different experts to deal with different fields, and that in consequence such groupings were convenient for organizational purposes.

The strategies shared a common structure:

— The objective;
— The guiding principles (in general, a restatement of the main principles of the OSPAR Convention and other relevant international agreements);
— The strategy itself (essentially, the framework of action agreed);

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[7] The author of the present paper was Chairperson of the negotiations on all these issues and reports from personal experience.

— The timeframe for implementation (which, in some cases, contained elements making the objective more precise);
— Implementation, that is, the main actions agreed;
— Provisions for reviewing the strategy.

An important element in the guiding principles was the OSPAR precautionary principle.

In line with this plan, the Strategy with regard to Radioactive Substances sets out first the objective [20]:

> "to prevent pollution of the maritime area from ionising radiation through progressive and substantial reductions of discharges, emissions and losses of radioactive substances, with the ultimate aim of concentrations in the environment near background values for naturally occurring radioactive substances and close to zero for artificial radioactive substances. In achieving this objective, the following issues should, *inter alia*, be taken into account:
>
> a. legitimate uses of the sea;
> b. technical feasibility;
> c. radiological impacts on man and biota."

This is very close to the objective of the Strategy with regard to Hazardous Substances, which likewise sets an undated ultimate aim of concentrations in the marine environment near background values for naturally occurring substances and close to zero for human-made synthetic substances. It is noteworthy that, in the case of hazardous substances, there are no points (such as technical feasibility) to be taken into account in achieving the objective.

The guiding principles that are invoked in the radioactive substances strategy are limited to the general principles of the convention, and the requirement to take into account (when dealing with radioactive substances) the recommendations and monitoring programmes of the appropriate international organizations and agencies. (It was intended that organizations and agencies cover both UNEP and the IAEA.) In addition (although not strictly a principle), this section requires existing scientific assessments of dose and risk.

The framework of action agreed is in very general terms. In summary, it includes commitments to:

— Identify substances that give rise to concern, including:
  • Exposure of, and effects on, humans and marine biota;
  • Adverse effects on legitimate uses of the sea;

— Assess and prioritize such substances;
— Develop programmes and measures.

The timeframe for the implementation of the strategy repeats some material (now spent) from the Ministerial Declaration made in Paris in 1992 at the time of the adoption of the OSPAR Convention on the need by 2000 for further substantial reductions in radioactive discharges, emissions and losses. It then goes on to add the following commitment:

> "By the year 2020, the [OSPAR] Commission will ensure that discharges, emissions and losses of radioactive substances are reduced to levels where the additional concentrations in the marine environment above historic levels, resulting from such discharges, emissions and losses, are close to zero."

This, again, closely parallels the timeframe for the Strategy with regard to Hazardous Substances, which provides that the Strategy will be implemented progressively "by making every endeavour to move towards the target of the cessation of discharges, emissions and losses of hazardous substances by the year 2020". Both show qualifications of the basic commitment, the one by means of the phrase "making every endeavour", the other through the concept of "additional concentrations" above undefined "historic levels" being "close to zero". One comment often made is that the radioactive substances strategy is far from easy to interpret: it was, however, a compromise reached after negotiations lasting nearly all night.

The implementation section focuses on the identification and assessment of situations which give rise to "reasonable grounds for concern", and establishing whether they are the result of general problems or are restricted to a regional or local area. There is, however, a commitment to the development of ecological quality criteria. This commitment will need to be taken up in the OSPAR Commission's current work on establishing a comprehensive suite of environmental quality objectives as a pilot project in the North Sea.

The review section commits the OSPAR Commission to a review of the strategy by 2003, a process which will begin shortly.

The radioactive substances strategy was the result (as has been said) of difficult negotiations, and did not lay down a clear blueprint for what was to be done in the way that was achieved for the hazardous substances strategy. In the run-up to the OSPAR Commission meeting in 2000, therefore, work was put in hand to develop a programme for the more detailed implementation of the strategy with regard to radioactive substances. This was adopted unanimously at the meeting of the Commission in Copenhagen in June 2000 [21].

It should be noted that this adoption was contemporary with discussion (and adoption) of the OSPAR Decision 2000/1 on Substantial Reductions and Elimination of Discharges, Emissions and Losses of Radioactive Substances, with Special Emphasis on Nuclear Reprocessing [22], based on a proposal by Ireland. In principle, an OSPAR Decision is an instrument binding in international law — but only for those Contracting Parties that vote for or accept it. However, this Decision's only substantive paragraph is concerned with a requirement for an immediate review of the licences of nuclear fuel reprocessing plants. Only two Contracting Parties have such plants in operation (France and the UK). These Contracting Parties abstained from supporting the Decision, and are therefore not bound by it. Fuller discussion of the division does not therefore seem necessary. The Decision, its extensive recitals and the discussion on them, are nevertheless an important part of the context in which the further implementation programme will be carried out.

The further implementation programme provides for:

- Submission of national plans for implementing the strategy. These will cover modifications of discharge authorizations, technical improvements to reduce discharges, and forecasts to the year 2020 of anthropogenic discharges as well as releases of radioactive substances according to sector/activity and region;
- Development of a collective overview of implied progress towards the Strategy's goals;
- Ministerial conclusions on how to manage future progress. These will cover baseline (discharge levels, concentrations in the sea, dosage to humans and biota) against which to evaluate progress; assessment of whether the combined effect of the national plans will deliver by 2020 what the Strategy requires; intermediate goals for each national plan; monitoring and reporting proposals; and, possibly, amendments to the Strategy as part of its review.

The aim of this process is therefore to establish a clear, transparent programme to move towards the agreed overall objective. The arguments to come will therefore be about the speed of progress, the way to interpret the detail of the objectives and the way to monitor and assess progress.

9. FURTHER DEVELOPMENTS

As has been argued, the international agreements and commitments in this field are a means of settling the balance between the rights of States to exploit their own resources in accordance with their own policies, and their responsibilities to ensure that such exploitation does not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction. This is a continuing process, not one settled once and for all. It is, therefore, always essential to keep one eye (at least) open for new developments that are emerging and which will be likely to take forward the debate. Two such emerging issues are worth highlighting.

First, a large number of States are concerned with the movement of radioactive waste through the seas adjoining their coasts. This concern has arisen in many forums. Among these at global level are the 1992 UNCED Preparatory Committee Meetings, the 1994 Barbados Conference on the Sustainable Development of Small Island Developing States, the 1996 and 1999 reviews by the United Nations Commission on Sustainable Development on the theme of the oceans and seas and the first meeting of the United Nations Open-ended Informal Consultative Process on the Oceans and the Law of the Sea.

Some international instruments have emerged as a result of these concerns. The Waigani Convention attempts to declare the transboundary movement through the 'convention area' of hazardous waste, including radioactive waste, to be illegal unless the transit States are notified. The 'convention area' is to be defined as the internal waters, territorial seas, archipelagic waters and exclusive economic zones of Contracting Parties, together with any area of the high seas enclosed within the exclusive economic zones. The Convention would require Contracting Parties to make it an offence to carry out such an illegal movement. Many States consider that provisions of this kind would be a breach of the provisions on freedom of navigation under the United Nations Convention on the Law of the Sea.

Similarly, under the Barcelona Convention for the Protection of the Mediterranean Sea against Pollution, the Protocol on the Prevention of Pollution of the Mediterranean Sea by Transboundary Movements of Hazardous Wastes and their Disposal has been developed [23]. Article 6 of this Protocol would require:

> "(4.) The transboundary movement of hazardous wastes through the territorial sea of a State of transit only takes place with the prior notification by the State of export to the State of transit, as specified in Annex IV to this Protocol. After reception of the notification, the State of transit brings to the attention of the State of export all the obligations relating to passage through its territorial sea in application of international law and the relevant provisions of its domestic legislation adopted in compliance with international law to protect the marine environment. Where

> necessary, the State of transit may take appropriate measures in accordance with international law. This procedure must be complied with within the delays provided for by the Basel Convention.
>
> (5.) Every State involved in a transboundary movement ensures that such movement is consistent with international safety standards and financial guarantees, in particular the procedures and standards set out in the Basel Convention."

This Protocol has not yet entered into force, not least because of doubts by a substantial number of States whether it is consistent with the provisions of the United Nations Convention on the Law of the Sea on freedom of navigation.

The same problem has been addressed in other forums in the form of 'soft' law. A resolution of the General Conference of the International Atomic Energy Agency in September 2001 [24] urged:

> "Member States shipping radioactive materials and spent fuel…to provide, as appropriate, assurances to potentially affected States that their national regulations accord with the Agency's Transport Regulations, welcomes the practice of some shipping States and operators of undertaking timely consultations with relevant coastal States in advance of shipments and invites others to do so. The information provided should in no case be contradictory to the measures of physical security and safety."

(Likewise, the Fifth International Conference on the Protection of the North Sea included in its 2002 Bergen Declaration a paragraph to the same effect.)

The second emerging issue is a regional one, but one with some substantial implications for a number of major nuclear powers. The Treaty establishing the European Community provides for general action programmes on environmental policy, setting out priority objectives [25]. The European Commission Sixth Environmental Action Programme provides for the development of a number of thematic strategies on environmental themes. One of these is the marine environment. The European Commission has published a Communication to the European Parliament and Council of Ministers [26], setting out its ideas on how that strategy might be developed.

Among the objectives proposed for the thematic strategy is one on radionuclides:

> "Objective 6: The objective with regard to radionuclides is to prevent pollution from ionising radiation through progressive and substantive

reductions of emissions, discharges and losses of radioactive substances, with the ultimate aim to reach concentrations in the marine environment near background values for naturally occurring radioactive substances and close to zero for artificial radioactive substances. This objective should be achieved by 2020."

It will immediately be noted that this objective is very close to the objective of the OSPAR Strategy with regard to Radioactive Substances. The very significant differences are:

— The omission of the qualifications relating to taking into account legitimate uses of the sea, technical feasibility and radiological impacts on man and biota;
— The absolute terms of the timescale.

The European Commission has also proposed as the action related to this objective that:

"Action 10: By 2004, the [European] Commission will review the relationship between the OSPAR Strategy with regard to Radioactive Substances and existing EC measures, in particular with respect to the reduction of discharges arising from nuclear fuel reprocessing plants. Based on the results of the updated MARINA project, it will determine whether any Community action should be considered."

The European Commission representatives have stated that the objectives in their Communication are aspirational, and not intended to be binding [27]. However, in this context, it should be remembered that the proposals from the European Commission for a Directive on a Framework for Water Policy was amended in the course of its enactment, largely at the initiative of the European Parliament, to incorporate into European Commission Law some of the significant features of the OSPAR Strategy with regard to Hazardous Substances, thus turning them from aspirational guidance on future international work into binding requirements that can be enforced by the European Court of Justice.

10. CONCLUSION

In summary, international law on the environment in general is to be regarded as a process rather than a steady state. As in the early 1970s, the current processes on international regulation of discharges of radioactive waste in relation to the marine environment are very active. When some of the processes to which this paper has drawn attention have reached their conclusions, a more steady state with respect to the settling down of such issues may nevertheless be apparent.

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Discussion following paper by A. Simcock

A.W. van WEERS (Netherlands): What is the meaning of 'close to zero' in the case of artificial radionuclides?

A. SIMCOCK (OSPAR Commission): This question is going to be discussed in about six weeks' time, under Netherlands chairpersonship, and I should not anticipate the outcome of the discussion.

Some OSPAR parties see the issue solely in terms of the radioactivity levels (in becquerels) in discharges, which they believe should be brought close to zero. Others are prepared to take a broader view.

In the current discussions on the baseline against which to measure progress, the focus has been on three aspects: radioactivity levels in discharges; concentrations in the marine environment (water, biota and sediments); and dosages. These aspects have been considered by three working groups. It will be interesting to see how the three working groups' reports interrelate.

Y. NISHIWAKI (Austria): When the London Convention was being negotiated, a major problem was that some countries were pressing for the exemption of radioactive waste from military applications. What is the present situation regarding such waste?

A. SIMCOCK (OSPAR Commission): The question of how far environmental agreements should apply to the military is an interesting question of international law.

The OSPAR view is that the OSPAR Convention applies equally to civilian and military shipping activities. Some OSPAR parties have slightly 'shaded' that view, but I think the consensus is that the controls should apply equally to everyone.

I hesitate to say whether that is the situation regarding the London Convention. I imagine that only the International Tribunal for the Law of the Sea would give you a conclusive answer.

AN ASSESSMENT OF THE IMPLICATIONS OF A REGIONAL CONVENTION ON DISCHARGE CONTROL POLICIES

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Abstract

Nuclear facilities located in the OSPAR region are required to regulate discharges into the sea based on the legal requirements under the Euratom Treaty, the OSPAR Convention, national regulations and international regulations (IAEA). The Sintra Statement of 1998 sets new targets for reducing environmental concentrations resulting from discharge practices. To meet new strict discharge limitations, the reprocessing plant in La Hague, France has improved technologies for the purification of liquid discharges despite the fact that the present level of radiological impact on the public is already negligible. Thus, in 2003, the discharge authorization restricts dose to individual members of the public to 0.03 mSv/a. In the first place, the discharge of radionuclides mostly contributing to the public dose, i.e. alpha emitters, will be reduced. Technologies to reduce discharges of less radiologically important radionuclides, e.g. T, ^{14}C and ^{129}I, will be elaborated later. Thus, French nuclear facilities follow the new strict international discharge limitations and seek the most appropriate technological solutions to reduce discharges and the associated public exposure.

1. INTRODUCTION

This perspective on the issue is narrow, from an industrialist point of view, and yet wide at the same time, as not only the OSPAR Convention but also regulations applicable in Europe as a whole and in France in particular are addressed. In the present paper, the subject is considered mainly from the point of view of the reprocessing plant in La Hague in France, but the position of the French Government and the case of other industrial nuclear facilities in Europe are also considered.

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[1] The present paper is a summary of the main points of the conference presentation, as the latter was not made available for publication.

2. THE SITUATION IN EUROPE REGARDING NUCLEAR DISCHARGES

The situation in Europe regarding nuclear discharges and how they should be regulated at an international level is relatively complex and unique. In non-European countries with a nuclear industry, the legislation issue appears to be rather simple. There is an international annual level, and a local level established by the country in which the nuclear facility is located. The government lays down discharge laws which comply with international law and which do not exceed limits recommended by the ICRP. This applies to countries such as China, the Russian Federation and the United States of America. In France, there are twice as many constraints, owing to two additional levels of legislation: European and OSPAR. Currently in France, the following four levels of legislation exist:

— French national regulation or the local level, which sets discharge limits. In France, this is the responsibility of the Nuclear Safety Authority, under the administrative supervision of the Ministry for Health, Environment and Industry;
— Euratom Treaty, Chapter 3, Articles 35, 36 and 37;
— OSPAR Convention;
— Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (2001).

These four levels overlap, are not harmonized and sometimes even contradict each other.

As can be seen from Fig. 1, the areas covered by OSPAR and the European Union are not the same. Paradoxically it may seem, enlargement will not simplify matters since Norway, Iceland and Switzerland are not set to join the European Union at the same time. This situation, which is inherently absurd in the eyes of a pragmatic industrialist such as COGEMA, means that the European Commission and OSPAR often find themselves sitting at the same table to discuss the same issues, but from different viewpoints, often resulting in their taking action separately. One example is OSPAR Recommendation 93/5, which requests the right to give an opinion on discharge drafts, although such a mechanism already exists in the European Union in the context of Article 37. For an industrialist, this is a problem and it is the reason why the French Government refused to endorse this recommendation in order to have only one European level on the question of giving advice on future discharge authorizations.

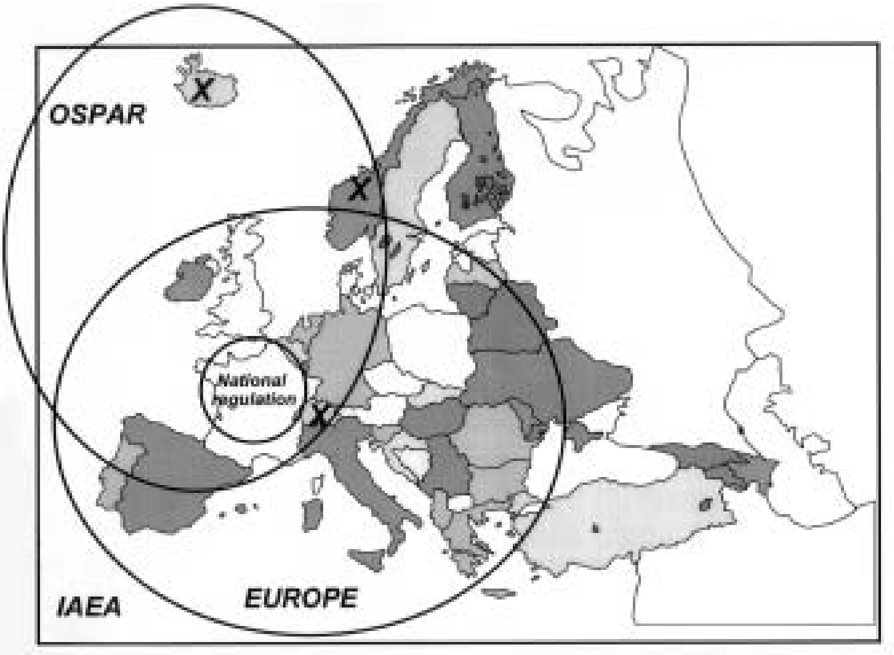

FIG. 1. Geographical areas and realm of regulations.

3. OSPAR CONSTRAINTS AND WEAKNESSES

In OSPAR, the radioactivity group is the focal point for all technical and political debate. Until very recently, this group was characterized by numerous lengthy discourses by Ireland and the historical debate with the United Kingdom. Radionuclide considerations have gained extreme political importance in Ireland and became the subject of meetings between the two governments. We all hope that this issue will be put to rest by the UK Government when the new release permits are granted for Sellafield.

There are two groups of countries: one is the group with no nuclear installation, and the other is the French and UK group with the entire fuel cycle activity (with reprocessing, enrichment, fuel fabrication, etc.).

The trends exhibited by OSPAR are of a particular nature in the following four ways:

— OSPAR considers the discharges issue per se, which means that numerous discussions are held with no other revisit of the issue;

— OSPAR deals with all marine discharges within its own limited zone, which often results in a desire to deal with issues that have little in common;
— OSPAR claims to be establishing an ambitious and general discharge policy by means of a multitude of concepts which lack being based on available technology (this is more problematic for the industry on a daily basis);
— OSPAR is preparing an ultimate, radical revision of certain issues, such as zero discharges.

Let us recall the Sintra Statement, which reads:

"We agree, in addition, to prevent pollution of the maritime area from ionizing radiation through progressive and substantial reductions of discharges, emissions and losses of radioactive substances, with the ultimate aim of concentrations in the environment near background values for naturally occurring radioactive substances and close to zero for artificial radioactive substances. In achieving this objective, the following issues should, inter alia, be taken into account: legitimate uses of the sea, technical feasibility, radiological impacts to man and biota..."

The ultimate aim 'close to zero' seems all right, but how can stated issues such as legitimate use of the sea and technical feasibility be taken into account? I do not want to insist on our responsibility of an operator like COGEMA, but we think that it is our responsibility to anticipate, assess, forecast and reduce, monitor and make known whatever impact our facilities will have on the environment at the different stages in their lifetimes (construction, operation and decommissioning). COGEMA's strict definition of environmental management also covers nuclear and conventional aspects (chemical), and applies to landscape, flora and fauna. Furthermore, continuous progress being made by the EFQM and the ISO 14000 standard is acknowledged.

4. COGEMA ACTIVITIES

Let us first look at the past activities of the plant, that of reprocessing. During the period 1976–2001, 17 000 t of spent fuel from French and foreign customers were reprocessed. Although the reprocessing activities increased steadily from 1976 to around 1997, liquid discharges decreased significantly as of 1987. Discharges of beta emitters to the sea, and the discharges of alpha emitters, were drastically reduced. Currently, the releases of beta emitters are one hundredth of those in the 1970s. Tritium discharges followed the pace of the production. Table I provides an overview of liquid discharges during the period 1999–2001, and Table II gives an overview on contribution by radionuclides in liquid discharges.

Table III shows that there is not a simple linear correlation between tonnage of fuel reprocessed and discharges.

In the future, the production will be increased (in 2003 to about 1200 t) and the capacity will eventually stay at 1700 t/a. However, the energy equivalent is an essential point for future discharges. A new discharge authorization for La Hague is expected for the beginning of 2003.

It has to be pointed out that reduction of radiation exposure of workers was also an important objective of COGEMA. Dosimetric surveys reflect a significant reduction of exposure of personnel over the years, particularly since 1985 from about 7 manSv/a to 0.44 manSv/a at present. The first step was the introduction of preventive maintenance in 1986, followed by the optimization of inspection of facilities with the greatest exposure in 1990 and, in 1996, by the optimization of daily inspection of all facilities.

5. THE NEW DISCHARGE AUTHORIZATION PROCESS

Radioactive discharges were regulated by three orders:

— Order of 22 October 1980: authorized limits for the site's liquid and gaseous discharges;
— Order of 27 February 1984: authorized limits for the site's gaseous discharges;
— Order of 28 March 1984: authorized limits for the site's liquid discharges.

Since 1995, France has been pursuing a revision process to reduce the authorization for radioactive liquid and gaseous discharges. As a result of an

TABLE I. LIQUID DISCHARGES (1999–2001) (TBq)

	1999	2000	2001
Tritium	12 900	10 500	9 640
All radionuclides except tritium	29.6	32.9	28.4
Sr-90 plus Cs-137	2.16	1.39	1.84
Alpha emitters	0.039	0.037	0.051

TABLE II. LIQUID DISCHARGES — CONTRIBUTION BY RADIONUCLIDE

Activity	Contribution (tritium excluded) (%)
Ru-Rh 106	61
C-14	25
I-129	4
Sr-Y 90	3
Cs-137	2.5
Tc-99	1
Sb-125	1
Co-60	1
Alpha	0.1
Others	<2

initiative by the Nuclear Safety Authority, authorization for radioactive liquid discharges granted to nuclear installations will be reduced in order to bring them closer to the current level of actual discharges, and thus better reflect the process of technical progress achieved by the operators. This authorization will be regularly reviewed with a view to fixing the limit as low as technically and economically possible, thus requiring the operator to continuously optimize the discharge process by using the best technique available at an acceptable cost. Électricité de France (EDF), for example, has committed itself to revising all the authorizations currently in force between now and 2006. It is a result of the government initiative that the discharge authorizations enforced at the COGEMA La Hague site are in the process of being modified in order to reduce the discharge limit and to get COGEMA to follow the route of continuous reduction of discharge, in line with the objectives laid down by the OSPAR Convention. The draft decision of the discharge authorization which makes explicit reference to the OSPAR

TABLE III. TOTAL TONNAGE OF REPROCESSED FUEL AND ITS ENERGY EQUIVALENT AS OF 1 JANUARY 2002

	1999	2000	2001
Tonnage reprocessed	1 562	1 197	951
Energy equivalent (Tw(e)·h)	430.7	325.7	303

strategy is the first translation into domestic law of France's commitment to the OSPAR Convention.

The procedure for revision of the plant operating decrees relating to a capacity for reprocessing and storing were the objective of a public inquiry from March to May 2000. The material submitted to this inquiry incorporated a study of the site with its discharges and impact on health and the environment. On the basis of this impact study — and various consultations — the conditions for liquid discharges at the COGEMA La Hague site will be modified. A final decision should be reached very soon.

The process of the reduction of discharges at La Hague was accompanied by an intense public debate in various forms. It is worthwhile to recall the different debates.

The *first* debate focusing on reprocessing was conducted by the OECD/NEA. The report, entitled 'Radiological Impacts of Spent Nuclear Fuel Management Options', was requested by opponents of a closed fuel cycle in OSPAR. The report concluded that:

— The radiological impacts of both the reprocessing and the non-reprocessing fuel cycles studied are small, well below any regulatory dose limits for the public and for workers, and insignificantly low as compared with exposures caused by natural radiation;
— The indicative difference in the radiological impacts of the two fuel cycles studied does not provide a compelling argument in favour of one option or the other.

The result was clear and the opponents were disappointed.

The *second* debate was a public consultation in the La Hague area for the next orders intended to be published for the future licence of the plant. The broad debate was conducted with everybody around the plant. The conclusion of the inquiry was totally positive in favour of the proposal of the authorities.

The *third* was a report of the Groupe Radioécologie Nord-Cotentin. It was the occasion to mix officials, international and national experts, and non-governmental organizations, to make a full assessment of the discharge of the nuclear installations in the La Hague area, including COGEMA, the Flamaville nuclear power plant and the nuclear submarine plant in Cherbourg. The report clearly dismissed any connection between leukemia cases and plant discharges.

The *fourth* was a group named NORCO (2000). It consisted of an international group of scientists to compare measurements of the activity around the plant and to make a comparison between different methodologies. The 2000 results of the NORCO group did not show that the local nuclear industry has a significant impact from a radiological point of view.

The *last* study, called the Marina II, was undertaken by the European Commission. Marina II evaluated the impact of discharges from a variety of nuclear activities (including nuclear tests, Chernobyl, the nuclear industry and other industries). The result was that impacts of the nuclear industry are low and decreasing, and that today less than 1% of the alpha emitters released can be attributed to the nuclear industry. The main contributions in terms of discharge of alpha emitters are now from oil and gas activities in the area, and from fertilizer manufacture (phosphate industry).

6. IMPACT OF THE LA HAGUE REPROCESSING PLANT

What is the impact today of the La Hague reprocessing plant? The natural radiation dose level in Cornwall, for example, is 7 mSv/a and in the La Hague area (North Contentin) the radiation dose is 3 mSv/a. The limit for the public in Europe is 1 mSv/a. The formal La Hague authorizations of 1981–1984, and still in place, were at the level of 0.15 mSv/a. What could be the impact in future? On 1 January 2003, for example, the impact of local activities will be 30 μSv/a, the future level of authorization. There will be a Ministerial Meeting in June 2003 which will consider the baseline situation (environment measurements, impacts and discharges) and address what could be 'zero' in the year 2020.

7. FRENCH POLICY

The French Government fully supports reducing discharges to as low as possible. The new discharge authorization for the La Hague reprocessing plants complies with OSPAR and will be published soon. One has to first take into account impact and reduce discharges of radionuclides with high impact. One has to concentrate on the discharge of alpha emitters, which in fact have a higher impact than beta emitters. Iodine-129, Tritium and Carbon-14 are not included in the reduction. Carbon-14 research is necessary and COGEMA has to perform work in order to propose a solution for Carbon-14. Further reductions need to be studied, as it is necessary for the authority to revise authorizations every four or five years. There will not be a decision in 2003 on what could be the goal in 2020, because nobody knows the technical possibilities of the future.

8. CONCLUSION

COGEMA wants to progress and reduce discharges. It is very important for COGEMA to make technical progress in order to reduce discharges to the sea and, together with reduced discharges from the La Hague reprocessing plant, to reduce area discharges. If one is progressing from reprocessing 1000 t to 1700 t of spent fuel annually, with higher burn-up, it is necessary to take into account the energy equivalent of the fuel. Since utilities want to have higher burn-up, this factor must be included in the discharge authorization process and in OSPAR Convention discussions. The impact of main importance and the future problem in the OSPAR area will be how to include discharges from oil and gas activities due to the discharge of alpha emitters from these activities in the area. Furthermore, it will be necessary to exclude radionuclides with low impact such as tritium. If the choice has been made to reduce again the level of discharges to the sea in correlation with the production, past policy is still strong and valid. We believe in continuous progress, broad dialogue and technical improvements. We have confidence in our future, and we believe more and more in recycling. This is the only sustainable policy for 2020 and beyond.

DEVELOPMENT OF NEW POLICIES ON PROTECTION OF THE ENVIRONMENT FROM THE EFFECTS OF IONIZING RADIATION

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Abstract

Protection of the environment is developing rapidly at the national and international levels. There are still no internationally agreed recommendations as to how radiological protection of the environment should be carried out. The International Commission on Radiological Protection (ICRP) is currently reviewing its existing recommendations for human protection. It has set up a Task Group with the aim of developing a protection policy, and suggesting a framework, for the protection of the environment that could feed into its recommendations for the beginning of the 21st century. The Task Group is proposing, as objectives for the radiological protection of the environment, to safeguard the environment by preventing or reducing the frequency of effects likely to cause early death, reduced reproductive success or the occurrence of scorable DNA damage in individual fauna and flora to a level where such effects would have a negligible impact on conservation of species, maintenance of biodiversity or the health and status of natural habitats or communities. To achieve these objectives, a set of reference dose models, reference dose per unit intake and external exposure values will be required, as well as reference data sets of doses and effects for both humans and the environment. The present paper provides a progress report of the work of the Task Group.

1. INTRODUCTION

The advice of the International Commission on Radiological Protection (ICRP) targets the regulators and implementers that have responsibility for establishing or suggesting radiological protection standards. The ICRP's current recommendations were published in 1991 [1]. The system of protection has become increasingly complex, as the ICRP has tried to cover the many situations to which it applies. The ICRP is currently reviewing its recommendations with the aim of simplifying the system and providing a single, comprehensive set of unified recommendations, consolidating all the work since Publication 60 [1]. In doing so, it proposes emphasizing the protection of individuals; broadening the concept of dose limits by integrating a range of action levels; distinguishing between actions that can be applied to the source and those that can be applied to the pathways leading from the source to the doses in individuals; clarifying the dosimetric quantities for protection; and proposing a framework for the protection of non-human organisms [2–4].

Environmental protection has made considerable progress in developing its philosophy and guidance since 1991 when the ICRP's recommendations on radiological protection were published [1]. The increasing public concern over environmental hazards has resulted in many international conventions, and the need to protect the environment in order to safeguard the future well-being of humankind is one of the cornerstones of the Rio Declaration [5]. Radiological protection of the environment has attracted increasing attention over the last decade, and at present there is a widely held view that explicit protection from harmful effects of ionizing radiation should also be provided for non-human organisms and ecosystems. In several countries, for example in Sweden, legal requirements are already in place providing such protection [6].

To date, the ICRP has not dealt explicitly with protection of the environment, except in those situations where radionuclide levels in non-human organisms were of relevance for the protection of humans. The view of the ICRP is expressed in Publication 60 [1]:

> "The Commission believes that the standards of environmental control needed to protect man to the degree currently thought desirable will ensure that other species are not put at risk. Occasionally, individual members of non-human species might be harmed, but not to the extent of endangering whole species or creating imbalance between species. At the present time, the Commission concerns itself with mankind's environment only with regard to the transfer of radionuclides through the environment, since this directly affects the radiological protection of man."

There are several examples of situations where this view is insufficient to protect the environment, for example, environments where humans are not present or have been removed, or situations where other organisms in the environment could receive much higher radiation exposures than humans. So far, the ICRP has not explained how it will address the issue of whether the environment should be protected in its own right or in the interest of humans, nor has it stated explicitly that the environment should be protected. Consequently, there is little guidance from the ICRP with respect to how radiological protection of the environment should be carried out, or why.

Today's development of approaches to protect the environment is to a large extent driven by the need of national regulators and of international organizations to develop their initiatives to safeguard a sustainable level of development. The Sintra Declaration of the OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic [7] emphasizes a need to:

> "prevent pollution of the maritime area from ionising radiation through progressive and substantial reductions of discharges, emissions, and losses of radioactive substances with the ultimate aim of concentrations in the environment near background levels for naturally occurring radioactive substances and close to zero for artificial radioactive substances."

The IAEA has addressed the issue of environmental protection on several occasions. "Effects of Ionizing Radiation on Aquatic Organisms and Ecosystems" was a report published in 1976 [8]. Other IAEA work, in support of the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, known as the London Convention of 1972, explored the possible effects of the sea dumping of radioactive waste packages on marine species and, in 1979, the IAEA published a report on a methodology for assessing impacts of radioactivity on aquatic ecosystems [9]. A further report, "Assessing the Impact of Deep Sea Disposal of Low Level Radioactive Waste on Living Marine Resources" [10], discussed the doses to a number of typical marine species living at or near the sea floor. In addition, the IAEA published a report in 1992 entitled Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards, which dealt with the effect of radionuclide releases on terrestrial and freshwater environments [11].

In 1999, the report published by the IAEA, "Protection of the Environment from the Effects of Ionizing Radiation" [12], presented various issues and approaches for establishing an environmental protection framework and criteria. The IAEA is continuing work towards the development of a Safety Standards document on radiological protection of the environment. At an IAEA Specialists Meeting in November 2001 [13], the participants agreed that it was necessary to develop a system for the radiological protection of the environment (or the biotic components of it), and it was agreed that the initial focus should be on the protection of biota. The meeting encouraged the IAEA to continue working towards the development of Safety Standards that are practically based, and identified the IAEA as having:

> "a potentially valuable role in the consideration of the way in which effects manifested in individuals are expressed on higher levels of

organization (populations, communities and ecosystems), and in the development of a compilation of transfer factors from different sources [13]."

The Specialists Meeting also agreed that "the use of reference organisms is a reasonable approach to adopt in the development of a system to protect biota from the effects of radiation", and recognized that "effects on higher levels of organization (e.g. populations) occur only if individual organisms are affected, and that effects data are generally available for individuals rather than higher levels of organization". This year, a report on the ethical considerations in protecting the environment was published [14].

Other international organizations have also addressed environmental protection. The OECD/NEA has stressed the need to clarify the ICRP's current view, and recently arranged an international forum on protection of the environment [4, 15]. In 2001, the International Union of Radioecology (IUR), in association with two other bodies, organized the Consensus Conference on the same topic [16]. The conference emphasized both the need to provide adequate protection of the environment and that the development of a protection policy should be conducted in an open and transparent manner. At the national level, authorities are introducing legislation to protect the environment from the harmful effects of radiation. There is thus a risk that such initiatives will lead to different scientific and social approaches and make harmonization with other systems used for environmental protection difficult.

In summary, there has been a clear shift in society from the long-held anthropocentric approach with respect to protection of the environment to one that embraces both biotic and abiotic components of the environment. All recent conventions, principles, reports and statements lend support to the now widely held view that there is a need to demonstrate explicitly that the environment can and will be protected from the effects of radiation.

The ICRP set up a Task Group under the Main Commission in the year 2000, with the aim of suggesting a framework and a protection policy for the environment.[1] The Task Group comprises six individuals, each representing one of the following countries: Canada, Norway, the Russian Federation, Sweden, the United Kingdom and the United States of America. In addition, there are 22 corresponding members from 12 countries as well as members representing the United Nations Scientific Committee on the Effects of Atomic Radiation, the European Union and Greenpeace.

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[1] The Task Group's report was available on the ICRP web site until 15 December 2002.

2. WHY IS A SYSTEM NEEDED TO PROTECT THE ENVIRONMENT?

Many contend that the environment is already sufficiently protected from radiation, and that there is no reason to put resources into the development of a system to protect non-human organisms. It is probably true that the human habitat has been afforded a fairly high level of protection through the application of the ICRP's current system of protection. The problem is to demonstrate convincingly that the environment is or will be protected adequately in different circumstances. No explicit sets of agreed assessment approaches, criteria or guidelines with international authority currently exist. This leads to different national approaches and makes harmonization with other systems used for environmental protection difficult.

Radiation is one of many factors affecting the environment and, although its impact is small compared with other environmental pollutants, the public perceives things differently. The community whose focus is radiation protection has, as yet, not taken full account of the implications of the Rio Declaration of 1992 or the range of legal obligations relating to environmental protection. Several approaches have been made to address the questions raised with respect to the current ICRP statement on protection of the environment. They can be divided into two broad approaches: those that have assumed, or try to prove, that the ICRP statements are essentially correct; and those that have used separate dose rate limits, or some other approach, to demonstrate independently and explicitly that the environment can and will be protected [17]. These include the following:

— Arguments that because humans are an integral part of the environment and are afforded such a high level of protection, all other components of the environment are protected (the axiomatic approach);
— Calculations to demonstrate that, in hypothetical situations and if radionuclide concentrations in the environment are such that humans would not receive more than 1 mSv/a, other organisms would receive dose rates that are lower than those likely to cause harm at the population level (the human-food-chain approach) [11];
— The use, or proposed use, of dose-limit standards for the protection of populations based on environmental dose rates considered safe, e.g. 10 mGy/d for aquatic animals and terrestrial plants, and 1 mGy/d for terrestrial animals (generic population protection standards) [18–20];
— The introduction of an ecological risk assessment framework to assess the effects on non-human species using dosimetric models and estimated no

effect dose rates for a number of biotic assessment endpoints (no-effects standards) [21, 22];
- The development of a hierarchical system for protection, consisting of defined dose models, data sets to estimate exposures, and data on dose effect relationships for individual fauna and flora to provide derived consideration levels (reference fauna-and-flora approach) [23, 24];
- Attempts to produce systematic frameworks for assessing environmental impact of radiation in specific ecosystems (regional application of systematic frameworks) [25].

All of these approaches have their strengths and weaknesses. Even when humans are present in a contaminated environment, they are unlikely to receive the highest radiation doses because of the spatial distribution of radionuclides in the environment, and because of the differences in the biological accumulation of radionuclides by different fauna and flora. Many of the organisms that would be exposed to radionuclides in the environment do not form part of the human food chain, and the level of protection afforded to the environment is not defined sufficiently in terms of biological end points or the levels of risk associated with them.

A systematic approach for radiological protection of the environment is needed in order to assess and manage radiation effects on non-human organisms. It is also necessary to develop an international system that is practical and that acknowledges the present level of knowledge concerning the effects of radiation on biota. In addition, there is a need for an approach that will allow regulators and operators to address environmental protection explicitly rather than assume that the protection of humans ensures the protection of the environment. Given the lack of any systematic and structured approach that has wide support, there are strong expectations from many quarters on the ICRP to act.

The ICRP is in a position to provide guidance that could be globally accepted and that could integrate the radiological protection of humans and the environment into a coherent framework. In its draft report, the ICRP Task Group does not define dose limits for biota. It recommends a framework that can be used to provide high level advice and guidance, and to help regulators and operators demonstrate compliance with existing environmental legislation.

There are several reasons why it is necessary to develop a system for the protection of the environment, including:

- The need to demonstrate that the principles of radiological protection are consistent with existing international principles and to recognize the interdependence of humans and the environment;

— The need for operators and regulators to demonstrate compliance with existing environmental requirements;
— The need to provide advice with respect to different situations, in particular, where the potential for human exposure is minimal or where action to protect people has already been undertaken;
— The need to demonstrate explicitly how knowledge of the potential extent of the effects of radiation on the environment can be used to inform stakeholders.

The question of whether or not radiation experts want to protect individuals, populations or ecosystems is becoming less important, because a growing number of animals, plants, areas and habitats are already legally protected from various kinds of harm, including from radiation. Many species are also protected at the individual level. In addition, at the national level, there is often the requirement to address environmental protection transparently through environmental impact assessments in order to demonstrate compliance with existing legislation. In the UK, for example, many common species are already protected at the individual level, including 30 mammals, 500 birds (and, for more than 200 species, their eggs), 40 invertebrates and 130 plants [23]. This reflects changes in attitudes and values.

The principles of environmental protection are thus well defined and internationally agreed upon. The challenge now is to develop an approach for radiological protection of the environment which conforms to these principles. The ICRP Task Group points out that it is not for the ICRP itself or the radiological protection community to derive an ethic upon which environmental protection should be based, because others have already done this on behalf of society as a whole. There is sufficient evidence to indicate the level of interface required between general knowledge of the effects of radiation and the requirements of environmental protection.

A system of protection is necessary to enable frequent reviews of what is known about radiation doses and their effects on different organisms and areas of further research. Such a system should be applicable to all situations and allow a systematic approach to the derivation and revision of the different parameters that it contains [23, 24]. Some basic elements of a system for the protection of the environment include:

— A clear set of objectives and principles,
— An agreed set of quantities and units,
— A reference set of dose models for a number of reference fauna and flora,
— A reference set of values to estimate radiation exposure,
— A basic knowledge of radiation effects,

— A means of demonstrating compliance,
— Regular reviews and revisions as new knowledge develops.

3. PROTECTION OF HUMANS AND THE ENVIRONMENT

The ICRP Task Group proposes an approach based on reference sets of dosimetric models and environmental geometries, applied to one or more reference sets of fauna and flora [23, 24], since it is not possible to provide a general assessment of the effects of radiation on the environment as a whole. This approach would allow judgements to be made about the probability and severity of the effects of radiation, as well as an assessment of the likely consequences for individuals, the population or the local environment.

The Task Group recommends that the radiation-induced biological effects in non-human organisms be summarized into three broad categories:

(1) Early death,
(2) Reduced reproductive success,
(3) Scorable DNA damage (such as mutations and aberrations) in order to simplify and enable the development of a management framework.

A fourth end point could be morbidity related to radiation damage. These categories comprise many different and overlapping effects and recognize the limitations of our current knowledge of such effects.

Calculations of the dose of radiation require a consistent set of reference values to describe the anatomical and physiological characteristics of an exposed individual. For humans, Reference Man [26] is the primary reference for dose assessments, supported by secondary sets of data, for example, for a foetus, a child, etc. For the environment, the Task Group supports the approach of a set of primary reference fauna and flora to serve as representatives of animals and plants, as well as a set of reference dose models and environmental geometries [23, 27].

Reference organisms are intended to serve as a standard and a point of reference for an estimate of the dose. A reference fauna and flora contains various components, and the selection criteria for these primary reference organisms will include many scientific considerations, such as reference dose models for different terrestrial and aquatic animals and plants, reference dose per unit intake (lookup tables), end points and 'derived consideration levels' [24]. The Task Group believes that such a system would make the best use of existing data on doses and effects in other organisms and would also identify gaps in the data for further research. In developing a system, it will be necessary to incorporate the best scientific information available. The effects of ionizing radiation on higher levels of biological organization (for example, populations and ecosystems) occur only if individual organisms are affected, and effects data are generally obtained for individuals rather than for higher levels of organization. There is already a wealth of information available on responses, mechanisms and the effects of ionizing radiation on biota. It is necessary to review the available information in a structured way, in order to apply it appropriately. The project funded by the European Commission, known as FASSET (which refers to the Framework for Assessment of Environmental Impact) will facilitate this process [25].

At the Third International Symposium on the Protection of the Environment from Ionising Radiation which took place in Darwin, Australia from 22 to 26 July 2002 [22], the participants recognized that the reference organism approach provides a practical basis for transparent assessments by a clear identification of the parameters involved, and by providing a basis for comparisons between different situations and management options. Work that would enable the definition of reference organisms was identified as having a high priority.

The Task Group has proposed a system for radiological protection of the environment that is harmonized with the principles for the protection of humans. This system can be integrated with methods that are already in use in some countries.

Two possible objectives of a common approach to the radiological protection of humans and the environment are:

- To safeguard human health by preventing the occurrence of deterministic effects, as well as limiting stochastic effects in individuals and minimizing them in populations;
- To safeguard the environment by preventing or reducing the frequency of effects likely to cause early mortality, reduced reproductive success or scorable DNA damage in individual fauna and flora to a level where they would have a negligible impact on conservation of species, maintenance of biodiversity or the health and status of natural habitats or communities.

A common approach to the achievement of these objectives could be centred on a set of reference dose models, reference dose per unit intake and external exposure values, as well as reference data sets of doses and effects for both humans and the environment. The variety of dose models needed for such reference organisms will depend upon the biological effects, and a hierarchy of dose model complexity has been suggested by Pentreath and Woodhead [27].

Such models have already been used and form the basis of the current studies in the FASSET project [25].

4. DOSE CONSIDERATION LEVELS

The ICRP is currently discussing an approach to protect humans based on bands of concern and action levels with reference to background dose rates [2]. The Task Group has proposed a similar concept (that is, derived consideration levels) for fauna and flora to guide the consideration of different management options [23, 24]. Natural background dose rates, and dose rates known to have specific biological effects on individuals are the only two factors upon which to assess the potential consequences for fauna and flora. Derived consideration levels for reference fauna and flora could be compiled by combining information on logarithmic bands of dose rates relative to normal natural background dose rates, as well as information on dose rates that are known to have an adverse biological effect. An example of what the derived consideration levels might be for a reference organism is shown in Table I.

Additions of dose rate that are fractions of the normal background would be of little or no concern, whereas dose rates higher than the background would be of increasing concern and potentially call for managerial action. One advantage of this approach is that for any given spatial and temporal distribution of radionuclides, one should be able to estimate both the relevant bands of concern with respect to both members of the public (based on Reference Man or ‘secondary’ data sets) and the environment (based on primary or secondary reference fauna and flora). These two concepts would be independent of each other although derived in a complementary manner, and they would each be

TABLE I. EXAMPLE OF POSSIBLE DERIVED CONSIDERATION LEVELS FOR A REFERENCE ORGANISM

Dose rate in one year	Likely effect on individuals	Aspects of concern
> × 1000	Early mortality	Remedial action?
> × 100	Reduced reproductive success	Assess numbers affected?
> × 10	Scorable DNA damage	Depend on organism?
Background	—	No action
< Background	—	No action

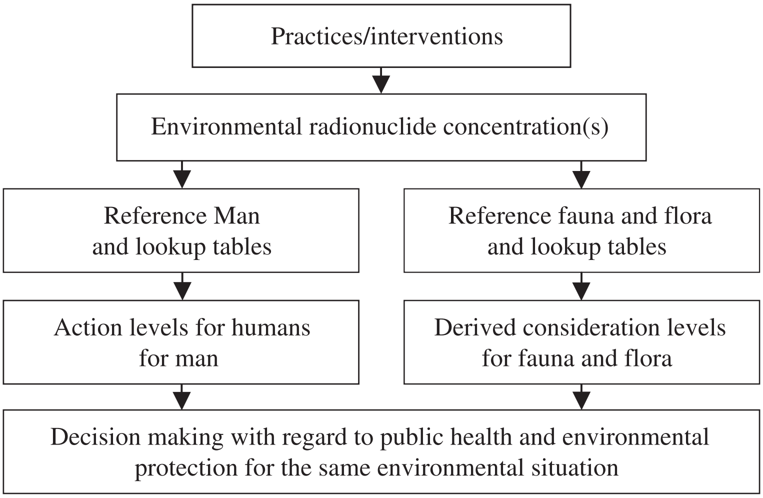

FIG. 1. Developing a common approach for the radiological protection of humans and the environment (based on Ref. [24]).

related to the same concentration of a specific radionuclide, within a specific environmental material, at any particular site (Fig. 1).

5. DISCUSSION

A systematic approach is needed in order to provide high level advice and guidance for the protection of the environment. A framework for radiological protection of the environment needs to be practical and simple in order to provide advice and guidance to help regulators and operators comply with existing legislation. Ideally, a set of ambient activity concentration levels would be the simplest tool, but in order to demonstrate transparently the derivation of such levels, the use of reference organisms would be helpful. The ICRP Task Group will therefore recommend that the ICRP, as a first step, develop a limited number of reference organisms for fauna and flora. This should include:

— A clear set of principles and objectives;
— An agreed terminology (in particular with regard to quantities and units);
— Reference dose models and related data sets to estimate exposures;
— Biological end points (effects of radiation);
— Data relevant to the needs of environmental protection;
— Guidance on the practical application of the system;
— Clear ownership and management of review and revision processes in the light of new data and interpretations.

Others can then develop more area and situation specific approaches to assess and manage risks to non-human species.

Given the speed with which radiological protection of the environment is developing, and the lack of systematic and structured approaches that have wide support, there are strong expectations from many quarters on the ICRP and the IAEA to act. These two organizations are well placed for providing guidance that could be globally accepted and that could combine radiological protection of humans and of the environment into a coherent framework. This is also reflected in the Resolution adopted on 20 September 2002, during the 10th plenary meeting of the General Conference of the International Atomic Energy Agency, where it is stated that:

> "The General Conference welcomes the steps taken by the Secretariat to assist in developing an international framework for the protection of the environment from ionizing radiation and looks forward to the International Conference on Protection of the Environment from Ionizing Radiation, which is to take place in Stockholm from 6 to 10 October 2003" [28].

The ICRP has considerable experience with the kind of foundation on which such a system of protection could be built. This would add to the credibility of both environmental protection (among those working with radiation) and the ICRP (among those working with other sectors of environmental protection). For the regulators and the industry, an ICRP initiative would increase the possibilities of demonstrating compliance with environmental requirements relating to the release of radionuclides into the environment. It would also provide advice in intervention situations on how to deal with questions relating to certain segments of the environment. Finally, it could also be used to inform stakeholders and help bring radiological protection more in line with the regulation of other potentially damaging industrial practices or of other contaminants associated with practices of interest to the ICRP.

The ICRP's system of protection has evolved over time as new evidence has become available and as our understanding of underlying mechanisms has increased. Consequently, the ICRP's risk estimates have been revised regularly, and substantial revisions are made at intervals of 10 to 15 years. It is, therefore, likely that any system designed for the radiological protection of the environment would also need time to develop, and similarly be subject to revision as new information is obtained and experience gained in putting it into practice.

It is necessary to develop an internationally agreed approach for the radiological protection of the environment. Both the ICRP and the IAEA are important organizations in terms of their role in co-ordinating and achieving an international consensus. Their main function should lie in the development of the overall framework, tools and objectives of protection, without being overly prescriptive. Detailed regulatory requirements and criteria should be developed by national authorities.

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Discussion following paper by L.-E. Holm

T. FLÜELER (Switzerland): In his presentation, L.-E. Holm spoke about the use of reference organisms in the development of a system to protect biota from the effects of ionizing radiation. Will the reference organisms be, for example, members of endangered species or members of species on which we have a lot of relevant data — such as Drosophila flies?

L.-E. HOLM (Sweden — ICRP): No, the reference organisms will be members of species which are of interest to humans because they are relevant when it comes to checking the ‘temperature’ of the environment, for example, ducks and crustaceans. We are not interested in flies or in viruses or bacteria.

T. FLÜELER (Switzerland): It seems to me that the choice of reference organisms may be a political decision, based on what species are of economic interest.

L.-E. HOLM (Sweden — ICRP): The purpose of the system, which will be a very rough one, will be to, say, help regulators to demonstrate transparently how they arrived at their conclusions about the establishment of a repository, making the value judgements clear.

PANEL

IMPLICATIONS OF THE NEW TRENDS IN DISCHARGE POLICIES FOR THE NUCLEAR INDUSTRY WORLDWIDE

Chairperson: **R.G. Holmes** (United Kingdom)

Members: **A. Simcock** (OSPAR Commission)
X. Rincel (France)
L.-E. Holm (Sweden — ICRP)
A.L. Rodna (Romania)

Panel Discussion

A.L. RODNA (Romania): Regarding L.-E. Holm's presentation, I would emphasize that in the view of the regulators in Romania, simply protecting individuals from the effects of ionizing radiation is not sufficient as a means of protecting the environment.

It is our understanding, however, that the ICRP set up the task group mentioned by L.-E. Holm for the purpose of helping regulators and operators to demonstrate compliance with already existing legislation, so we do not expect any dramatic changes regarding the discharge limits which we have now.

On the other hand, I realize, in the light of current trends and of X. Rincel's presentation, that it is undoubtedly possible to further reduce emissions to the environment. In order to do so, however, it is necessary to thoroughly understand the behaviour of the radionuclides of interest in the environment (alpha emitters differ from tritium, for example) and to bear in mind their various half-lives.

In his presentation, A. Simcock referred to 'close to zero concentrations'. It is possible to achieve close to zero concentrations in the sea, but in my view the reason for opting for trying to achieve them is simply a lack of knowledge about the effects of the discharges. That is far from what I understand by optimization; the costs associated with such an approach will be extremely high.

In Romania, there is a downward trend in radioactive discharges. We regulators are trying to promote further reductions by introducing new requirements with regard to models and to the establishment of derived emission limits, and by pushing for the application of best available techniques, but it is important to recognize our limitations.

A. SIMCOCK (OSPAR Commission): It seems to me that A.L. Rodna wished to draw attention to the problems that an OSPAR style approach could cause for the nuclear industry owing to the need for very costly measures.

If my impression is correct, I would like to recall the *Brent Spar* incident, when Shell Oil ultimately decided not to dump a disused offshore installation at sea but to decommission it, at much greater cost, on land. It decided to do so in the interests of maintaining public acceptance of its activities; the environmental benefit due to the decision was not provable. It was prepared to pay more than the prudential calculus would warrant because its expressed intention to dump the installation at sea had created public resistance to the sale of its products. Public acceptance is important also for the nuclear industry, which could learn a useful lesson from the *Brent Spar* incident.

A.L. RODNA (Romania): In the light of what A. Simcock has just said, it seems to me that the principle of optimization will no longer apply to radioactive discharges and that the entire basis of radiation protection will have to be changed.

L.-E. HOLM (Sweden — ICRP): I should like to follow on from what A.L. Rodna just said about optimization.

In most countries with nuclear power plants, the doses associated with the discharges from the plants are well below the dose constraint applying in the country in question. In Sweden, for example, the dose constraint for any nuclear installation is 0.1 mSv/a and the actual dose to the critical group is only a few per cent of that dose constraint every year. Nevertheless, Sweden's nuclear power plants top UNSCEAR's list of plants discharging activity into the environment. The reason is that, because of their locations and because of dispersion in the environment, Sweden's nuclear power plants give rise to a very low dose to the critical group. Nevertheless, it is of course technically feasible to reduce activity discharges even if they are not causing any threat to humans.

In my view, this is important in relation to the public acceptability of such discharges, including such discharges into the North Sea and the Baltic.

I think that when optimizing, we should be asking ourselves whether we have done everything reasonable to lower the present doses to humans — so as to minimize the detriment in terms of stochastic effects. What is the detriment in the case of the environment? Unless we define the detriment, we do not know what to optimize against. In that situation, use of the best available techniques not entailing excessive costs — a kind of ALARA approach — is, in my view, justified.

I think that in most countries we shall see the optimization or ALARA principle being applied more and more often in parallel with the best available techniques not entailing excessive costs.

C. McCOMBIE (Switzerland): In my view, expressions like 'prudential calculus' really mean giving in to pressure that does not have a scientific basis. What about things like risk informed regulation and intergenerational equity?

We scientists tell the politicians that radioactive discharges can be further reduced, which is what they want to hear. What they do not hear is what A.L. Rodna has been saying: radioactive discharges cannot be reduced to zero.

Bodies like the OSPAR Commission and the ICRP, unlike the OECD/NEA, do not make enough use of comparisons between ionizing radiation and other potentially harmful phenomena. I think they are wasting their time.

L.-E. HOLM (Sweden — ICRP): I do not think the ICRP is wasting its time.

In my view, if the ICRP can develop a system for assessing and managing the effects of ionizing radiation on the environment and demonstrate the scientific basis for its value judgements, we shall all be in a much better position than we are now. I believe that the lack of such a system drives discharges down unnecessarily and that such a system would help nuclear facility operators.

The ICRP does not intend that there should be dose limits for snails, frogs and so on. Its aim is a system for recognizing situations where, say, the environmental radiation exposure is much higher than normal for a certain organism, and for providing a perspective on such situations. One may well decide that there is no need to bother about them.

What I consider to be of great importance both for nuclear facility operators and for nuclear regulators is that such a system could show that the present situation is acceptable in most parts of the human habitat, since that is where we have been controlling releases.

A. SIMCOCK (OSPAR Commission): I am sorry that the expression ‘prudential calculus’ creates difficulties for C. McCombie. I have been using it as a shorthand way of describing what is, in my view, the normal way of arguing in well over 90% of cases.

The problem is that the public does not always react in accordance with the prudential calculus. For example, the public started demanding lower levels of pesticide residues in drinking water as soon as the ability to analyse drinking water substantially improved, even though there was no evidence that the previously detectable levels had an adverse impact on human health and even though reducing the pesticide residue levels was costly. Moreover, the politicians backed the public’s demand; no politician wanted to see newspaper headlines like “Minister defends pesticides in drinking water”.

I hope that with the system being developed by the ICRP, it will be easier to argue against some of the excessive demands made by the public.

A.L. RODNA (Romania): If we have to accept and live with such a system, we should be careful about how to apply it. One becquerel is one becquerel, but 1 Bq of tritium and 1 Bq of plutonium produce different health effects. So, reducing discharges to zero in terms of activity is nonsense from a scientific point of view and will cost a lot of money. If the isotope is short lived or if the beta energy is low and the health effects are low, the reduction in dose both to individuals and to parts of the environment will be small. For example, if you reduce tritium discharges from 100 Bq to 10 Bq, there will be very little benefit. In any case, if we have to spend money, we ought to understand what we are spending it on. If the total activity in, say, a glass of water is 100 Bq, of which 99 Bq are due to tritium and 1 Bq is due to strontium, you will prefer to reduce the 1 Bq due to strontium rather than the 99 Bq due to tritium.

H. FERNANDES (Brazil): I would like to ask L.-E. Holm about what seems to me to be a contradiction.

In the Opening Session, A.J. González spoke about ICRP conclusions regarding residual dose ranges. For intervention situations, there would be a range of 10 to 100 mSv/a, within which remediation would be recommended, and below 10 mSv/a probably nothing need be done.

Taking into account a new type of waste, if I may describe NORM and TENORM waste in this way, if we apply the same principles of zero emission or the concept of residual dose approaching zero in this kind of situation, would we not be setting a trap for ourselves? More and more countries are regarding NORM and TENORM as waste (this is happening in Brazil, for example, with phosphor gypsum). X. Rincel showed that the emissions from the oil industry and from fertilizer production are higher than those from nuclear power plants — even if we take into account the environmental risks. Why should we think about zero emissions from nuclear power plants into open waters but accept what can be significant doses from NORM or TENORM waste in terrestrial situations?

L.-E. HOLM (Sweden — ICRP): The ICRP is not in favour of zero dose. What I failed to stress was that in the future recommendations, the main emphasis will be on the protection of humans; that is where we have action levels. What we are proposing is a system based on a few (five to ten) reference organisms for checking the 'temperature' of a given environment, for giving consideration levels and for providing guidance on whether one needs to bother, and I do not see any contradiction in that. In the ICRP's 2005 recommendations, the dose limits will probably not change. What we are trying to add is advice on how to assess effects in the environment. I think this will prevent us from having new political requests for zero discharges.

But maybe I misunderstood your comment.

H. FERNANDES (Brazil): Perhaps the interpretation of 'zero dose' from the ICRP was a mistake by me. But there is still a lack of knowledge about the effects of low doses on humans. For example, epidemiological studies have a lot of gaps that must be filled. As far as we know, the effects of low level radiation are cancers, and if we include this environmental approach with this lack of knowledge regarding what happens to humans, we will be diverting efforts and resources to enlarge our knowledge from an area where there is a lot of knowledge to be gained to an area where there are even more things to learn. In this situation, I am afraid that we might be forced to move towards 'zero emission' policies.

L.-E. HOLM (Sweden — ICRP): There is a wealth of information about the effects of ionizing radiation on non-human organisms, but it has been used only in producing risk estimates for humans. With the system being developed by the ICRP, you could use that information after identifying a few suitable reference organisms.

The development of the present system of radiation protection began in the 1950s, and I do not think that, even without the mistakes that were made during the past 50 years, we can expect reference organisms to provide guidance for you over the next five to ten years. The guidance will be such as to help in deciding whether one need bother to even consider the effects on non-human organisms. There is no reason to fear that the system will complicate matters and ultimately lead to new dose limits.

I think that it is necessary to come up with a publicly acceptable system for assessing environmental effects. In an environmental impact assessment, the regulator or operator must, in a transparent and credible manner, make it clear how the different components are assessed — be it human beings or other parts of the environment — and, of course, different weights would be given to these things

X. RINCEL (France): I should like to add a few words about zero discharges.

A. Simcock presented the OSPAR Commission's policy as a good policy, but that is his job. In my view, the objective of zero discharges is politically bad; it is of no use where public acceptance is concerned. When we have a lot of success regarding public acceptance in France, it is not because we say that in 2020 we will be at zero level.

I made it clear that our policy is to try to get a better result, but not zero. Some OSPAR countries say that they have already gone as far as they can go and that they do not want to have better results or less discharges to the sea.

For Romania and Finland, it is not a problem at present, since they are not within the OSPAR area. If you want to implement a nuclear power plant in Finland, for example, you do not have to subscribe to the OSPAR objectives.

A. SIMCOCK (OSPAR Commission): I do not think that it is helpful to say that the OSPAR commitments constitute a commitment to zero discharges. The wording of those commitments is complicated, and one can argue about it, but the commitments are to a long term objective in terms of concentrations in the marine environment — not discharges into it — which are near background values for naturally occurring radioactive substances, and close to zero for artificial radioactive substances, with account taken of things such as technical feasibility.

The objective for 2020 is rather carefully worded: the reduction of discharges to levels where the additional concentrations above historical levels resulting from past discharges are close to zero. So it is the addition to the background that is close to zero.

Quite what that means will, I think, require a lot of discussion, but the European Commission has now put forward a proposal for ‘close to zero’ by 2020, without any of the qualifications related to technical feasibility or to additions to historical concentrations. This is for the European Union as a whole, not for the OSPAR area, and I think it is a rather different proposition.

As regards the discussion about reference organisms, I would like to point out that a reference organism approach is already being widely followed in connection with non-radioactive hazardous substances. Several countries in northern Europe are using the common mussel (Mytilus edulis) as a reference organism in studies of the impacts of chemicals and heavy metals. One measures the mussels in order to determine whether their growth rates fall short of the typical growth rates for different levels of nutrient in the water. If their growth rates fall substantially short of the typical ones, that may well be due to high concentrations of chemicals or heavy metals.

Reference organisms can be a means of showing that there are problems, but also a means of showing that there is no need to worry. In the nuclear field, there are at present no easily understood yardsticks that can be used in conveying risk levels to the public, and I think that negative public reactions will become stronger and stronger unless reassurance of some kind is given. My main point is not that the OSPAR approach is a good thing, but that a solution must be found to the problem of persuading the public that nuclear power is a good thing.

A.W. van WEERS (Netherlands): If I understand it correctly, L.-E. Holm’s reasoning is that application of the ALARA principle to discharges from nuclear power plants and other nuclear installations has reduced the discharge levels to the point where, as far as protecting humans is concerned, there are no good reasons for trying, at very great expense, to reduce them further — but then we ‘discovered’ the environment, with non-human biota about which we know very little and must therefore be very careful, further reducing discharge levels after all.

In my view, it is only reprocessing facilities — in Europe, Sellafield and La Hague — where discharges into the marine environment could lead to exposures higher than those which Mother Nature gives rise to. However, the levels of the discharges from Sellafield and La Hague have been reduced substantially over the years, and we have learned quite a lot about the exposures of non-human organisms inhabiting the marine environment near those two facilities — because we enjoy eating mussels and so on. In fact, radioecology research relating to Sellafield and La Hague had declined during the past three decades because there is not much of significance left to be learned. So what threat would be avoided by very expensive further reductions in discharge levels for the purpose of protecting non-human biota near those two facilities?

L.-E. HOLM (Sweden — ICRP): The ICRP Task Group does not believe that, because we do not know much about many non-human organisms, we have to be extra careful. What it does believe is that the environment of the human habitat has probably been well protected by the present system of radiation protection and that we need to be able to demonstrate this convincingly to stakeholders. That does not mean that we must reduce discharge levels in order to protect the environment — far from it.

A.W. van WEERS (Netherlands): I am pleased to hear that.

L.-E. HOLM (Sweden — ICRP): Let me emphasize that we need a system capable of showing to what extent a particular environment is being protected and whether the legislation is being complied with. It is not a question of reducing discharge levels.

A.W. van WEERS (Netherlands): What should we do pending acceptance of the system being developed by the ICRP Task Group?

L.-E. HOLM (Sweden — ICRP): A number of countries, for example, Canada, France, the Russian Federation and the United States of America, have decided to develop their own systems in the absence of an internationally accepted one. In Sweden, we will probably wait until the ICRP Task Group has completed its work.

In that connection, I think that the IAEA could usefully do work on identifying suitable reference organisms, as the ICRP Task Group's system will be based on only five to ten organisms.

R.G. HOLMES (United Kingdom): I believe the IAEA is now focusing more on radiation protection of the environment rather than simply of humans.

G. LINSLEY (IAEA): The IAEA currently sets discharge control levels based on the radiation protection of humans, but we have begun considering how to set such levels for the protection of the environment as a whole.

Something that puzzles me in this connection is the fact that environmental levels close to zero are being set within the OSPAR framework, apparently on the basis of the wishes of society. But what is 'society' in this environmental context? Is 'optimization' being reinterpreted? IAEA Safety Standards specify particular criteria, but for non-technical reasons the criteria actually being applied in IAEA Member States are orders of magnitude lower than those proposed by the IAEA. That is both puzzling and troubling.

A. SIMCOCK (OSPAR Commission): I do not find it so puzzling.

The people working in the radiation protection field have been convincing one another of the effectiveness of their standards, but not the general public, which reacts strongly — and, in the opinion of the experts, irrationally — to reports about things like BSE and radioactivity. Better public education regarding risks would be helpful in this connection, but I doubt whether it would lead to everybody thinking in terms of the prudential calculus.

Radioactivity has for a long time been treated differently from, say, chemicals, and many people believe that it is treated differently because the risks associated with it are extremely great — greater than they really are. Such people demand levels of protection that are not justifiable on a prudential calculus basis.

In order to convince the general public, it may be necessary to expend a great deal of effort, as in the case of the *Brent Spar* incident, to which I referred earlier.

C. McCOMBIE (Switzerland): A. Simcock spoke about the newspaper headline "Minister defends pesticides in drinking water" which no politician would like to see. Why, in connection with the *Brent Spar* incident, were there no headlines like "Decision to risk the lives of humans on shore rather than the lives of fish in the sea"? We technical people should be trying to help ensure that the right messages are conveyed to the general public. For example, rather than yielding to pressure which has no scientific basis, we should be saying that radioactivity is well understood — unlike, say, the link between BSE and Jakob-Creutzfeldt disease. I do not think that the reference organisms which L.-E. Holm spoke about will be very helpful in that connection.

B. FROIS (France): I agree with C. McCombie that technical people should not yield to pressure which has no scientific basis.

Working in the French Ministry for Research, I see the attitudes prevalent in the nuclear industry and those prevalent in, for example, the chemical industry, and it is clear to me that the people in the nuclear industry care about the risks associated with that industry to an unparalleled extent.

Our civilization involves risks, no matter how careful we are, and those risks should be calibrated. The risks associated with the nuclear industry are far from being the greatest risks which we face, but the general public does not know that.

G. COLLARD (Belgium): I am in favour of keeping radioactivity releases as low as possible throughout the nuclear fuel cycle. However, the radioactivity that is not released will ultimately end up in a radioactive waste repository — a nuclear facility that will itself release radioactivity. If people become convinced that zero releases are possible and necessary during the pre-disposal stages of the nuclear fuel cycle, they will reject the idea of building a repository because they know that the repository will release some radioactivity.

L.-E. HOLM (Sweden — ICRP): Radiation protection is based on science, but the risk assessments are value judgements. When talking with the public about radiation risks, we should, in my view, be more ready to acknowledge that "here is a scientific conclusion, but here is just a value judgement".

G. LINSLEY (IAEA): I should like to hear from A. Simcock whether he believes that OSPAR type thinking will spread to parts of the world beyond the countries and the zone covered by the OSPAR Convention.

A. SIMCOCK (OSPAR Commission): In the light of what has happened in the context of the London Convention, and given the global nature of certain campaigning organizations, I think that it will spread. Some of the arguments which I have had in the OSPAR context are mild compared with some of those which I have heard being put forward by countries of the South Pacific region.

G. LINSLEY (IAEA): In your presentation, you spoke about 'zero environmental levels'. Does what you said apply also to non-radioactive contaminants?

A. SIMCOCK (OSPAR Commission): Yes, it does.

There is now a tendency for radioactivity to be regarded as just one of many reasons why substances may be considered dangerous, and the OSPAR approach to non-radioactive hazardous substances is the same as the OSPAR approach to radioactive substances. As regards non-radioactive hazardous substances, the long term OSPAR objective is to prevent pollution of the marine environment by continuously reducing discharges, emissions and losses, with the ultimate aim of achieving concentrations in the marine environment near background values for naturally occurring substances and close to zero for synthetic substances — almost verbatim the long term OSPAR objective with regard to radioactive substances, without the qualification about technical feasibility being taken into account. The idea is that every effort should be made to bring about a cessation of discharges, emissions and losses of non-radioactive hazardous substances by 2020.

In my view, those belonging to what one might call 'the radioactive discharge community' should pay close attention to what is happening in 'the hazardous discharge community'.

S. St-PIERRE (France): With the OSPAR process leading to zero or near zero discharges of radioactive substances, admittedly with qualifications about technical feasibility, what will happen if an OSPAR country now wishes to build a nuclear power plant?

A. SIMCOCK (OSPAR Commission): In my view, that is a matter of the balance between a country's international obligations and the right of that country to determine its own energy policy. The OSPAR mechanism is a means of striking that balance through negotiations among the countries concerned.

LONG TERM STORAGE OF RADIOACTIVE WASTE

(Session 3)

Chairperson

A. NIES
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LONG TERM WASTE MANAGEMENT
Historical considerations and societal risks

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Abstract

In the past decade, the concept of deep geological disposal of radioactive waste has been revised. The following paper presents the state of discussion on radioactive waste disposal strategies in the deep geological formations and at surface facilities. It considers ethical, social and technical criteria, and shows the advantages and weaknesses of the different concepts. Based on a discussion of methodology, the predictability of models — and, therefore, of waste disposal or storage strategies — is discussed, for natural as well as for social systems and for different periods of prediction. Historical considerations about the resistance and durability of materials or structures as well as about the breakdown of structures by natural or social events shows that the safety of human-made structures is less influenced by natural catastrophes than by social effects. Finally, the paper discusses the concept of monitored long term geological disposal (the EKRA concept) developed by a commission of the Swiss Federal Department of Environment, Transport, Energy and Communication in order to assess the advantages of a deep underground repository and monitoring of the repository site. The combination of definitive disposal and deep underground monitored waste disposal sites should ensure a safety optimum of the disposal facility and provide better acceptance of disposal projects.

1. THE PARADIGM OF SOCIETY'S RESPONSIBILITY FOR MANAGING ITS WASTES

During a few decades — more or less between the 1960s until the mid-1980s — the concepts of radioactive waste disposal were broadly accepted by the scientific community in charge of the search of solutions, as well as by society as whole. Worldwide, the countries dealing with nuclear energy focused their efforts in the field of nuclear waste elimination on deep underground repositories. At that time, geological formations were conceived as being the best available to guarantee safety over long periods of time. No major doubts were formulated and the social consensus seemed to have been attained.

Doubts progressively emerged in society, especially in the context of the opposition to nuclear power generation. The needs for safe and long term solutions for radioactive wastes were quickly seen to be one of the basic items in the dispute about nuclear energy. In this debate, the complexity of the deep geological underground became apparent. The scientific companies in charge of waste dossiers had to admit that the efforts to prospect the deep underground had been underestimated, and that the geological architecture and the processes inside these structures were effectively much more complex than originally expected. This insight shook the confidence both of the public and especially of critical groups. The planning and exploration work of the companies in charge of the scientific work started to be questioned, and the ability and even possibility of predicting future events — and therefore long term safety of deep underground repositories — were totally dismissed. The unresolved disposal problem became a welcome tool for the anti-nuclear movements in order to stop the nuclear power energy development.

It was understandable, in this political context, that the management of nuclear wastes was re-evaluated. Older strategies, refuted by former experiences as mausoleums and socially controlled long term storage of wastes, re-emerged and were reintegrated under the pressure of public opinion in the strategic planning of waste management programmes of the nuclear industries. The discussions surrounding these topics went so far as to bring up classic debates on the quality of scientific work. At last, basic questions were addressed on the possibility of understanding the scientific knowledge, methods and progress. These debates were old and known even in the philosophical debates about the pursuit of truth since antiquity. Some of the major aspects of this debate on seeking scientific truth, and the ability of making prognostics, are outlined in the following sections.

2. SOME THOUGHTS ON THE RELATIVITY OF KNOWLEDGE

Saint Augustine, one of the most eminent Christian bishops and philosophers of late antiquity, had a broad impact on thinking throughout the Middle Ages. His contribution to the philosophical debate on knowledge was founded on a closed and irrevocable system conceived from the Holy Scriptures. Some 1100 years before Descartes, Augustine raised the question of the status of human knowledge in an only partially understandable, rational world. In contrast to Descartes, who shaped the modern rational and cognitive approach to science through his famous ‘cogito ergo sum’, Augustine believed that absolute and definitive truth was only possible through a spiritualized relation to the Lord. The materialistic, exterior world, he claimed, is a world of illusion, doubt and error. ‘Si enim fallor, sum’: ‘If I am wrong, I am’, is the shortened form of this insight [1].

With this conception of the world, Augustine had taken up the world view of antiquity, as manifested by sophist and sceptical thinkers [2, 3].[1] However, Augustine reinterpreted these findings in a different metaphysical way. Doubts and errors were confined to this earthly world and were the proof that real knowledge needed faith: 'Believe to see (know), see (know) to believe' [4].

Even though these reflections were developed from different perspectives, Augustine's approach to the status of reality or knowledge is applicable today. The debate on scientific progress and epistemology started many decades ago, and revolves around questions such as the objectivity of perception, and the influence of 'faith' on 'truth'. Particularly in social sciences, doubts arose on the objectivity of perception and led to a reconsideration of the scientific methodology behind the search for 'truth'. Even in the fields of natural sciences and the history of science, the positivistic scientific approach [5] was questioned. Doubts even went so far as to dismiss the existence of ultimate scientific 'truth'. However, what revealed itself more and more visibly was that the terminology of science was not adequate as a sole guarantee of objectivity. T.S. Kuhn, for example, showed in his study [6] that the changing process of theories and their evidence ('paradigms') is characterized by a continuous shifting of terminology, and relies therefore on different and changing perceptions. Karl Popper[2] argues in a similar way: knowledge is not a result of a systematic process of perception which comes from separate observations, leading to the development of more and more general and universally valid natural laws. Knowledge, as established in laws and theories, remains, in fact, incomplete and uses or processes only a (very) limited part of the available information, which can furthermore be interpreted in different ways. Therefore, knowledge simply reflects the knowledge of a period (and culture). However, these approaches do not question the reality concept of the world [7].[3]

In contrast to this conception of rational science, doubts have been formulated about the basic methodology used in the process of accumulating scientific knowledge. P. Feyerabend, for example, stated that knowledge was not a succession of theories free of contradictions, which converge towards an ideal theory, nor is it a gradual convergence towards 'truth'. It is merely a growing 'sea' of incompatible and even incommensurable alternative theories [8]. Modern constructivism is even more radical. The basic tenet of the different

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[1] See, for example, the theorems of Protagoras, Gorgias, Pyrrhon of Elis, Sextus Empiricus in C. Helferich [2]. Also, the specific 'rationalism' of Greek philosophers is well described by E.R. Dodds [3].

[2] K. Popper, "Logik der Forschung" in C. Helferich, Ref. [2] 386.ff.

[3] D.L. Hull [7] comments on the wide perceptions and reactions of the work by T.S. Kuhn, see Ref. [6].

constructivist currents is that knowledge is just a construction or creation of the observer and reflects, therefore, the observer's subjective perception of the world [9, 10]. Radical constructivists even go so far as to question the term and concept of reality, replacing it with an image of absolute relativity of perception, and therefore of knowledge [11, 12].[4]

3. A METHODOLOGICAL APPROACH IN THE FIELD OF NUCLEAR WASTE MANAGEMENT

It is not the aim of the present exposition to start an epistemological discussion on the extent to which the positivist approach to the process of accumulating scientific knowledge can be brought into accordance with the constructivist image of created and subjective universes. In the context of nuclear waste management, however, questions arise as to which scientific methods should and could be used in order to promote the progress of knowledge, and to what extent methods of scientific prediction based upon this traditional knowledge process can effectively be developed and applied. The use of these methods is of great concern, because scientific and political decisions of great impact depend on them.

What should rather be focused on, in the context of nuclear waste management, is the search for and increase of adequate knowledge by the elimination of inconsistent methodologies, theories and/or strategies. In this sense, Popper's approach on falsifiability is very useful. This approach rejects the way of seeking 'truth' by a process of increasing generalization of individual cases or empirical findings (induction), replacing it by a process of refutation or disproving of acquired knowledge (falsifiability), leading in this way to a gradually more precise description of 'truth'. Lakatos's proposition for the evaluation of scientific research programmes, including a characterization of their progression, stagnation or degeneration, aims in a similar direction. This approach is particularly interesting in the present context because he includes 'disputes between advocates of different research programs' [7], which also means of different ideological currents.

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[4] See Ref. [12]: "May be that biologists and science theorists will criticise me, but in my opinion the radical constructivism is right when he states: What research is telling us, is what reality isn't." (Translation by M. Buser: "Möglicherweise werden mich die Biologen und Wissenschaftstheoretiker kritisieren, aber ich bin der Meinung, dass der radikale Konstruktivismus recht hat, wenn er sagt: Was uns die Forschungen erklären, ist, was Wirklichkeit nicht ist.")

A final methodological element often employed by constructivism may complete our methodological tools. By reviewing the results of confrontations of different scientific (or non-scientific) conceptions, the process of fitting perception, knowledge or data to theoretical findings ensures a critical approach — as a key fits, or does not fit, a lock.

4. WASTE MANAGEMENT STRATEGIES

An analysis of the very extensive literature on nuclear waste management strategies since the end of the 1940s shows a strange convergence of concepts for the ultimate disposal of radioactive wastes (see Table I). Numerous strategies were suggested and applied at the beginning, such as sea dumping, dilution of radioactive sludges in sea, seepage of liquid wastes in ponds and pits (e.g. ORNL, Hanford), or injection into decommissioned oil wells. The possibilities of controlled long term storage for indefinite periods of time (e.g. mausoleums, surface disposal in prohibited arid areas) were also explored but were later mainly dismissed by the nuclear scientific community [13].[5] Options such as transmutation and space disposal appeared after reprocessing became available and the Soviet Sputnik circled around the world. However, the evaluated strategies soon converged towards ultimate geological disposal in continental formations or under the sea-bed.[6] All rock formations proposed for this purpose in the early stages of research (clays, evaporites, crystalline rocks, tuffs) are still undergoing detailed study. However, the sub-sea-bed option has been abandoned due to problems related to international law, long term protection of the oceans and public acceptance.

Despite the considerable progress made in the last two decades in the study and realization of deep underground repositories, long term storage strategies, involving monitoring over thousands of years, recently re-emerged at the end of the 1980s. Initially, the rebirth of this controlled storage strategy was promoted by various schools of thought which can be brought together under the heading of 'nuclear guardianship'. Originally supported mainly by Green movements with strong mystical and romantic roots, the idea of guardianship quickly gained popularity, and was later — and for other reasons — taken over by strong political movements, such as Greenpeace [14].

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[5] Some later publications were exceptions, for example, see Ref. [13].

[6] This was an option raised in early 1950s by Woods Hole Oceanographic Institute, USA, and later picked up by the sub-sea-bed disposal programme under the leadership of Sandia Laboratories, Albuquerque, USA.

TABLE I. DISCUSSED OPTIONS OF NUCLEAR WASTE MANAGEMENT THROUGH THE DECADES IN AVAILABLE LITERATURE

	HLW/TRU	LLW/ILW
Dispersal	*Dispersal in oceans under special conditions (Glueckauf, 1955)*	*Releases in air and water (different authors, since end of 1940s)*
Partial containment	*Disposal in deserts or special zones (Glueckauf, 1955)* International prohibited areas (WHO 1956)	*Sea dumping in canisters or drums (different authors, since end of 1940s)* *Continental disposal (different authors, since end of 1940s)* *Burial of wastes (different authors, since end of 1940s)* *Seepage of liquid waste streams in pits, trenches, cribs, ponds, basins (different authors, since end of 1940s)* *Injection in wells (different authors, since end of 1940s)* *Grout injection (ORNL, 1966)*
Containment	Controlled long term storage for indefinite periods of time: 'mausoleums' (Forrest 1948) *Calcination vitrification/ceramics, etc. (different authors, since end of 1940s)* *Disposal in deep geological formations (different authors, since early 1950s)* *Sub-sea-bed disposal (Evans 1952)* *Oceanic trenches (Renn, 1955)* *Disposal in Antarctica ice (Philbert, 1959)*	Controlled long term storage (different authors) *Disposal in caverns (different authors, since 1950s)*
Others	**Transmutation (HLW)** **Space (HLW)**	

Italic text indicates strategies based on passive safety measures.
Bold text indicates special options relying on exceptional technical applications.
Regular type indicates strategies based on the active participation of society.

Parallel with these movements, similar strategies were reintegrated in the evaluation of major nuclear waste management programmes (in the United States of America, Canada, France). The French programme [15], established by a law adopted in 1991 (loi Bataille), is based on the following three strategies which will be followed officially until 2006:

— Underground disposal, relying on passive safety systems;
— Long term storage, relying on the active participation of society;
— Transmutation.

Similar programmes are running in the USA and Canada. This evolution is a result of growing public concern about the previous policies of nuclear waste management by the implementing organizations, which are increasingly experienced as too narrow. However, it is questionable whether the broader, redefined programmes will really be able to achieve more acceptance than those based solely on ultimate disposal. Acceptance not only depends on the quality of scientific programmes: it is also strongly influenced by a different risk perception in industrial societies, as well as by contradictory technological and political outlooks [16].

5. CONSIDERATIONS ON ETHICS AND IDEOLOGY

It is precisely a several decade old conflict related to the peaceful use of nuclear energy that weighs heavily on the programmes for waste disposal. Effectively, debates on nuclear waste management have replaced the older conflicts centred on nuclear energy production, since power plant construction has practically ceased. For more than a decade, the struggle between supporters and opponents of nuclear energy has turned around the future of nuclear technology. The whole nuclear fuel cycle, in general, and radioactive waste management, in particular, are used as a pledge by opponents in order to scotch as quickly as possible the nuclear ‘adventure’. The key argument is that the problem of nuclear waste disposal is not resolved, never will be resolved and, indeed, cannot be resolved. Green movements conjure up in dark colours the risks of underground disposal, the lack of knowledge in geology and hydrogeology, the weakness and even impossibility of modelling and predicting the future and, therefore, the irresponsibility of all nuclear power programmes. Many lament the fate of humanity, conjuring up the enormous burden that the present generation will transmit to its descendants for thousands of years to come [17]. The absoluteness of these public declarations recalls older statements from the promoter side in the 1970s and early

1980s, when the question of nuclear waste disposal was declared categorically as having been resolved [18].

Often, the different stakeholders involved look upon such statements as representing ethical viewpoints on how to manage the problem. However, modern ethics does not include moral attitudes as to what is 'good' or 'bad', but aims at defining what is more or less 'just' within a broader and more complex social system, including present as well as future generations (IAEA). In this context, questions must be addressed about the ethical content, both of the current waste management strategies, and of the long term surface storage of radioactive wastes supported by the opponents of current practices. Is it acceptable on an ethical basis to burden future generations with a problem considered to be scientifically insoluble by promoting a socially controlled risk system? Are social structures really prepared to take over responsibility in order to ensure the required radiological protection over the involved time spans? What conclusions can be deduced from historical knowledge and analyses about the possibilities of safe storage over hundreds and thousands of years and as a long term source of risk to society? And what are the technical requirements and economic impacts of the considered strategies of long term storage?

As indicated above, no scientific method exists for reaching 'truth', and the search for knowledge is to be considered as a step by step process leading gradually to a better understanding of 'reality'. In this process, inconsistent knowledge should, as far as possible, be eliminated. Comparative analyses of contradictory theories, facts or plans can help to identify and select less diverse or problematic conclusions or no-go issues. Within this context, some crucial points should be considered in order to evaluate the feasibility of the debated strategies for nuclear waste management. Of particular interest are the following four points:

— Methods and problems of prognostics in relation to complex systems;
— Problems related to the ideological status of radioactive waste;
— The way in which societies have dealt with ideological items historically;
— Questions related to technical robustness and technical development.

6. PROGNOSTICS IN RELATION TO COMPLEX ENVIRONMENTAL AND SOCIAL SYSTEMS

As already mentioned, the strategy of long term surface storage is based on the assumption that developing a geological system which is sufficiently safe is inherently impossible because of the unreliable nature of scientific prediction. Following this thread of argument, the question must be raised whether the evolution of social systems can be predicted more reliably in order to ensure safe long term storage over the involved time spans. Simple considerations about system dynamics and the scales of movements in different media show that movements in the lithosphere are generally many orders of magnitude smaller than those in the atmosphere, hydrosphere or biosphere (Table II). If the rates at which processes occur are linked to the reliability of predictions, it soon becomes clear that social developments can, at best, be predicted over periods of the order of a few decades (Table III). Looking back over the last decade, some major, unforeseen social and economic events or changes become evident, such as the fall of the Soviet empire, the spread of Islamic fundamentalism and terrorist attacks, or the crash of the 'New Economy' in the past year — all events which were not predicted by the involved systems. Contrary to the tenets of dialectical materialism, the future of society is neither controllable nor predictable in the long term and it is clear that social evolution is considerably more uncertain than geological change occurring — at the quickest — on scales less than a few centimetres a year. These simple reflections should be sufficient to eliminate definitely the strategy of long term surface storage of radioactive waste, controlled by society. In addition, as shall be seen in the following discussion, surface storage increases the attractiveness of waste and therefore the risk of mismanagement.

7. PROBLEMS RELATED TO THE IDEOLOGICAL STATUS OF RADIOACTIVE WASTE

Three major sources of interest — and therefore of potential misuse — exist in relation to radioactive waste. The first is related to the high risk of the waste itself. In fact, there is a pronounced ambivalence in modern societies between the perception of danger and risks and the way the problems of risk management are tackled politically. Influential movements in Western industrial societies are opposed to the proposed solutions of underground disposal, and create a climate of distrust in which waste management is styled as an insoluble problem. Through this policy, defence positions of local opposition movements ('Nimby' attitudes) are not only reinforced, but a general attitude towards risk perception is also generated in order to be used as a political instrument and as a pledge against nuclear power generation. These linkages completely mask the real nature of the scientific problem and support an ideological, and sometimes even mystical [17], approach to dealing with waste management options. As will be seen, this ideological component is a major source of concern when socially controlled strategies of waste management are considered. It can be foreseen that waste storage, and even disposal projects,

TABLE II. RATE OF CHANGE FOR TYPICAL EVENTS IN NATURE

	Subsystem	Event	Speed of movement (approx.)			Relationship (factor)
'inhabited' nature	Air	Zephyr	1 km/h	0.3 m/s		10^6
		Storm	150 km/h	40 m/s		10^8
	Surface water	Torrent		1 m/s		3×10^6
		River (e.g. Amazon)		0.1 m/s		3×10^5
	Groundwater	Flow velocity, for example, in the gravels of a river valley or along a fast flowpath in fractured rock (Molasse)		$> 1 \times 10^{-5}$ m/s	> 3 m/d	30
		Flow velocity in fine-grained sediments		3×10^{-7} m/s	10 m/d	1
		Diffusion in clays		$<3 \times 10^{-10}$ m/s	< 1 cm/a	$< 10^{-3}$
	Lithosphere	Plate tectonics, orogeny		3×10^{-10} m/s	1 cm/a	10^{-3}
		Isostatic movements (Alps)		3×10^{-11} m/s	1 mm/a	10^{-4}
		Erosion (Alps)		3×10^{-11} m/s	1 mm/a	10^{-4}
Inhabited world	Biosphere	Worms in earth		1.5×10^{-4} m/s	1 cm/min	5×10^2
		Fish in water		0.1–1 m/s		3×10^5–3×10^6
		Bird flight	50–300 km/h	10–80 m/s		3×10^7–2×10^8
	Human	Walking	4 km/h	1 m/s		3×10^6
		Cycling	40 km/h	10 m/s		3×10^7
		Car	100 km/h	25 m/s		10^8
		Flying	800 km/h	220 m/s		10^9

TABLE III. PREDICTABILITY IN TIME OF NATURAL AND SOCIAL EVENTS

Events		Period of prediction							
		Minutes to hours	Hours to days	Days to weeks	Weeks to months	Years to decades	Decades to centuries	1 000 years to 100 000 years	100 000 years and more
Natural events	Global climatic evolution	Predictability high					Trends recognizable?	Uncertain to speculative	
	Weather prediction	Predictability high to average			Uncertain to speculative				
	Earthquake magnitude in various risk zones	Predictability high						Relatively high	Average to uncertain
	Time of occurrence of an earthquake	Predictability average to low			Uncertain	Speculative			
	Groundwater circulation at specific locations (deep groundwater)	Predictability high						Average	Trends recognizable to speculative
	Impact of a comet the size of the Arizona meteorite	Predictability high					Relatively high	Average to uncertain	Speculative
Social events	Possibility of changes in the European political system	Predictability high				Average to	Speculative uncertain		
	Tendencies in development of new technologies	Predictability high				Average to uncertain	Speculative		
	Tendencies in development of pardigms (political, ideological, religious)	Predictability high				Average to uncertain	Speculative		

will be subject to extremely close vigilance by some interest groups and that the hundred eyes of Argos will be kept on them, even after repository closure. Public unrest will probably remain at a high level as long as fear and inquietude exist, and as long as major interest in reusing the wastes is still alive.

Precisely the latter point is a second and third reason for concern: the potential for use and misuse. The potential reusability of spent nuclear fuel may keep awake the interest of technically highly developed societies in radioactive waste in the future — not only as a valuable resource (future use), but also for military reuse or terrorist aims (future misuse). From the point of view of long term safety, it is evident that closed deep underground repositories are much better shielded against misuse than long term surface storage facilities. As history shows, high risks of misuse will remain, as long as economically or strategically valuable resources are under direct social control. Even for the deep underground facilities, these dangers must be kept in mind. It would be recommended to reanalyse — as proposed by R. Dautray — the options of the reuse of fuel [15] prior to waste disposal, and to reinforce the reflections made by the OECD/NEA on this topic [19]. As long as some use is still available for the waste, waste facilities will be a focus of interest in the concerned societies.

However, of the three potential sources of misuse, the first is probably the one which is the more difficult to deal with. Fundamentalistic world conceptions are particularly susceptible to undifferentiated violent eruptions and may cause major harm when considered with dangerous technologies.

8. HOW SOCIETIES HAVE DEALT WITH IDEOLOGICAL ITEMS IN HISTORY

The destruction by the Taliban Government in 2001 of the 2000 year old Bamian Buddhas in Central Afghanistan, and the older cultural heritage in general, shocked enlightened opinion in Western industrialized countries. However, voluntary devastation of this type has been a feature of fundamentalist ideological movements throughout history and in many parts of the world. The basic aim of such movements is to blur methodically the cultural and religious identity of dissident world conceptions. In this sense, the Holocaust is — until now — the best organized attempt to destroy cultural heritage and the identity of several nations. This example also shows that such developments are still possible in the so-called civilized world, if economic or political conditions lead to major social crises.[7]

[7] There is a newly emerging historical discussion on the extensive surface destruction of civilian targets in Germany by allied forces at the end of World War Two.

Looking back in history, similar attitudes of fundamentalist or autocratic governments, movements and groups become evident in their attempt to impose the 'good way' in this very bad world [20, 21].[8] Historical analyses support the conclusion that conflicts with high ideological and unilinear content lead, very often and in a very specific way, to the destruction of the ideological and cultural background of the defeated parties. Some examples can serve to illustrate these conclusions. The cultural and religious identity of antiquity was voluntarily destroyed by upcoming Christianity towards the end of the fourth and the beginning of the fifth centuries. With some exceptions, most of the temples and the religious and cultural identities of the Roman Empire were razed to the ground in a time span of only a few decades. Similar devastation can be observed during the advance of Islam in the seventh century, in the southern and eastern parts of the Mediterranean basin, and later — in the opposite direction — after the Reconquista of southern Spain and Portugal by the autochthonous Christian kingdoms. The same methods were applied in the conflicts between Protestants and Catholics — as we can see in the England of the 17th century.

In contrast to this destruction, more or less stable ideological conditions during the Middle Ages can be observed in the major European continental areas. Roman and Gothic buildings have mostly been preserved, which means that the threshold of ideological clash was not reached during this epoch. However, even such long periods of ideological 'continuity' should not lead us to construct stable worlds and 'ends of history'. History remains unpredictable — contrary to the tenets of Hegelian or dialectic materialistic conceptions.

Technology and technical development — and in the present context, the management of radioactive wastes over long storage periods — should be conceived from this viewpoint. The time dependant societal risks over longer historical periods, with changing technologies and under different economical and political regimes, must be evaluated in order to ensure a complete safety analysis. Precisely these societal risks are a major source of worry because there is no way of predicting the development and the future of societies. Only a look backwards can give some information about what can be expected in major and minor crisis situations.

9. TECHNICAL ROBUSTNESS AND TECHNICAL DEVELOPMENT

The long term societal impact of radioactive waste management has been recognized and discussed for many decades [22]. That was precisely the reason

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[8] See the large classical literature in this context; some examples are listed in Ref. [20].

why attention was focused on deep underground disposal, and why surface storage options and strategies were quickly dropped. The need to keep communication structures active over time spans of hundreds, thousands, even tens of thousands of years, and the unusual technical and economic challenges and burdens of such plans, make it illusory to guarantee the required levels of societal, technical and financial continuity needed for these purposes. Robustness of a long term effective management system for radioactive waste implies that simple and stable conditions be established and maintained — which cannot be attained in a dynamic societal process. Once more, history provides striking arguments to refute safety systems based on long term active measures and plans. No or little experience exists for the management of reparation and long term monitoring funds. No prognostics are available for long term technical expenditures and the associated long term costs. Even the remaining buildings or infrastructures of antiquity, constructed with durable materials and still in operation today — such as Porta Nigra in Trier, the Pantheon in Rome, or Segovia's aqueduct — have had to be maintained and repaired continuously.

Rough calculations made for this purpose in connection with some Swiss municipal waste landfill projects showed that considerable financial reserves must be built up in order to fulfil the legal requirements of safety[9] — and this only for some decades. Other calculations have been done for the technical maintenance and the replacement of defect installations (such as drainage systems, leachate control, reparation of cover, etc.), as well as the costs due to these operations.[10] The results have been disappointing, with the expected life span of these elements varying from several decades to several hundreds of years at best, and with long term costs exploding (see Table IV). Additionally, the acceptance of such long term financing systems would first have to be demonstrated.

Technical progress must clearly be included in this type of consideration, although there is a major difficulty in predicting the direction and speed of technical and technological developments, even over small time spans (see Table IV) [23]. Furthermore, there are no indications that revolutionary new technologies for radioactive waste treatment or encapsulation are underway, which could change the scope of waste management strategies. On the contrary, since the beginning of radioactive waste management, there has been a step by step optimization of procedures and technologies to ensure the required radioprotection standards in waste disposal programmes. From whichever point of

[9] Of the order of millions to dozens of millions of euros for 50 years (Canton of Zurich) and up to 25% of the investment costs for a time span of 100 years.

[10] Calculations done for the Oberholz landfill project, Suhr, Aargau.

TABLE IV. EVENTS IN PAST SOCIETAL DEVELOPMENT AND POSSIBLE FUTURE EVENTS IN WASTE DISPOSAL

Future event	Time (years) (start at year 2000)		Event in the past
End of functioning of drainage systems of a conventional waste disposal site (reactive waste site in Swiss TVA classification)	100	-100	• Technology: first offshore drilling in search of hydrocarbons • Physics: beginning of quantum theory • Biology: rediscovery of the experiments of Gregor Mendel • Philosophy: death of Friedrich Nietzsche • History: Evans discovers the palace of Knossos (Minoan culture, Crete)
Time span of risk evaluation of a conventional waste disposal site (example of municipal waste dump of Riet, Winterthur)	200	–200	• Technology: electrolysis with galvanic battery (Nicholson/Carlysle) • Physics: W. Herschel discovers infrared radiation • Medicine: first use of chlorine to disinfect water (W. Cruikshank) • History: directorate (consulate) of Napoleon (1799–1804)
Probable end of functioning of engineered barriers of a conventional waste disposal site (reactive waste site in Swiss TVA classification, locations of Oberholz, Suhr AG and Feldmoos, Niederhasli ZH)	400	–400	• Technology: construction of a first armored warship by the Korean Admiral Vinsunsin • Physics: William Gilbert claims that the earth is a spherical magnet • History: Giordano Bruno is burned to death in Rome
Radiation protection criteria for disposal sites for short lived LLW fulfilled	500	–500	• Technology: Leonardo da Vinci develops the concept of the helicopter • History: Cabral discovers Brazil (Porto Seguro)

TABLE IV. (cont.)

Future event	Time (years) (start at year 2000)		Event in the past
End of functioning of engineered barriers of a waste disposal site (reactive waste site in Swiss TVA classification, locations of Oberholz, Suhr AG and Feldmoos, Niederhasli ZH)	800	–800	• Technology: new generation of mills developed by Cistercian monks • Mathematics: introduction of number 0 by Chinese mathematicians • Philosophy: death of Averroes • History: preparation for 4th crusade
Ion exchange capacity of underground environment exhausted for the compartment for reactive wastes (example: waste disposal site of Feldmoos)	2 500	–2 500	• Technology: production of steel (India) • Mathematics: death of Greek philosopher Pythagoras • Geology: Greek philosopher Xenophanes of Kolophon describes fossils (Fragment 5) • History: Greek-Persian wars (Marathon, Xerxes etc.)
Ion exchange capacity of underground environment exhausted for the compartment for inert wastes (example: waste disposal site of Feldmoos)	30 000	–30 000	• Upper Paleolithic: uses of line marks (groups of 5) for counting (cattle)
Time span of isolation needed for HLW repository, orders of magnitude	100 000 until 10E6	–100 000 until –10E6	
Isolation time span for an underground disposal site for industrial chemical wastes (e.g. salt mine of Herfa-Neurode, Germany)	?	– ?	

view long term storage is considered, the required robustness of a durable technical, environmental, economic and political handling is, at the moment, neither proven nor expected to be [24]. Hence, there is no technical, economic or political reason to question again the general policy aim that radioactive garbage should not be bequeathed to future generations, as Weinberg pointed out already 30 years ago [22].

10. OUTLOOK

The ongoing discussion on underground disposal versus long term storage in controlled facilities reflects the old debate about the significance of passive versus active measures for repository safety. As shown in Table I, major emphasis was laid in the past on passive safety systems and final underground disposal. However, the final uncertainty of prognostics in geological systems lead some authors to raise questions about the sense and necessity of additional measures. In the course of the years, different concepts have been proposed, including the additional need for long term monitoring and retrievability of wastes [13, 25, 26, 27, 28]. Today, it is commonly accepted that these items must be concretely treated in future waste disposal programmes.

In Switzerland, the discussion on nuclear waste management was extended in the 1990s and led to an extended debate, known as the ‘Energy Dialogue’, in which operators, authorities and environmental organizations were represented. The final report of this dialogue commission, compiled in 1998, recommended a bridge building strategy between the positions of geological disposal promoted by the operators and the guardianship concept defended by the nuclear opponents. Therefore, Federal Councillor Leuenberger set up an Expert Group on Disposal Concepts for Radioactive Waste (EKRA) in June 1999, and asked for a critical review of all concepts and strategies discussed in the context of radioactive waste management. EKRA experts focused their attention on retrievability and monitoring, and presented the concept of ‘monitored long term geological disposal’ in their report of January 2000 [29, 30].

The basic idea was to divide the underground repository into three different facilities. Although this idea was not new,[11] EKRA adapted it to the requirements of a step by step procedure in which repository safety based on active measures was progressively replaced by passive safety systems. Key issues, such as monitoring and retrievability of wastes, were handled in such a way that surveillance and intervention options were kept open over longer time

[11] See, for example, the old conceptions of LBL, Ref. [25].

spans. However, the system could be safely closed at any time, if social decisions or constraints made it necessary.

Three facilities were considered (see Fig. 1). The test facility was conceived as a conventional rock laboratory, where the adequacy of the site and the general feasibility of the disposal concept should be demonstrated. Only after this demonstration should the main facility and the pilot facility be realized. The main facility, where the bulk of the radioactive waste (up to 99% or more) would be emplaced, would be operated and backfilled immediately after emplacement of the waste canisters. It is not intended to keep this facility open longer than necessary. The small remainder of the waste (<1%) would be placed in a pilot or validation facility which would then be monitored over longer periods of time. Access shafts would also be kept open and possibly other special monitoring tunnels in the far field of the repository. The pilot or validation facility serves as a long term testing and demonstration facility, where predictive models can be verified and monitoring assured. All tunnels which would be held open during longer time spans (decades and more) would be equipped with self-closure mechanisms, in order to ensure definitive isolation of the repository in case of failure of the social systems. The details of this 'monitored, long term geological disposal' concept are being worked out at the present time.

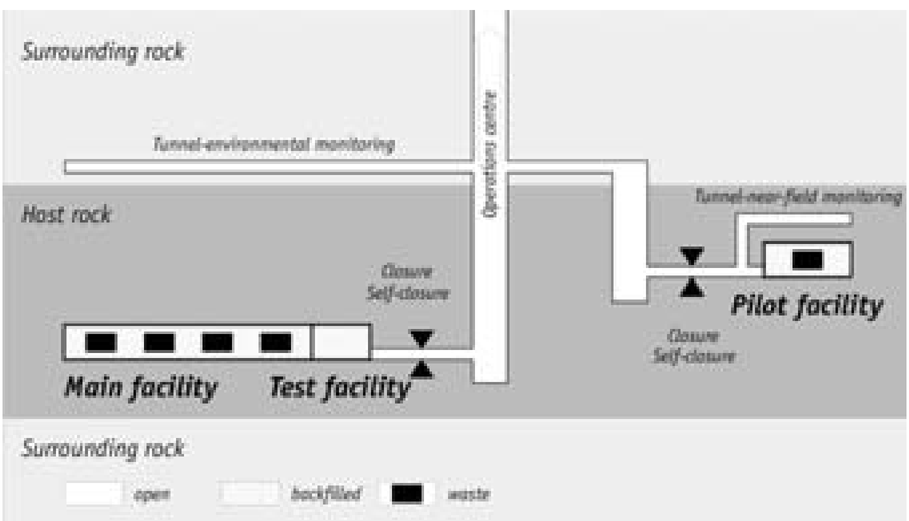

FIG. 1. The underground facilities in the 'monitored, long term geological disposal' concept of EKRA.

11. CONCLUSIONS

Comparing waste disposal and long term storage strategies from the ethical, technical, social and economic points of view results today in the following four major conclusions:

(1) Risks resulting from nuclear waste should be eliminated as far as possible without delay, with competent methods and adequate knowledge and staff. There is no reason for opening the doors for a strategy of long term storage of nuclear waste.

(2) Social systems are not predictable — not even over time spans as short as a few decades. In contrast to the conceptions of dialectical materialism, which are based on the scientific predictability of history, the 'end of history' is open, as is the scope and direction of technical progress.

(3) Hence, socially based nuclear waste programmes are not sustainable. The principle of intragenerational equity is violated by placing the burden of further waste management decisions on future generations. This does not mean that future generations are not free to implement new technical progress in the waste management systems conceived today. However, the duty of our generation is to conceive and realize a waste management system capable of ensuring long term safety without the further participation of society. At the present time, only deep underground repositories fulfil this condition.

(4) Periodic re-evaluation of waste management strategies, including social criteria and historical knowledge, is needed. A risk assessment of socially based radioactive waste management must include historical evidence, especially concerning major social crises and over longer historical time spans. Problems should also be analysed from the point of view of the needs of countries outside the rich Western industrial world. There may be some evidence there on what might be done and what should not be done when considering socially controlled nuclear waste management.

It is evident that the implementation of such programmes needs active and engaged political support, especially from governments. Dialogues between the different stakeholders are certainly necessary in order to establish full transparency and obtain support from the principal societal actors. But implementation is only possible if there is a representative and independent body which is willing to stand deputy for society with regard to a politically unpleasant, and even embarrassing, but urgent problem. Only governments can play this role.

Coming back to the basic methodological questions, it must be admitted that objective scientific methods for the prediction of future developments are not available, particularly in social sciences and history, and that ‘truth’, as conceived by metaphysical thinking or even positivism, cannot be obtained by any single method. What is, however, possible is to better understand past developments through a broad historical approach and to include some general reflections and findings on the nature of humankind and society into the future — particularly during crisis situations. It is essential to be aware and open to new ideas in the context of radioactive waste management. But these ideas must stand up and be tested in a critical and pragmatic debate, and with care to avoid typologies or simple conclusions by analogy. The present conceptions of socially controlled long term surface facilities do not stand any test, nor even comparative analysis as suggested by Lakatos or Popper (falsifiability); for this reason such ideas must clearly be refuted today.

In this context, it may be interesting to come back to reflections of thinkers such as Voltaire, who showed in his *Candide* [31, 32] where paradisical or apocalyptic visions of the world through simple ideological glasses might lead. We are not in the best of the worlds of Leibnitz’s thoughts, represented in the novel by the optimistic tutor of Candide, Maître Pangloss, nor in the abysses of Manichaean worlds of evil claimed by the scholar Martin, and conjured even now (the ‘axis of evil’). So let’s get away from desires, dreams and fears and let us be just as realistic and pragmatic as Voltaire’s Candide towards the end of the novel. Only in this way can we come as close as possible to realizable philosophies of life, and thus to realizable concepts and projects of handling risks and managing nuclear wastes.

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DEVELOPMENT OF THE 'INTERIM SAFE STORAGE' CONCEPT

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Abstract

The present paper provides a brief history of the nuclear industry of the United Kingdom, including a review of how radioactive waste is dealt with in the UK. Emphasis has been placed on demonstrating that there are treatment and storage or disposal routes available for most current and historic wastes. However, attention is drawn to a specific set of wastes, historic intermediate level waste (ILW), which requires specific attention. Detailed background is provided on categories of waste, the disposal criteria for ILW, and historic ILW. An explanation of the facilities and the challenge faced with historic ILW is presented. Against this background, interim safe storage is introduced as an approach to address this issue. It is intended as a pragmatic approach that will significantly reduce the overall risk and hazard currently associated with historic ILW, while maintaining due consideration of time, cost and regulatory requirements.

1. INTRODUCTION

This paper is concerned with the question of waste disposition in the United Kingdom. It describes the background to past events in the UK related to waste disposal; provides a status report on the current situation with respect to existing wastes; and describes an industry development (interim safe storage) for resolving, on an interim basis, the management of the various and varied waste streams.

2. THE UK NUCLEAR INDUSTRY

The UK nuclear programme started in the 1940s, with the production of nuclear weapons materials for defence purposes. The first UK commercial nuclear power station was built at Calder Hall in Cumbria. The power station included four Magnox reactors and was opened in 1956. It was followed by a further 22 Magnox reactors constructed on ten sites across the UK. From the

1960s, the UK commissioned the Advanced Gas-cooled Reactor (AGR) fleet. In total, 14 were constructed on seven sites. Finally, in 1995, the latest nuclear reactor to be constructed in the UK came into operation. It is a Pressurised Water Reactor (PWR) and was built at Sizewell in Suffolk.

The UK Government is currently carrying out a review of energy policy. It is unclear at this time whether this will include a programme of new nuclear build in the UK.

3. RADIOACTIVE WASTE MANAGEMENT IN THE UK

Radioactive waste has been generated for as long as there has been a nuclear programme in the UK. Consequently, the UK has stockpiles of radioactive waste, some of which dates back to the 1940s.

The UK Government recently announced plans to establish a Liabilities Management Authority (LMA) to manage all of the UK's civil nuclear liabilities. In addition, the Department for Environment, Food and Rural Affairs (DEFRA) is in the process of establishing an independent body to oversee a review of the options for managing the UK's inventory of radioactive waste.

3.1. History

The nuclear industry has for many decades been concerned about the build up of radioactive wastes and has taken a number of steps to deal with the issue. Over the years, requirements have changed reflecting the changes in society's demands. An example of this was the dumping of drums of packaged and cemented low level waste (LLW) into the Atlantic Ocean and the English Channel. This was considered an acceptable practice between the 1940s and the early 1980s, but since then, the practice has been abandoned internationally.

In 1982, the Nuclear Industry Radioactive Waste Management Executive (Nirex) was established to develop a long term solution for the disposal of intermediate level waste (ILW). The recent history of radioactive waste disposal in the UK has been dominated by the ability of the Nirex organization to locate and build a repository. Nirex carried out investigations of a number of possible disposal sites, including clay strata in Bedfordshire and anhydrite deposits under Teeside. However, public opposition was such that further evaluation was not followed up. In 1989, Nirex focused on two possible sites, Sellafield and Dounreay, for the deep geological disposal of ILW. In 1991, Sellafield was selected as the preferred site and a conceptual design was developed for a deep geological repository in the rock strata below Sellafield (see Fig. 1). Planning permission was submitted for an underground rock laboratory to investigate the geology and groundwater regimes of the proposed repository in more detail.

In 1997, following a long public inquiry, the Secretary of State for the Environment decided that planning permission for a rock characterization facility should not be granted. This decision called into question whether an underground repository would be the long term disposal policy for the UK.

Although it is recognized that policy has not formally changed, the impact of the rejection of the planning permission has been significant. From that moment, the practical effect has been that the UK has been committed to the storage of ILW for at least several decades to come. It is, currently, expected that this storage will be interim (i.e. that a disposal policy will, in time, be agreed) and it must, self evidently, be safe. In practice, there is no option other than interim safe storage (ISS) of ILW. Current predictions of when a disposal facility might be available vary widely. However, it seems prudent to plan for an interim storage period of up to 100 years.

3.2. UK arrangements for radioactive waste

Radioactive waste has been categorized to assist with waste management and disposal strategies. The categories used in the UK are low level waste

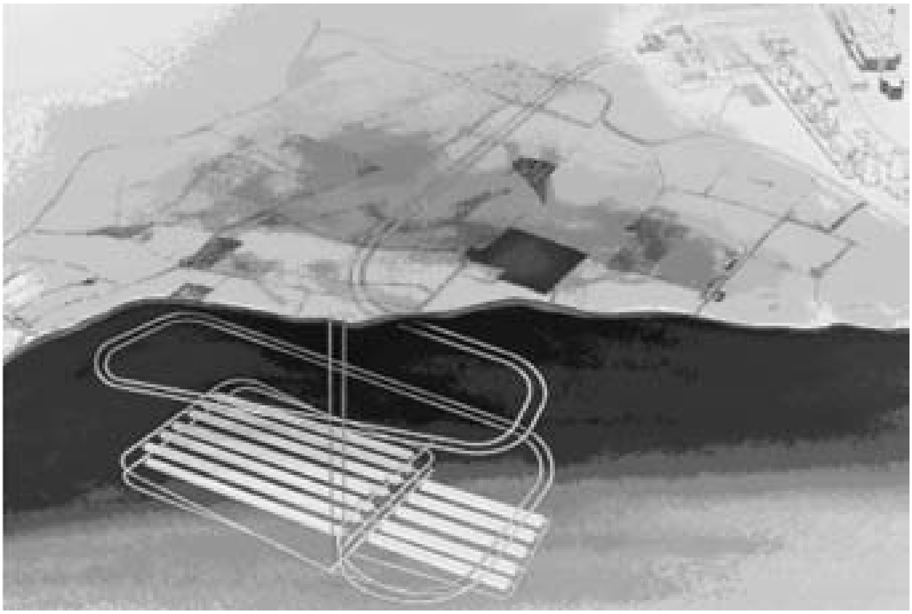

FIG. 1. Nirex concept of a deep repository at Sellafield.

(LLW), intermediate level waste (ILW) and high level waste (HLW). Some international categorization systems differentiate between short lived and long lived radionuclides, but this is not the practice in the UK. Adequate arrangements already exist for the vast majority of ongoing radioactive waste arisings.

3.2.1. LLW

For LLW, a national repository exists at Drigg in Cumbria. Drigg has operated safely as the national repository for LLW for more than 40 years, allowing the safe management of wastes from the UK nuclear industry, general industry, universities and hospitals.

3.2.2. ILW

Current ILW arisings result, in the main, from the reprocessing of fuel and power reactor operations. They are virtually all immobilized by encapsulation in cement inside stainless steel drums. These drums are then held in a shielded concrete store, above ground, pending the identification of a final disposal route for the ILW.

Historic ILW resulted from the reprocessing and other treatment processes that were carried out prior to the introduction of modern waste encapsulation facilities. Much of this waste is poorly documented, difficult to characterize and housed in facilities that were designed with little attention paid to emptying and decommissioning. These wastes are a result of strategic decisions taken over the past 50 years. It is the safe, timely, and effective retrieval and treatment of this historic ILW that is the prime subject of this paper.

3.2.3. HLW

HLW is the liquid waste stream from reprocessing containing the fission products. At Sellafield, HLW is concentrated by evaporation and stored inside double walled stainless steel tanks, housed in cells with thick concrete walls. Multiple cooling coils inside the tanks remove the heat that the waste produces. The liquid waste is being converted into very dense glass and poured into stainless steel containers. This process is known as vitrification. The containers are then stored in a purpose built shielded store, where they are cooled by natural convection. This reduces the hazard by immobilizing the liquid waste, making the waste easier and safer to handle.

In summary, treatment and storage or disposal routes exist for most current and historic wastes. However, one particularly difficult set of wastes, historic ILW, requires special attention. This waste is a legacy of the formative years of the nuclear weapons programme and the civil nuclear industry, from a time when the consideration of issues such as decommissioning and waste management were not held to be such a high priority as they are today.

4. ILW DISPOSAL CRITERIA

The proposals for an ILW repository in the late 1980s and 1990s corresponded with a change in regulatory approach. This required waste producers to develop processes to deal with wastes as they arose. Before investing in new waste treatment plants, operators required some level of assurance that the waste packages produced would not, ultimately, be rejected as unsuitable for disposal. An assessment process, the 'Letter of Comfort' (LoC) system, was introduced to record that waste packages would be acceptable for disposal within currently anticipated criteria.

Safety and engineering criteria underpin the LoC for those waste packages that are to be consigned to the repository. These criteria set the following requirements:

- For the robustness of the packages, to ensure their fitness for safe transfer from store to repository.
- For package contents (in terms of permitted quantities of specific radionuclides and fissile isotopes), to ensure safety in the repository and of the population in the surrounding area in the distant future after the closure of the repository.
- For package contents, to limit the amount of specific environmentally 'mobile' isotopes and certain chemical species (principally organics) that were considered likely to enhance the mobility of radioactive species in the centuries following closure of the repository.

A 'generic' repository was assumed when establishing these criteria, i.e. a package, which satisfied these criteria, should be suitable for disposal in a broad range of foreseeable repositories. No site specific factors were included and, as a consequence, the criteria were very demanding and could be considered pessimistic.

Both UK regulators, that is, the Nuclear Installations Inspectorate (NII) and the Environment Agency (EA) (which includes the Scottish Environment Protection Agency, known as SEPA, in Scotland), now require, except in exceptional circumstances, that all ILW packages have an LoC. This is required before they permit the construction and operation of ILW treatment plants and processes.

From the outset, British Nuclear Fuels plc (BNFL) developed plans for modern waste management plants to be built to the latest standards and with a view to their ultimate decommissioning. These plans were developed in the 1970s, with the plants being constructed and brought into service in the late 1980s and early 1990s. Three such plants were built at Sellafield. The three plants are identified and described as follows:

— *Magnox Encapsulation Plant (MEP):* Processes Magnox swarf and fuel element components from the Fuel Handling Plant decanning lines.
— *Waste Encapsulation Plant (WEP):* Processes fuel element 'hulls' and other wastes from Thorp. Figure 2 shows mechanical handling of a waste drum in the WEP.
— *Waste Packaging and Encapsulation Plant (WPEP):* Encapsulates ferric flocs from the Enhanced Actinide Removal Plant (EARP).

These plants have been successfully commissioned, and are manufacturing drummed, cemented waste packages, 'sanctioned' by the LoC. In contrast, there are operational wastes, for example, graphite and stainless steel from advanced gas-cooled reactor fuel dismantling and miscellaneous beta

FIG. 2. Waste drum handling in the WEP.

gamma wastes, which are processed for long term storage without Nirex LoCs. This, in the main, is due to the fact that the wastes were produced by facilities designed and introduced before the advent of the LoC.

As discussed in Section 3.1, a repository may not be available for many decades. Technological and societal changes over these time-scales are likely to be significant. The waste package assessment process, developed by Nirex, is a sound discipline based on current understanding and criteria. However, uncertainty remains on the final acceptance criteria for waste when a disposal route is eventually chosen. This raises the issue over the extent to which rework of waste packages may eventually be required.

5. HISTORIC ILW

The principal storage facilities for historic ILW are the B30, B38 and B41 plants. B30 is an old, disused Magnox fuel storage pond and decanning plant. A recent photograph of the facility can be seen in Fig. 3.

FIG. 3. B30, a fuel storage pond.

B38, a wet silo with a number of compartments, started over 30 years ago as a facility for the underwater storage of the Magnox swarf generated from Magnox fuel decanning operations. The silo also stores miscellaneous beta gamma waste. Figure 4 provides a recent photograph of B38.

B41, a dry silo, was commissioned in 1952 as part of the UK defence programme. It is used for the storage of miscellaneous intermediate waste and consists largely of metal swarf from decanning. Scrap metal and graphite, as well as quantities of organic wastes and pieces of uranium fuel residue, are also stored in B41. Figure 5 shows a photograph of B41. The B41 silo is protected through the use of the inert gas argon. The waste within the silo is covered with an argon blanket, which will ensure the safety of the plant for the future.

The historic ILW stored at Sellafield is potentially hazardous. The inventory of radionuclides in ageing facilities is substantial, comprising fission products, actinides and activation species. All facilities contain reactive metals (magnesium, aluminium and uranium). In B38 and, to a lesser degree, in B30, the water has become highly contaminated and would represent a mobile hazard should containment be lost.

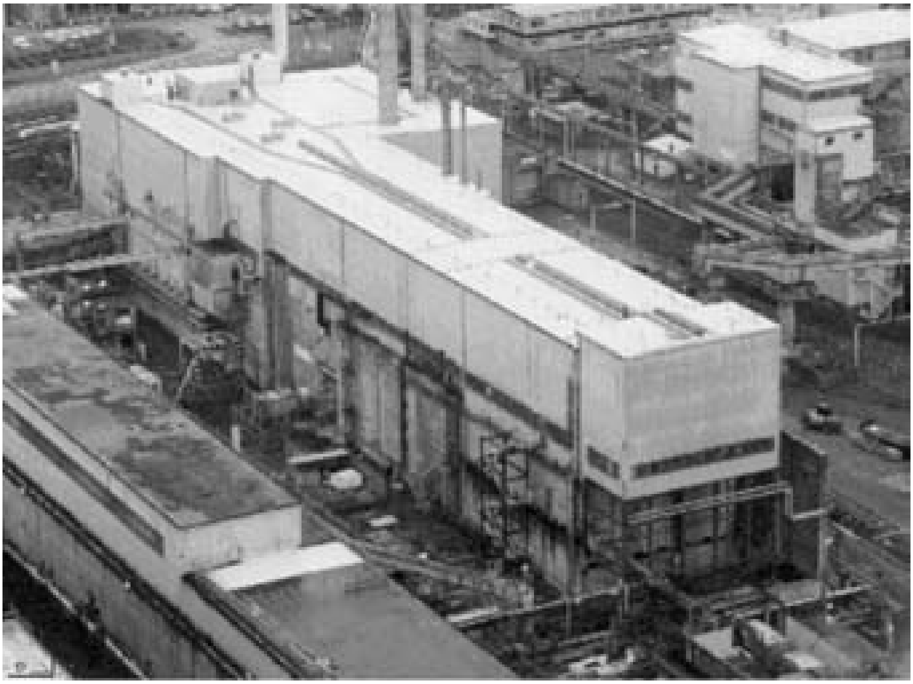

FIG. 4. B38, an underwater storage facility for Magnox swarf.

The storage of hazardous wastes in ageing facilities results in a greater risk, both on and off the Sellafield site, than would be presented by modern facilities. In addition, if no action is taken, the risk from these ageing facilities will increase over time, as the structures degrade and the risk of containment failure increases. The preferable objective would be to retrieve these raw waste materials, treat them to enhance their passivity and dispose of them in a way that isolates them from the biosphere. However, even with no UK disposal route likely to be available for many decades, action to manage the Sellafield site risks cannot be deferred.

6. THE CHALLENGE OF HISTORIC ILW

The ILW disposal criteria established by Nirex requires that waste to be encapsulated is well characterized and, in many cases, that mixed wastes are segregated. Characterization and segregation are relatively straightforward for

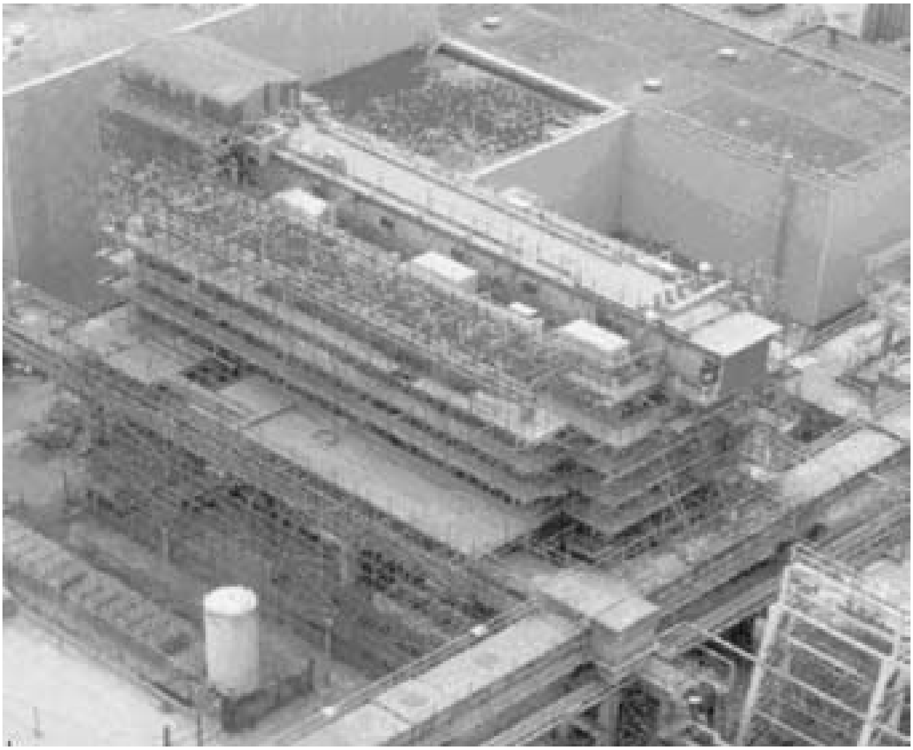

FIG. 5. B41, dry storage of miscellaneous ILW.

‘fresh’ arisings, as waste streams to be encapsulated are known and can be controlled and segregated as necessary. Historic wastes present a wholly different challenge for the following reasons:

— Detailed records of what was tipped into waste silos were not always produced. In some cases, records that were produced are no longer available.
— Until the 1980s, little segregation of wastes was carried out. Production plants had not been designed to facilitate segregation. Figure 6 illustrates the best estimate of the contents in the B38 compartments.
— Much of the waste, for example aluminium and Magnox fuel cladding, has degraded over time. In the B38 water filled silo, a very substantial proportion of the Magnox is known to have corroded. In the B41 ‘dry’ silo, some corrosion of the material must have occurred but in both B41 and B38, the exact state of the contents is unknown.
— B38 and B41 are simple concrete ‘box’ constructions designed for waste to be tipped into, not to be retrieved or sampled. The size of the silo compartments, the mixtures of waste, the physical access difficulties and the very high levels of radioactivity dispersed throughout the contents and, in the case of B38, the water in which the waste is immersed, make representative sampling impossible. Some samples have been taken from

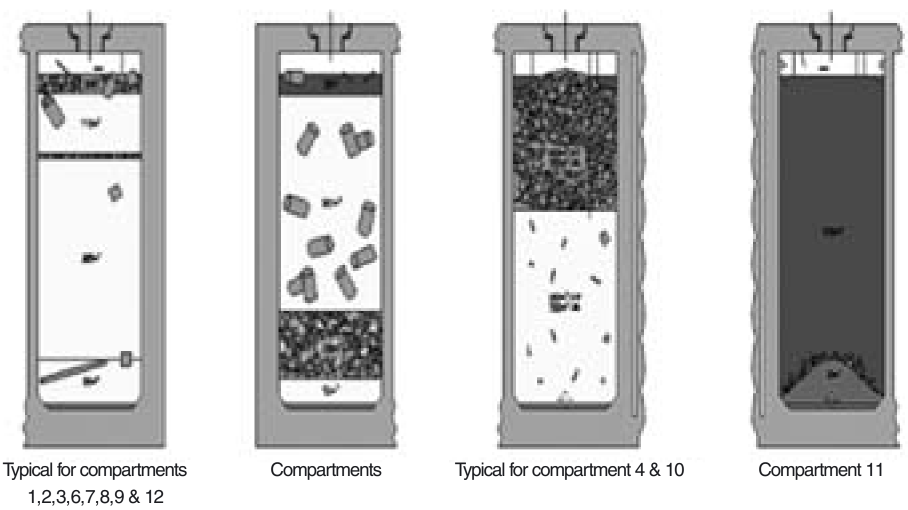

FIG. 6. B38 compartments 1 to 12, best estimate of contents.

the early B38 compartments. Also, relatively uncorroded Magnox swarf from the later compartments has been successfully retrieved and encapsulated in the WEP. This experience has enhanced understanding of the silo retrieval challenge but has also indicated the need to re-examine retrieval and treatment plans, as the behaviour of the waste has proved to be very different from prior assumptions. It is recognized, however, that the data from sampling and retrieval cannot be taken as representative of the overall contents.

— Particularly in the case of B38, the corrosion processes have distributed the radioactivity, once concentrated in pieces of broken fuel. With such highly radioactive mixed waste, it will be practically impossible, using currently available instrument technology, to routinely and reliably distinguish fuel pieces in retrieved waste. As a consequence, effective segregation of retrieved wastes will also be impracticable.

— Much of the historic waste, particularly that from B38 and the Magnox storage and decanning plant, B30, will be coated in Magnox corrosion product, much like plaster. It will, therefore, be almost impossible to determine by viewing through lead glass windows or by television camera whether items of waste are Magnox, steel, uranium or plastic.

To put this challenge into perspective, approximately 5000 m^3 of ILW Magnox waste has already been encapsulated in packages that have an LoC. Approximately 8500 m^3 of similar wastes are anticipated before the end of Magnox reprocessing. The historic waste volumes for which LoCs are not required are: B38, approximately 10 000 m^3; B41, approximately 3000 m^3; and B30, approximately 2400 m^3.

7. INTERIM SAFE STORAGE

It is the intention of this paper to draw attention to, and explain why, a particular set of wastes, historic ILW, requires special attention. Against this background, the concept of ISS can be introduced as an approach to the timely retrieval of historic ILW.

It is central to the concept that, in principle, it is a greater priority to enable retrieval of historic ILW and enhance its passivity than it is to delay for an uncertain period, while continuing the search for new techniques that would allow the safe retrieval, characterization, segregation and packaging to meet in full Nirex disposal criteria, or the disposal criteria which might be ultimately established.

This concept does not preclude or trivialize the Nirex disposal criteria as representative of a desirable objective. However, what it leads to is a set of principles that should be observed by those responsible for managing the historic ILW liability.

These principles are aimed at ensuring the overall risk and hazard are reduced in a timely manner and that appropriate regulatory requirements are in place. Section 7.2 looks more closely at the risk and hazard reduction through the use of ISS and the eventual implementation of a final disposal route. These principles allow the work to be discharged in a variety of ways. BNFL is developing a variety of approaches to address historic ILW in line with these principles.

One approach under consideration is that historic ILW be retrieved and processed as necessary in order to package it in approved Nirex containers. Every effort will be made to conform to Nirex ILW disposal criteria and produce drummed, cemented waste packages that are sanctioned by LoCs. However, for waste streams where it becomes evident that Nirex ILW disposal criteria cannot be fully satisfied, work would be carried out to understand the potential consequences of the non-conformance. Those non-conformances that could potentially breach safety criteria will be of most concern, and strategies would be required to mitigate such safety concerns. Where non-conformances raised repository operability concerns, then the priority would be to retrieve and store the waste. Non-conformances of any of the Nirex criteria would have to be assessed and the likely impact understood. It must be emphasized that nothing will be done which is not acceptably safe and which does not meet regulatory requirements.

In summary, the overall drive would be to meet Nirex criteria, paying specific attention to safety criteria while ensuring timely retrieval and safe storage of historic ILW.

A second approach considers the risk of rework to drummed, cemented waste. The approach, known as design for storage, centres on the safe and timely retrieval of ILW. Processing these wastes focuses on their being stabilized and rendered passive. Once processed, wastes would be transferred to suitable containers to allow safe mechanical handling and storage for a period of the order of 100 years. Design for storage would require specific purpose built storage facilities. These would include modern security, environmental monitoring and mitigation systems (including nuclear ventilation and fire systems).

Design for storage will almost inevitably require waste containers to be reworked in order to meet disposal requirements. Interim storage should be designed so as to allow relatively straightforward rework. This is in contrast to cemented, drummed waste, which may prove extremely difficult, costly and slow to rework.

As described in this paper, the Nirex disposal criteria are designed so as to ensure disposal of ILW to a generic repository. This has forced Nirex to prepare a stringent set of criteria. If it were possible to modify aspects of the disposal criteria, this may allow the disposal of historic ILW in line with other ILW waste streams.

Discussions on these and other appropriate options for dealing with historic ILW will be required with the principal stakeholders. Once a final set of options can be agreed, detailed plans can be developed and implementation can commence.

This paper has explained the challenges faced when dealing with historic ILW. Owing to the nature of the waste and the manner in which it is currently stored, increased demands will be placed on both worker dose levels and environmental discharges. Consideration of these issues will be incorporated into the decision making process, in order to arrive at solutions that minimize worker dose and discharges. However, the continual reductions in both worker dose and discharges that have been achieved over the last 20 years may not continue while the topic of historic ILW is being tackled.

This report has identified time-scales of the order of 100 years for ISS. These time-scales may be reduced in the event of significant progress being made on the provision of a final disposal route. Similarly, the time-scales may be extended. However, ISS is not envisaged as an indefinite solution. The protracted storage above ground of ILW would demand continuous attention by subsequent generations. Surely the generation that has benefited from cheap, clean, safe and affordable electricity should put in place a clear plan to deal with the wastes it created.

7.1. Interim safe storage principles

In order to manage and, over the earliest possible time-scale, reduce the risk from historic ILW, the following principles should be considered:

— Deploy simple, proven technologies for the retrieval and treatment of historic wastes.
— Recognize that some of the historic wastes such as those stored at Sellafield cannot, in general, be representatively sampled or comprehensively characterized.
— Seek waste treatment processes which can accept the inevitable uncertainties in waste characteristics or mix, and which require, at worst, only minimal waste segregation.
— Maintain that it is inappropriate to restore historic wastes, untreated, in new stores.
— Maintain that it is impractical to develop new or untested technologies for waste characterization, segregation or treatment in order to satisfy the requirements of Nirex disposal criteria.

— Establish a radioactive inventory of waste packages before storage but avoid segregation of wastes before treatment and packaging.
— Develop waste packages which are demonstrably safe for extended storage (of the order of 100 years) but which can be inspected and repackaged should their long term integrity prove poorer than predicted.
— Limit the fissile content of waste packages to meet the requirements of safe storage and not the post-closure repository model.
— Ensure that, if necessary, design for safety in storage takes primacy over requirements to ensure repository post-closure performance (as currently modelled).
— Treat the Nirex disposal criteria as a sound assessment process to be used to provide guidance on the quality of waste package design.
— Minimize the integrated risk during ISS by seeking to enhance the passivity of waste packages.
— Develop an overall model of the magnitude and timing of the secondary waste streams (principally aerial and liquid discharges) that will result from retrieval and treatment operations.

By following these principles, BNFL seeks to manage the retrieval, treatment and storage of historic wastes in ways that will produce the greatest time integrated reduction in risk, while avoiding grossly disproportionate expenditure. BNFL recognizes that in deciding to adopt these principles, there will be difficulties in ensuring that the waste packages produced fully satisfy the Nirex assessment criteria. This will create regulatory difficulties, as there is a requirement for all waste packages to have an LoC before approval is given for construction, commissioning or operation.

7.2. Overall risk and hazard reduction

Timely retrieval of historic ILWs and appropriate treatment to render them demonstrably safe for extended storage is required. The timely reduction of risk must be the key objective. Figure 7 illustrates the risk and hazard reduction strategy.

This graph illustrates how, if retrieval is delayed, the risk of non-passively stored wastes will rise with time. However, through the implementation of ISS principles, the risk can be reduced significantly. The availability of a final disposal route would then offer a further opportunity to reduce the risk still further and for the longer term. Put simply, this is a two stage process aimed at ensuring that risk reduction is achieved in a timely manner.

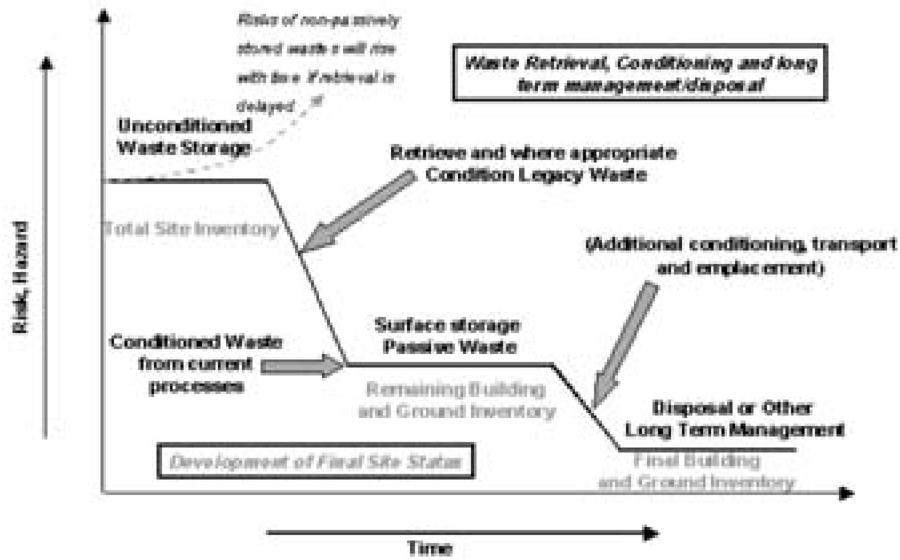

FIG. 7. Overall risk and hazard reduction.

8. CONCLUSIONS

This paper has explained how radioactive waste is currently dealt with in the UK. Emphasis has been placed on demonstrating that there are treatment and storage or disposal routes available for most current and historic wastes. However, the focus has been on a specific set of wastes, historic ILW, which requires special attention due to the difficulty with them of meeting current Nirex disposal criteria. ISS has been introduced as an approach aimed at addressing this issue. It is intended as a pragmatic approach that will significantly reduce the overall risk and hazard currently associated with historic ILW, while maintaining due consideration of time, cost and regulatory requirements. This will allow early progress in hazard reduction in the UK and may be of benefit to other nations where dealing with the legacy of nuclear development is an issue.

APPENDIX

FUTURE ASSESSMENT OF BNFL ILW WASTE STREAMS

Following the initial completion of this paper, significant progress was highlighted on the joint efforts of Nirex and BNFL to establish an approach to the management of ILW at Sellafield. This appendix summarizes a possible way forward that is currently under discussion.

The appraisal process that has been adopted to date involves the development of waste packaging proposals by BNFL ('the producer'), review by Nirex, followed inevitably by discussion, reappraisal, and sometimes redesign. Many of the problems with this process resulted from the 'arm's-length' relationship that excluded Nirex from an early and full understanding of the drivers, constraints and range of options examined; it simply presented the chosen 'solution'. At best, this approach is very time consuming and at worst very inefficient, resulting sometimes in impractical requirements being placed upon specific waste package specifications. In addition, the process has created a 'pseudo regulator' role for Nirex when it has no formal remit to act in such a role and their accumulated expertise is best deployed in providing independent technical advice to inform waste management decision making (by the industry and the regulators).

For the future, specifically for the legacy wastes that demand timely, effective retrieval and treatment, a much more effective, inclusive process is required which will significantly speed up the appraisal and agreement of appropriate waste packaging options. A new approach is proposed in which Nirex *would* be closely involved in the evaluation of waste treatment options and through this close involvement, would be fully aware of all stream specific waste treatment drivers and constraints. As an active participant in the 'optioneering' process, Nirex would determine whether, if a waste form cannot meet disposal requirements, these requirements could be modified to accommodate. As appropriate, Nirex advice would review whether deviations of a proposed waste package from the LoC criteria were considered to be fundamental or to present an acceptable risk.

A.1. The proposed process

Figure 8 illustrates the process. A key objective of the process would be to facilitate timely retrieval and processing of the waste to reduce the hazard and ensure safety during storage. The process would consider overall legacy drivers, priorities and constraints but would also ensure that appropriate

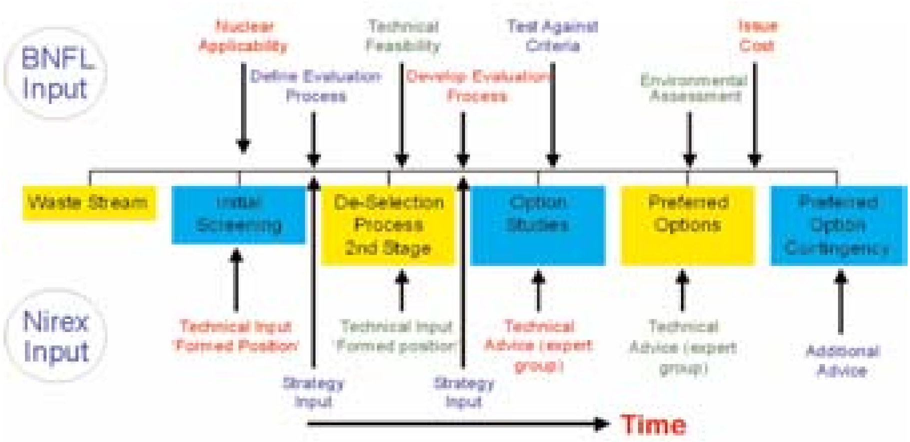

FIG. 8. BNFL/Nirex interaction on ISS projects.

consideration is given to long term management issues when developing and selecting preferred treatment and packaging options for the management of legacy wastes.

The process would consider all legacy wastes at Sellafield and would seek Nirex input at all stages. The Nirex input would firstly help identify whether appropriate disposal criteria could be met currently. If they cannot be met, the Nirex input to options studies would be to ensure that long term management issues are identified for the options under consideration, the aim being to ensure that any interim storage packaging solution did not preclude, or make unnecessarily difficult, future conversion to a disposable form. It would be important to understand the whole life-cycle implications of different waste management options.

Discussion following paper by D. Bonser

M.V. FEDERLINE (USA): Are the institutional controls at the decommissioned facilities referred to by you furnished by the UK Government or by a commercial organization?

D. BONSER (United Kingdom): They are furnished by BNFL — a commercial organization. However, there are plans to establish a Liabilities Management Authority which would take the facilities into governmental ownership.

M.V. FEDERLINE (USA): Have any of the facilities been released for unrestricted use?

D. BONSER (United Kingdom): No, the end point issue is still being debated.

P. METCALF (IAEA): With interim storage for up to, say, 100 years, the United Kingdom's new strategy is going to entail huge operating costs, followed by disposal costs. Is that compatible with fulfilling the Joint Convention obligation not to place undue burdens on future generations?

D. BONSER (United Kingdom): We feel that, in the case of the particular set of waste referred to in my presentation, an undue burden would be placed on future generations if we did not implement the new strategy and instead waited — at least a decade — for processes to be developed and decisions to be taken.

A. NIES (Germany): I understood your presentation message to be that, in the absence of a viable disposal route at present, the United Kingdom has decided to convert risky historical situations into safe interim storage situations, but that the decision does not mean a preference for interim safe storage over disposal.

D. BONSER (United Kingdom): That's correct. In our view, interim safe storage — an intermediate step — is necessary today, for this generation.

THE CASE FOR LONG TERM STORAGE OF RADIOACTIVE WASTE

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1. INTRODUCTION

I am very honoured to be here today, and to be given the opportunity to speak about alternative views of radioactive waste containment. I would like to express my gratitude to the IAEA for inviting me, as this represents engaging in an open dialogue, which may include different perspectives from those generally explored in IAEA conference forums.

There is now a new sense of openness between constituencies on many issues. There is an increased incidence of industry, non-governmental organizations and governments coming together to share information, and seeking to work in collaboration to protect the environment and future generations from radioactive contamination. This is why I am pleased to be here, to take part in an honest, open discussion. We may advocate different approaches to the same problem, but in this new spirit of dialogue, all options must be considered and all viewpoints must be invited. In assessing the options for radioactive waste containment, citizens' groups and laypeople can offer much in the way of critical analysis, and many in this room possess the technical know-how and expertise that can augment alternative proposals for the long term management of radioactive waste. And together a critical analysis and a technical expertise will generate response options that people can comment on democratically, and consensus options that can be implemented. The democratization of the radioactive waste issue includes education about the social, environmental, health and human security impacts of nuclear power, and these are some of the concerns addressed in this paper.

But first, who am I?

I work in New York City for Educators for Social Responsibility and teach high school students critical thinking skills about war and peace, with a particular focus on nuclear weapons. Just last week, I returned from a trip to Japan, sponsored by their Ministry of Foreign Affairs, where I taught nuclear disarmament education to secondary school and university students in Tokyo, Hiroshima, Nagasaki and Kochi City. This was a profound honour and privilege, which came about through my involvement in the United Nations Study on Disarmament and Non Proliferation Education. The two year study was conducted by Government representatives, representatives from United Nations organizations and non-governmental organizations, working together to define the vital necessity of educating for disarmament. A report was launched in October 2002, and 34 recommendations were unanimously adopted by the First Committee of the General Assembly. I have brought the report here with me today, and the recommendations are also available online at <reachingcriticalwill.org>.

The reason I was invited to speak to you is because I did my PhD on what we are here to discuss, radioactive waste disposition, and the social, environmental and temporal effects of nuclear waste management. I've been following this work for many years and have been particularly drawn to a concept for long term storage called Nuclear Guardianship. Guardianship is a framework for thinking about and implementing the safe and responsible care of radioactive materials.

The concept of responsible care is at the forefront of Guardianship thinking, and such responsible care of radioactive materials assumes an important role for future generations. That the future be remembered. That the future has information about the nuclear legacy that we bequeath to it. That the future be considered in the decision making process. Unfortunately, and all too often under the cloak of secrecy, the nuclear industry has made decisions on behalf of the future generations. Nuclear Guardianship advocates that options be left open for the future, in a safe and responsible manner.

So what is Nuclear Guardianship?

Nuclear Guardianship advocates four main points that I will continue to allude to throughout my presentation:

— Interim containment of radioactive materials in accessible, monitored storage, so that leaks can be repaired, and future technologies for reducing and containing their radioactivity can be applied;
— Stringent limits on transport of radioactive materials, to avoid contaminating new sites, and to minimize accidents;
— Transmission to future generations of the knowledge necessary for their self-protection;
— The cessation of the production of nuclear weapons and nuclear energy, which further creates radioactive materials.

Nuclear Guardianship is an educational effort aimed at developing the political, technical and ethical understandings required for the responsible care of radioactive materials, materials which remain cancer causing and mutagenic beyond a human conceptualization of time. Such an educational effort, on all levels, has yet to take place because of the secrecy which still prevails, under the mantra of national security, regarding many nuclear related matters. But let this moment mark the beginning where both educational and citizen led efforts permeate the minds of nuclear decision makers. And in our discussions, let there always be, if not physically then metaphorically, an empty chair to represent the future.

Oppenheimer said that we cannot hold back progress because of fears of what the world will do with our discoveries. This statement is about risk. No one in this room will doubt that there are certain risks involved in the production of nuclear power. I remember Three Mile Island as a child. I was a budding nuclear campaigner in the year 1986, when Chernobyl became a byword for nuclear danger. And now my parents' home looks across Lake Erie to the Davis-Besse reactor, which recently suffered a near miss, when it was discovered that acid had corroded a 6½ inch thick reactor pressure vessel down to a paper thin 3/16 of an inch.

It is time to question whether we have the power to control the risks inherent in nuclear energy (not to mention nuclear weapons), especially given the current security climate.

The unknowable is our universe. Although scientists can claim to know certain things, and can claim that certain risks are acceptable, when we place ourselves in juxtaposition with this, we know that there are certain things that we will never know. One of these things seems to be how to keep radioactive materials from the biosphere for 250 000 years. To grapple with these questions, I believe, is the reason we are here today.

One of the things I want to review with you regards current methods of disposition. This will be a practice familiar to many of you. An example of one method of disposal is found at the Hanford Nuclear Weapons Facility in Washington State, United States of America, where radioactive waste is deposited and covered with backfill in an unlined trench in the earth.[1] Canisters of nuclear materials are buried there, again in an unlined trench which, in the case of the Hanford facility, are then topped off with river rocks. There are no markers, no warning signs that nuclear materials lie beneath the surface. This runs contrary to an essential principle of the Nuclear

[1] When the present paper was delivered, several illustrations accompanied the text. Owing to publishing constraints, including copyright clearances, it was not possible to reproduce all of the images.

Guardianship concept, which maintains that materials must be not only monitored and retrievable, but also visible — something that can be seen and maintained by future generations who will inherit many nuclear sites, including this so-called burial garden at the Hanford facility.

We turn now from shallow burial to the deeply geological. The illustration presented depicts a view from Yucca Mountain on to Jackass Flats in the desert of Nevada, which may or may not look familiar because it is from an unlikely vantage point. I like the photograph presented here because it is a view from Yucca Mountain, instead of a view of Yucca Mountain. This view reminds us of earth time, or Deep Time — an unimaginably vast amount of time, such as 250 000 years, the hazardous life of plutonium. It also helps us think from the mountain's viewpoint. If the mountain could speak, would it tell us that radioactive materials would be safe within its care? Or would it say that the water that moves through its body would carry the radioactivity to the above ground environment? The United States Department of Energy (USDOE) estimates that high level nuclear waste buried here will be safe for 10 000 years, a fraction of the dangerous lifetime of the radioactivity it is meant to contain.

As many of you are aware, the United States Congress has recently approved Yucca Mountain as the end storage for spent fuel from US reactors. At an estimated cost of $58 billion, the USDOE intends to bury 70 000 metric t of high level nuclear waste in Yucca Mountain, located in an area of seismic activity, the third highest rate of seismic activity in the USA.

Years of debate and research have heralded many criticisms of this proposal. I cite some here, as a way of underscoring the essential points of Nuclear Guardianship, that is, why deep geological burial is not regarded as responsible care.

According to the Nuclear Waste Technical Review Board (NWTRB), on 30 January 2002: "Many of the DOE's assumptions regarding Yucca Mountain are extreme and unrealistic."

2. SITE CHARACTERIZATION

Such assumptions include the one expressed in a commercial announcement by the American Nuclear Society, with reference to a 'complex diagram'). Much of the thinking about deep geological disposal assumes that the host rock will be dry. However, with Yucca Mountain, evidence shows that engineers continue to run into groundwater. By the USDOE's own characterization data, rates of water infiltration are 100 times higher than expected. But this makes sense, considering that the repository sits 300 m above the water table.

The Waste Isolation Pilot Plant (WIPP) in Carlsbad, New Mexico, home to the US deep geological burial site for plutonium contaminated waste from weapons manufacturing, suffers a similar fate. Below the WIPP site is a highly pressurized brine reservoir extending beneath much of the burial area, while above is a layer of groundwater that feeds into the Pecos River, which makes its way into the Rio Grande, which in turn flows into the Gulf of Mexico.

3. TRANSPORTATION CONCERNS

Other concerns include transportation. If Yucca Mountain opens, high level radioactive waste will travel through 44 states within the USA, from 77 different power stations, past 50 million people, for 25 years. Within the first year of Yucca Mountain opening, there would be more nuclear shipments through the USA than the past 40 years combined. By their own estimate, the USDOE has predicted that 50 accidents may happen while transporting this material. Furthermore, outside a heavily protected reactor site, and on the open road, these shipments are made more vulnerable to sabotage.

4. CAPACITY VERSUS VOLUME

Finally, the cavity into which spent fuel and other radioactive wastes may be deposited can hold up to 70 000 metric t. Yet, by the time Yucca opens, if it opens, there will be in excess of 107 000 metric t of high level radioactive waste to be managed. And, of course, if we continue to rely on nuclear power, high level waste will continue to be produced.

The USDOE has not chosen to warn the ‘future’ about the hazards of radiation, but to warn them away from the sites of radioactive burial grounds. Here one could argue that the USDOE is not only predicting the geological nature of the earth but also attempting to predict the future of human communication.

Some of the images displayed during the presentation of this paper[2] are taken from reports written in the early 1980s, conducted by the Battelle Memorial Institute under a contract to the USDOE.

There were attempts, for example, to “bridge communication for millennia”, but still relying heavily on current notions of symbol and language (see Fig. 1). Some of the examples are a bit dated.

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[2] As mentioned, many of the images referred to are not available in the present publication.

FIG. 1. 'Don't Dig Here'.

A more contemporary approach is demonstrated in a project called Human Interference Task Force, initiated in the 1990s and funded by the USDOE. Their remit was to predict future human activity around deep geological burial sites, assess the durability of information archives detailing the repository's contents, and warn future generations away from the site. The members from the Task Force came from disparate disciplines: semioticians, astronomers, anthropologists, architects and nuclear scientists. The desired outcome of the research is not, as prescribed by the Nuclear Guardianship concept, to develop methods that would attract people to the site in order to watch over and safeguard radioactive materials from the environment. The USDOE's future vision of a geological burial site incorporates signs that are meant to repel a would-be 'intruder' and thus spell imminent danger.

As of 1994, these were the winning proposals to repel future generations from radioactive burial grounds. The notion of proposing a threat to future generations, warning them away from deep geological burial sites, has defined the USDOE's research into market design and durability. Although it is admitted that the prediction of future human activity is speculative, the research maintains that inadvertent intrusion into radioactive waste burial sites is a persistent possibility, one that most probably will occur.

FIG. 2. Reactor.

5. WHY ON-SITE STORAGE?

This brings me back to a guiding principle of Nuclear Guardianship: decentralized on-site storage (see Figs 2 and 3). To again cite Yucca Mountain, 90% of the repository will be filled by waste already being stored on-site at existing nuclear reactors, with the remaining 10% coming from US defence programmes. These are de facto Guardian sites that can be improved by such initiatives as the Harden on-site storage. This proposal from the Institute for Energy and Environmental Research (Maryland, USA) requires that:

> "current dry storage can be converted to HOSS. The federal government should pay for HOSS at closed nuclear power plant sites since it has defaulted on its obligation to begin taking the waste on January 31st, 1998, and has large amounts of ratepayer money dedicated to waste management that has not been spent. HOSS should be able to withstand most terrorist attacks without significant off-site releases. A second level goal is to prevent catastrophic off-site releases in case of even severe attacks".

I have information with me on this proposal. Please ask me for a copy.

FIG. 3. Reactor.

On-site storage also avoids the risk of accident and sabotage possible in transportation; it can and in many cases does accommodate the volume of waste; and the sites themselves will require decommissioning and can be transformed from power plants to storage facilities where industry, governments and citizens work together to safeguard radioactive materials.

6. STOP MAKING FURTHER WASTE

One of the underpinning arguments of Nuclear Guardianship is that we cannot go on producing radioactive materials. We have more than we can handle, and we have no foolproof solution or consensus for nuclear waste safe management. For the United Kingdom alone, the amount of radioactive waste being stored there has doubled in the last 15 years.

According to a newspaper article [1], the UK Government "has released figures showing that stocks of nuclear waste, including high-level waste that will remain hazardous for tens of thousands of years, increased from 45,580 cubic meters in 1986 to 92,103 cubic meters last year." Almost all of the reprocessed nuclear waste, often originating from other countries such as Japan and

Germany, is stored at Sellafield in the north of England. The article also noted that UK Government officials are not certain as to the exact amount of radioactive materials stored in the UK because “no central records were held before 1984”.

Records or no records, we have to be willing to stop.

7. EFFECTS OF RADIATION

The images shown at this point in the conference presentation demonstrate a few reasons why we need to stop producing nuclear waste, and safely isolate it from the environment. In brief, the images include:

- A dandelion leaf from the fallout region of Chernobyl (see Fig. 4).
- A rose from the Three Mile Island fallout region, from a photograph taken in 2000 (see Fig. 5).
- Alpha tracks in the lung tissue of an ape, illustrating the carcinogenic effects of ionizing radiation.

FIG. 4. Chernobyl dandelion.

FIG. 5. Three Mile Island rose.

All too often, the practice of radioactive waste management is like closing our eyes, burying it where ‘no one’ lives, or shunning it as something undesirable for our own ‘backyard’. The photograph (see Fig. 6) is of a uranium mine worker, a portrait of him with his eyes closed. This represents that he cannot see invisible radiation, or the threat that extracting uranium has meted out on living beings of the present and of the future. If we are not responsible, we are, in effect, closing our eyes to future generations.

Guardianship requires that citizens become more actively part of radioactive waste management. And for the future, a deliberate transferral of knowledge about nuclear dangers is paramount: that radioactivity must not escape into the biosphere, or it will have adverse effects, many of which we in the present have already experienced. And in passing this information on, we keep the knowledge alive.

Kofi Annan asked this question in 1999: “What happens if we face Rwanda?” From this came The Responsibility to Protect (Report of the International Commission on Intervention and State Sovereignty). When a State cannot, will not, or is itself a perpetrator of a massive human rights violation, then the international community has a responsibility to protect. A question for us is: does this responsibility extend to future generations? One way to protect future generations is to cease our reliance on nuclear power (as well as nuclear weapons). And dissent is occurring within the ranks. According

FIG. 6. Mine worker with his eyes closed.

to a newspaper article, the UK Cabinet Minister Peter Hain has suggested that nuclear power should be completely phased out [2]. Hain, the former Energy Minister, stated that alternative energy sources could replace nuclear power. He is quoted as saying: “I don’t see a queue of companies wanting to build nuclear power stations. And there’s an enormous legacy of liabilities in terms of storing and disposing the waste.”

And today we have new levels of risk involving nuclear energy relating to security concerns since the 11 September 2001 terrorist attack, with the fear that a terrorist might strike a nuclear reactor, or even worse, the spent fuel ponds, often situated in far less fortified buildings. G. Thompson, a nuclear analyst from Cambridge, Massachusetts, USA refers to nuclear reactors as “pre-deployed radiological weapons to be activated by an enemy”. Thompson also conducted research last year related to a terrorist attack on the plutonium separation and waste production facilities at Sellafield, wherein he suggested that a similar type of attack to the 11 September 2001 attack, using a plane armed with fuel would render the north of England uninhabitable.

I want to end where I began, back in the day of the Manhattan Project. And this is where it all started, 16 July 1945 at 5.30 in the morning, when the Trinity Test was detonated. Many people argue that without nuclear weapons development we would not have nuclear power, and in a multitude of ways they are intricately connected. But what can the spirit of the Manhattan Project, that no-holds-barred effort to make the bomb, contribute to the radioactive waste debate? What if we had a similar project, of ingenuity, discovery and no expense spared, in an effort to isolate radioactive materials from the biosphere? It could be such an endeavour as to inspire a spirit of openness and honest communication. We require this sort of effort, this sort of dialogue between non-governmental organizations, governments and industry. And with that, I look forward to continuing this collaboration, and thank you for your attention.

REFERENCES

[1] A letter by UK Environment Minister Michael Meacher to the UK Parliamentarian Norman Baker, MP, dated 23 October [no year given], The Independent, 21 November 2002.
[2] Guardian, 24 November 2002.

Discussion following paper by K. Sullivan

J. GREEVES (USA): I should like to make it clear that what the United States Congress has approved is not the disposal of radioactive waste at Yucca Mountain but a review process that could lead to a positive or negative decision about the disposal of radioactive waste there.

C. McCOMBIE (Switzerland): I am in favour of dialogue between, on one hand, scientists and, on the other, representatives of the general public, and I try to understand the — sometimes novel — language which representatives of the general public employ. However, I see very few signs that representatives of the general public are trying to adopt a scientific approach. In her presentation, K. Sullivan, having quoted criticisms of the US Department of Energy's scientific approach, showed a picture of a deformed rose from 'the Three Mile Island fallout region'. It is possible to find deformed roses in many places, so I regard the showing of that picture as a mixture of science with exhibitionism. Does K. Sullivan not see any contradiction between the way in which she uses science and the way in which we scientists use it?

K. SULLIVAN (Educators for Social Responsibility): I am not a scientist, and I am not trying to put forward arguments against science.

C. McCOMBIE (Switzerland): But you are using science — and scientists — in a selective manner and appealing to the emotions.

K. SULLIVAN (Educators for Social Responsibility): I believe that I was invited to speak here in order to provide a perspective different from that provided by the scientists addressing this conference. For the general public, the management of radioactive waste is an emotional issue, eliciting emotional responses which, in my view, it is important to be able to consider in different forums.

I commend the IAEA for enabling such responses to be considered here, even if some participants in this conference find the experience troubling.

C. McCOMBIE (Switzerland): Clearly, you can use emotional arguments much better than we scientists can, and perhaps we should try to learn from you. But perhaps you should try to learn from us how to use scientific arguments. At all events, I think you would be more convincing if you did not show pictures of things like deformed roses.

PANEL

IS LONG TERM STORAGE A TECHNICALLY ACCEPTABLE MANAGEMENT STRATEGY FOR RADIOACTIVE WASTE FROM SAFETY, SUSTAINABILITY AND PHYSICAL SECURITY PERSPECTIVES?

Chairperson: **A. Nies** (Germany)

Members: **M. Buser** (Switzerland)
D. Bonser (United Kingdom)
A. Wallo (United States of America)
K.-L. Sjoeblom (IAEA)
K. Sullivan (Educators for Social Responsibility)

Panel Presentation

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I would like to discuss the case for the long term storage of radioactive waste. To start with, I would like to pose the following questions:

(a) What is the final solution to the radioactive waste problem?
(b) Which types of radioactive waste are proposed for storage and which types should be managed in other ways?
(c) How long is the period of radioactive waste storage?
(d) What are the advantages and disadvantages of long term storage of radioactive waste?

Several approaches have been proposed as the final solution of the radioactive waste problem (they include transmutation, release to space, underground disposal), but only the last of these has received wide support throughout the world. In practice, long term storage is seen as a first step in the geological disposal approach.

Opinions on radioactive waste disposal often seem to be polarized. On the one hand, the collective opinion of waste management experts is, and has been for many years, that the problem is not particularly difficult to solve; that we already have mature disposal technologies which can ensure the long term safety of all radioactive waste.

On the other hand, there is a widespread and deeply rooted perception in the general public and its political representatives that the management of radioactive waste poses a tremendous problem that the nuclear industry has consistently failed to acknowledge, and for which there is no adequate solution. This divergence of views is perhaps strongest and most apparent in the context of the long term storage and geological disposal of high level waste.

Our challenge is to narrow these gaps in perception, and to work towards solutions that are both technically sound, logically coherent and which, furthermore, have broad public acceptance. The future of atomic energy must be both safe and acceptable; otherwise there will be no future for the nuclear technologies that generate radioactive waste.

Long term storage of radioactive waste is a reality in many countries. I would like to say a few words about technical aspects using the example of the experience of the Russian Federation, but first, I must make one more point. Often people (including specialists) do not distinguish between spent fuel and ‘actual’ radioactive waste. This may be appropriate if a country is using an open fuel cycle. In the Russian Federation, we use the closed fuel cycle. This means that spent fuel is considered as a raw material to reprocess and thereby produce components for fresh fuel. Thus, spent fuel is not radioactive waste in our context, but in the context of this presentation spent fuel has to be included in one set along with high level waste as an object for long term storage.

Real radioactive waste arises as the result of spent fuel reprocessing. Other types of radioactive waste result from past nuclear activity for military purposes and arise from a different application of radionuclides, from decommissioning nuclear facilities, etc.

The Russian Federation has a reprocessing plant, but its capacity is quite low: about 150 t/a. The 10 nuclear power plants in the Russian Federation produce about 850 t/a of spent fuel and most of this is stored at the power plants and at a central wet storage facility at one of the radiochemical plants. The capacity of this facility is 6000 t; it is half full. The facility is being expanded to a capacity of 9000 t, and there are plans to build an additional dry facility with a capacity of 24 000 t. Storage before reprocessing is proposed for a period of not less than 50 years.

In the experience of the Russian Federation, wet storage of spent fuel is around 70 years. It has provided a good demonstration of safety without any release of radioactivity to the environment. Moreover, there have been no accidents at any of the stages of spent fuel management, including transportation, storage and reprocessing. We consider long term storage to be a necessary stage before reprocessing, in order to decrease the spent fuel radioactivity and, as a result, to improve the process.

Thus, we are sure of the technical feasibility of long term storage of spent fuel and its safety. Moreover, the Russian Federation now has a legislative basis for the arrangements to store and reprocess spent fuel from other countries. We made the necessary corrections to our laws a year ago. However, this legislation allows the import and processing of spent fuel only from foreign States but does not apply to ‘real’ radioactive waste. Some members of the public and some politicians do not agree with the potential import of spent fuel and its reprocessing in the Russian Federation. The important task now is to look for, and to achieve, some consensus on this question.

Panel Presentation

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The issue of the role of extended storage of radioactive waste was raised in the Cordoba Conference in March 2000 at the session concerning more general safety issues in the geological disposal of radioactive waste. The Chairperson's report of the session noted, for example, that "The perpetual storage of radioactive waste is not a sustainable practice and offers no solution for the future, it is an interim phase in the integrated management of radioactive waste."

As the follow up of the Cordoba Conference, the Report on Safety of Radioactive Waste Management was presented to the General Conference of the International Atomic Energy Agency in September 2001. The report included a plan of seven actions to strengthen the work of the IAEA in the waste safety area. Action 2 requested the IAEA Secretariat to investigate the role of extended storage in a sustainable programme of radioactive waste management, and especially the implications for safety.

Consequently, the IAEA is preparing a short, non-technical, pamphlet type international position paper entitled Sustainability and Safety Implications of Long Term Storage of Radioactive Waste. In the paper, long term storage versus early disposal is discussed from different points of view such as safety and security, need of maintenance, institutional control and information transfer, community attitudes and availability of funding.

The draft paper was discussed at a Technical Meeting in November 2002 and the following conclusions were drawn:

(1) Storage and disposal are complementary rather than competing activities, and both are needed. The timing and duration of the process of moving from storage to disposal is influenced by various factors including the types of wastes being considered and national circumstances.

(2) Storage is a necessary phase in safely managing most types of radioactive waste. During the storage phase, for example, the radiation levels and heat generation intensities may decrease to levels that are more manageable. Also, storage is a necessary part of waste treatment and conditioning

programmes. Storage has been carried out safely within the past few decades, and there is a high degree of confidence that it can be continued safely for limited periods of time.

(3) For the types of radioactive wastes considered here, perpetual storage is not considered to be either feasible or acceptable because of the impossibility of ensuring active control over the time periods for which these wastes remain potentially hazardous.

(4) Strategies for storage and disposal need careful consideration in respect of many issues. These include transport of radioactive wastes from the storage to the disposal site; security of the waste; retrievability of the waste from storage, and from disposal for a given period of time; availability of suitable disposal sites; confidence that adequate levels of safety can be achieved; and the availability of finance.

The plan is to publish the position paper in early 2003.

Panel Presentation

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Session 3 Panel members were given six questions to address in our opening remarks. I would like to make some general observations and then some specific suggestions related to just a few of these questions.

Panel questions:

(1) How far into the future can we rely on institutional controls being maintained?
(2) Should concerns about terrorism affect storage policies?
(3) What are the prospects for alternatives to underground disposal?
(4) Is the long term storage of waste likely to be an undue burden on future generations?
(5) Can financial provisions realistically be made for long term storage?
(6) Is a sealed repository underground significantly preferable to a surface facility from a security perspective?

Waste management is a risk management process and it is important not to foreclose on alternative solutions prematurely. Solutions include various disposal and storage options that may operate in conjunction or separately based on specific needs.

— Generic decisions can waste resources if they are too conservative and be non-protective or non-effective if they miss important attributes to a specific decision.
— In general, it is best to identify the criteria or attributes that need to be considered in a decision making process and let the process run its course.
— It does not seem appropriate to generically foreclose on alternative solutions or arbitrarily select one specific alternative. Rather, the decision making process should consider the specific needs as well as the risks and benefits of the alternative solutions.

Therefore, the current process of identifying waste management principles, which recognizes that both disposal and storage have their place in waste management, is the most flexible and responsible approach. Decisions on when, where and for what (either disposal or storage, or some combination of both should be used), need to be addressed as part of specific waste management decisions. These decisions should be made by applying those principles to specific decisions considering specific needs and constraints as part of an open and transparent risk management process.

Two of the specific questions we were asked to consider dealt with intergenerational equity issues. One related to the time for relying on institutional controls, and the other regarding societal burdens. The IAEA's current principles, published in Principles of Radioactive Waste Management Safety Fundamentals, Safety Series No. 111-F, IAEA, Vienna (1995), have two principles that deal with these issues, namely, principles 4 and 5:

— *Principle 4:* "Protection of future generations' radioactive waste shall be managed in such a way that predicted impacts on the health of future generations will not be greater than relevant levels of impact that are acceptable today."
— *Principle 5:* "Burdens on future generations' radioactive waste shall be managed in such a way that will not impose undue burdens on future generations."

These were developed back in the mid-1990s, and I think do not reflect the complexity and multi-attribute nature of intergenerational issues. The result is that they are sometimes interpreted so generally as to be of little use, and other times so prescriptive as to foreclose on important options or flexibility that may represent a flexible and effective response. These issues alone can be the subject of an entire conference, not just a session, so I will limit my comment to a suggestion that the IAEA consider re-evaluating these principles giving consideration to a set of intergenerational equity principles that resulted form a very thorough and comprehensive study conducted by the US National Academy of Public Administration (NAPA). The report, Deciding for the Future: Balancing Risks and Benefits Fairly Across Generations, was issued in June 1997.

The report contained four principles:

— *Trustee Principle*: "Every generation has obligations as trustee to protect the interests of future generations."
— *Sustainability Principle*: "No generation should deprive future generations of the opportunity for a quality of life comparable to its own."

— *Chain of Obligation Principle*: "Each generation's primary obligation is to provide for the needs of the living and succeeding generations. Near term concrete hazards have priority over long term hypothetical hazards."
— *Precautionary Principle*: "Actions that pose a realistic threat of irreversible harm or catastrophic consequences should not be pursued unless there is some compelling countervailing need to benefit either current or future generations."

Although the principles do a nice job summarizing the factors that must be considered, they alone do not do justice to the study and the NAPA framework. I highly recommend this report. The final report is reasonably short and very readable. We have obtained permission from NAPA to post the report on our web site at www.eh.doe.gov/oepa, under "Env. Reports and Data".

Finally, I want to close on a more specific but related issue, that is, my concern with what we see as confusion over 'dependence on institutional controls'. In most situations, site selection and disposal facility design are based on safety assessments. As a general practice, we strive to minimize credit for institutional controls (particularly active controls) in those assessments. This is a reasonable approach because it helps develop designs and sites that are stable and have minimal need for maintenance over the long term. However, this is for the purposes of planning and that goal or assumption should not be confused with actual implementation and closure requirements. It is essential that we recognize the importance of institutional controls as part of our 'defence in depth' process. We should always make these needs known and strive to maintain records (which are in themselves institutional controls) that inform future generations of this generation's expectations. It is necessary, reasonable and responsible (as the NAPA principles indicate) for us to be trustees for future generations, however, it is also reasonable for us to expect future generations to be responsible and (as we and the generations before us have) accept some responsibilities passed to us from previous generations (the rolling future concept). One recognizes that society changes, governments change and, indeed, there may be lapses in institutional controls, but on average, society tends to improve and hence, act responsibly. If proper records are maintained and the knowledge is passed on, the most likely scenario is that lapses in institutional controls, if they occur, will be temporary.

Text from recent IAEA draft:

"Geological disposal facilities are designed to ensure long term safety through the passive protection provided by engineered and geological barriers, not relying on monitoring, maintenance or institutional controls after the facility is closed. This does not mean that the waste could not be retrieved, or that monitoring and maintenance could not be carried out, if this or future generations choose to take such actions. It is likely that institutional controls will be applied for a period after closure of a geological disposal facility, for example, to provide a framework for longer term monitoring, to prevent inadvertent disturbance of the facility, and for the purposes of nuclear safeguards."

Panel Discussion

P.P. POLUEKTOV (Russian Federation) In some countries, spent nuclear fuel is regarded not as radioactive waste but as raw material for reprocessing. In the Russian Federation, for example, spent fuel storage is simply the step before reprocessing. At present, the Russian Federation generates about 850 t/a of spent nuclear fuel, but it has a reprocessing capacity of only 125 t/a, so there are plans to create additional capacity (24 000 t) for the dry storage of spent nuclear fuel.

A. WALLO (USA): In my view, high level waste management, of which long term storage and disposal are essential steps, is fundamentally a risk management issue.

When reviewing the Principles of Radioactive Waste Management (Safety Series No. 111-F) in the future, the IAEA should perhaps broaden the scope of Principle 4 (Protection of future generations) and Principle 5 (Burdens on future generations) and elaborate on the issues of institutional control and intergenerational equity. In that connection, it should be borne in mind that: with disposal, there is really no need for institutional control; intergenerational transfer of knowledge is essential in order to maintain institutional control; and future generations may be willing to accept some responsibility for the management of radioactive waste generated by previous generations.

K.-L. SJOEBLOM (IAEA): At the International Conference on the Safety of Radioactive Waste Management held in Cordoba, Spain, in March 2000 (the Cordoba Conference), it was concluded that the perpetual storage of radioactive waste was not a sustainable practice. Pursuant to the Cordoba Conference, the IAEA was requested to implement several actions, one of which was to 'Assess the safety implications of the extended storage of radioactive waste and of any future reconditioning which may be necessary'. A position paper drafted in response to that request was reviewed recently by an IAEA technical group which recommended that in the final version of the position paper: it be emphasized that storage and disposal are complementary activities; it be clearly stated that storage is a necessary phase of radioactive waste management and is demonstrably safe; it be explained that perpetual storage for periods extending throughout the hazardous lifetime of radioactive waste is not feasible; more is to be said about strategies for storage and disposal — with consideration given to issues such as retrievability and transport. Also, the group concluded that the final version of the position paper should concentrate on high level waste and long lived intermediate level waste.

A.V. GIL (USA): In the United States of America, the Department of Energy is talking about leaving the Yucca Mountain repository open for about

300 years — a kind of long term underground storage concept, with monitoring, institutional controls and retrievability. In my view, this is in keeping with the 'disposition' — rather than 'disposal' — concept recently put forward by the National Academy of Science. I should be interested in hearing the views of Panel members regarding this matter.

M. BUSER (Switzerland): If the Department of Energy's concept is accepted, there might be at Yucca Mountain a monitored long term geological storage facility rather like the disposal facility shown schematically in the paper I presented.

The basic question would be to assess the risks associated with an underground cavity that is open for a long time, a major risk being that of flooding.

K. SULLIVAN (Educators for Social Responsibility): If the Yucca Mountain project goes through, regardless of the length of time for which the repository is kept open, there will be a central facility to which radioactive waste will be transported from all over the USA. Some people are very worried about the risks associated with the transport of radioactive waste and, although others point out that very little has happened during radioactive waste transport, the public concern persists.

Another point regarding the Yucca Mountain repository is that if it is built and comes to be regarded as the solution to the country's radioactive waste management problems, there will be less incentive to stop generating radioactive waste. With the monitored, retrievable storage of radioactive waste at the sites where it is generated, on the other hand, there would be greater awareness — especially in the local communities — of how much radioactive waste exists, and perhaps more people, including industrial and governmental representatives, would question the wisdom of continuing to generate radioactive waste in the first place.

D. BONSER (United Kingdom): I think the United States Department of Energy's concept has a great deal of merit. At the same time, I think that those who take the decision to leave the Yucca Mountain repository open for a long period must know, at the time when the decision is taken, how to close the repository safely using technology which is already available. They should not pass on the problem of how to close the repository safely to a future generation.

An attractive feature of the Department of Energy's concept which I would highlight here is that a future generation would not — in, say, 100 years' time — be prevented from reprocessing the spent fuel in the repository, if by then the spent fuel has proved to be a valuable energy source.

A. SUZUKI (Japan): In my view, the need for interim storage will increase — and with it, the problem of gaining public acceptance of interim storage facilities. In Japan, for example, people asked about proposals for a new interim storage facility want to know what the final destination of the radioactive waste will be. It is difficult to answer that question if one does not know how the radioactive waste is to be managed in the long term.

D. BONSER (United Kingdom): I agree. One needs to be clear about the final destination of one's radioactive waste. In the United Kingdom, we are endeavouring to achieve clarity in that regard and increase the confidence of society through a step by step consultative process which we hope will result in society's endorsing the solution ultimately proposed.

K. SULLIVAN (Educators for Social Responsibility): With regard to the concept of 'public acceptance', the nuclear industry should not think of the public as being 'out there' and simply try to persuade it to accept whatever the industry wants to do. The nuclear industry must engage the public in genuine dialogue.

M. BUSER (Switzerland): Dialogue is a wonderful thing, but what should the nuclear industry do if the public — or at least various NGOs — do not want dialogue? That is a situation which we have had in Switzerland on several occasions.

L.R. SCHNEIDER (Germany): I believe in dialogue, but on what should it be based? Certainly not on things like pictures of deformed roses; that would be like saying that all Viennese are drunkards after you have seen one Viennese lying drunk in the street.

Moreover, when engaging in dialogue about radioactive waste management, we should bear in mind that enormous amounts of toxic chemical waste are disposed of above and below ground each year without any protests from the public, which seems not to be concerned about the environmental consequences or about the accident and terrorism risks associated with the transport of toxic chemical waste.

M. BUSER (Switzerland): There has been some opposition from Green organizations to the disposal of chemical waste in disused salt mines and coal mines, and also criticisms by experts, but society has not taken the matter up seriously. I am concerned about the disposal of chemical waste in that way partly because any problems which arise could result in negative parallels being drawn with radioactive waste disposal.

K. SULLIVAN (Educators for Social Responsibility): I am glad that I showed that picture of a deformed rose from the Three Mile Island fallout region; it has certainly caused ripples here in this room. Of course, the picture does not mean that every rose in that region is deformed, but I hope that it served as a reminder of the risks associated with ionizing radiation, which can alter the DNA of life forms.

On the question of dialogue, I express citizens' concerns that I am aware of, and I would mention that since 11 September 2001, public acceptance of nuclear power in the USA has plummeted, mainly owing to concern about possible sabotage of or terrorist attacks against nuclear power plants — especially ones like the Indian Point plant, which is situated on the Hudson River only 25 miles upstream from New York City.

Regarding L.R. Schneider's comments about chemical waste, I am surprised that the German public is not concerned about chemical waste dumping given the fact that Germany is a country with such a high level of ecological consciousness.

D. BONSER (United Kingdom): Regarding the question of dialogue, we scientists think that we have things in perspective and cannot understand why the public cannot get things in perspective. The answer is that we have not succeeded in getting our technical message across to the public, which consequently continues to believe that we do not have things in perspective. We tend to make scientific points — regarding, for example, the fact that the human species has evolved in a radiation environment — in a manner which confuses most members of the public. Perhaps it would help if there were independent dialogue facilitators between us scientists on one hand and the public on the other. At all events, we should enter into the dialogue with open ears, open minds and respect for the public. The radioactive waste already exists, and the two sides have a lot in common — above all, a need to resolve the issue of how to manage that waste safely.

C. McCOMBIE (Switzerland): It seems to be generally agreed that radioactive waste can be stored safely, but not forever, and that currently the only feasible long term solution to the radioactive waste management issue is disposal. I, therefore, believe that even if you opt for long term storage, you should create disposal options for future generations by providing technology, funding and a site. In my view, it is unethical to store radioactive waste and not make preparations for disposal, and there are countries — for example, Spain and the United Kingdom — which are doing just that.

B. ROBINSON (Environmentalists for Nuclear Energy): Besides the chemical waste which is being disposed of in salt mines and coal mines, one should bear in mind the millions of tons of carbon dioxide which are being pumped into the atmosphere every year.

A. WALLO (USA): We in the nuclear industry should not feel that our industry is the only one being persecuted. Certainly in the USA, there is concern about hazardous chemical waste and, since 11 September 2001, there are task groups working on the risks associated with shipments not only of radioactive waste but also of hazardous chemical waste. Moreover, obtaining authorization to open a hazardous chemical waste disposal site is almost as difficult as obtaining authorization to open a radioactive waste storage facility.

R. LAHODYNSKY (Austria): The picture of the deformed rose shown by K. Sullivan caused ripples here in this room, but we scientists should remember that our illustrations are as a rule highly idealized. For example, our illustrations of proposed underground disposal facilities show homogeneous geological formations without any fault lines that might affect things like groundwater flow.

B.E. HEDBERG (Sweden): I should like to make three comments.

First, the expression ‘long term storage’ is being used very loosely. For some people, it means storage for 50 years, for others it means storage for 100 years, for still others it means storage for 300 years, and so on.

Second, people are saying that the nuclear industry and nuclear regulators need to earn trust. In my view, other participants in the dialogue, for example, Greenpeace, also need to earn trust.

Third, I think there is a need to help the public to gain a better understanding of comparative risks, for example, of the risks associated with radioactive waste as opposed to those associated with chemical waste, with naturally occurring radioactive material, with radioactive substances used in a wide variety of fields, and so on.

R. HEARD (South Africa): In the developing world, especially Africa, long term storage, which requires substantial resources and presupposes political stability, is not an option. We would prefer that the radioactive waste generated in our countries be disposed of straightaway.

I. R. HALL (United Kingdom): In view of the criticism voiced here of the United Kingdom, I should like to emphasize that our new strategy for the interim storage of intermediate level waste does not reflect a decision to do nothing but a decision to carry the public with us in arriving at a technical solution.

A. ZURKINDEN (Switzerland): It is generally assumed that proposals for the construction of a radioactive waste repository are more likely to be accepted by the public if they provide for a step by step approach combined with waste monitoring and retrieval. However, a step by step approach combined with waste monitoring and retrieval certainly does not guarantee public acceptance.

In 1995, in the Swiss canton of Nidwalden, a referendum was held on whether to grant an excavation concession for the establishment of a repository for low and intermediate level waste. The result was narrowly against the granting of the concession.

Subsequently, many people said that they had voted against because the project plans did not envisage a step by step approach or waste monitoring and retrieval. The project plans and the repository design were therefore modified, and the canton’s citizens were asked in September 2002 to vote on the granting of a concession just for the sinking of an exploratory shaft — it being understood that waste monitoring and retrieval would be possible in any repository that was ultimately built.

In the September 2002 referendum, there was a large majority against the modified plans.

A. NIES (Germany): I now invite concluding remarks from each of the Panel members.

K.-L. SJOEBLOM (IAEA): As I come from Finland, I should like to say a few words about the 2001 Decision-in-Principle of the Finnish Parliament, which has been widely praised.

The taking of the decision was facilitated by the fact that the planning leading up to it started already in 1984. Also, during the period from 1984 to 2001, the necessary funding for final disposal was created. Lastly, the relevant legislation provided that the prospective host municipality should have a veto right.

A. WALLO (USA): I should like to emphasize the importance of documenting why decisions are taken, especially if they are taken for social or political reasons rather than risk based or technology based ones. Only if we document the reasons will future generations be able to judge whether the decisions made sense at the time when they were taken.

P.P. POLUEKTOV (Russian Federation): In my country, spent fuel is not regarded as radioactive waste. Within the context of long term storage, however, spent fuel and radioactive waste are considered together.

Different countries have different ideas as to what is meant by 'long term storage', the envisaged period varying from about 50 years to thousands of years.

Several countries envisage storing their spent fuel for periods of not less than 50 years, after which the spent fuel will be reprocessed or placed in a geological repository.

D. BONSER (United Kingdom): In my view, governments must not only develop policies and take decisions designed to take account of the interests of future generations, they must also reduce the risks to this generation. Both storage and disposal are important in that context, but, as A. Zurkinden implied, success is not guaranteed.

M. BUSER (Switzerland): I should like to make three comments.

First, I agree with what R. Lahodynsky just implied — that there are geological risks associated with underground disposal.

Second, risk analyses for long term storage must take possible societal and political developments into account.

Third, in my view, our experience in Switzerland suggests that governmental representatives and other politicians need to become more directly involved whenever there is a dialogue regarding long term storage.

K. SULLIVAN (Educators for Social Responsibility): I, too, would like to make three comments.

First, the human species did indeed evolve in a radiation environment but, as we all know, there is a difference between natural radiation and man-made radiation.

Second, the impression has been created that the 1997 decision not to proceed with the Rock Characterization Facility at Sellafield was prompted solely by public opposition. In fact, it was prompted also by scientific arguments regarding the unpredictability of crack formation if a repository was built.

Third, I am concerned about the fact that the various stakeholders — the nuclear industry, governments, NGOs, affected communities and so on — are not talking much about whether we should be continuing to produce nuclear waste through the continuation of nuclear power generation and the continued production of fissile material. Quite enough nuclear waste is going to be produced through the decommissioning of existing nuclear power plants and nuclear weapons facilities.

GEOLOGICAL DISPOSAL OF RADIOACTIVE WASTE

(Session 4)

Chairperson

M.S.Y. CHU
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THE US NUCLEAR WASTE MANAGEMENT PROGRAMME
The path forward to licence application for a geological repository at Yucca Mountain

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Abstract

After completing more than 20 years of intensive scientific and engineering investigations at the Yucca Mountain site in Nevada, United States of America, the United States Department of Energy (USDOE) has determined that the site is suitable for hosting a nuclear waste repository. Following this determination, the site was recommended to the US President for repository development. The US President approved the recommendation and forwarded it to the US Congress for site designation. As provided by law, the Governor of Nevada vetoed the recommendation with a notice of disapproval to the US Congress. The US Congress subsequently overrode the Governor's veto with a joint resolution which the US President signed into law. With site designation in effect, the USDOE is now focusing its work on the development of a licence application for repository construction. The present paper summarizes the work that had been done to support site recommendation, work that is currently being done for licence application and the necessary next steps that may be required to allow repository operations to begin in 2010.

1. INTRODUCTION

Since the enactment of the Nuclear Waste Policy Amendments Act of 1987, the United States Department of Energy (USDOE) has focused its site characterization activities exclusively at Yucca Mountain in the United States of America, located about 160 kilometres north-west of Las Vegas in Nevada. The activities included extensive surface and subsurface testing, laboratory testing, analyses, studies, modelling and designs.

Most of the work has been performed by hundreds of scientists and engineers from contractor organizations, national laboratories as well as federal and state agencies. Major aspects of the work have been critically reviewed by the following federal bodies: the Nuclear Regulatory Commission (NRC), the Environmental Protection Agency (EPA), the National Academy of Sciences, the Nuclear Waste Technical Review Board (NWTRB), as well as peer review groups impanelled by the USDOE, state and local agencies, stakeholders and other interested parties. In addition, the international bodies that have provided critical review are the IAEA and the OECD Nuclear Energy Agency (OECD/NEA). Results of the site characterization have been documented in a comprehensive science and engineering report [1]. The publication of that report marked the end of formal site characterization at Yucca Mountain and pointed the way to site recommendation and licence application.

2. SITE RECOMMENDATION

After performing an elaborate evaluation in accordance with its published siting guidelines [2], the USDOE subsequently found the Yucca Mountain site to be suitable for hosting a repository [3]. On 14 February 2002, the US Secretary of Energy, after a comprehensive review of the science, testing and analyses that had been completed at the site, recommended to the US President that the site be developed as an underground repository for spent nuclear fuel and high level radioactive waste. Citing compelling national interests that warrant this decision, the Secretary stated that a repository was vital to:

— Ensure national security,
— Support energy security,
— Support nuclear non-proliferation objectives,
— Secure disposal of nuclear wastes,
— Provide for a cleaner environment.

Subsequently, on 15 February 2002, the US President approved the Secretary's recommendation and forwarded it to the US Congress for site designation.

Pursuant to the Nuclear Waste Policy Act of 1982, the Governor of the State of Nevada vetoed the recommendation by submitting a notice of disapproval to Congress on 8 April 2002. Congress overrode the Governor's veto with a joint resolution which the US President signed into law on 23 July 2002 effectively designating the Yucca Mountain site for repository development.

3. LICENSING REQUIREMENTS

With site designation in effect, the USDOE plans to submit a licence application to the NRC in December 2004 for construction authorization for the repository in 2008. The repository must be licenced in accordance with the NRC's licensing regulations [4] that implement the EPA's health and environmental protection standards [5].

The licence application is to contain general information and a safety analysis report, and is to be accompanied by an environmental impact statement. The general information is to include the following:

— A general description of the repository system,
— Proposed schedules for construction, receipt and emplacement of waste,
— A physical protection plan,
— A material control and accounting programme plan,
— A description of site characterization work.

The safety analysis report is to include the following:

— Preclosure repository safety,
— Post-closure repository safety,
— A research and development programme to resolve safety questions,
— A performance confirmation programme,
— Administrative and programmatic requirements.

It is anticipated that the final environmental impact statement [6] which accompanied the site recommendation would be updated to incorporate new information.

The NRC review of the licence application is to be conducted in accordance with a proposed Yucca Mountain review plan [7]. Upon successful completion of the review, a safety evaluation report would be issued by the NRC. As required by the NRC licensing rules [8], public hearings on the licence application would be conducted by an atomic safety and licensing board designated by the NRC. Final disposition of the licence application would be contingent upon the outcome of these hearings. The Nuclear Waste Policy Act of 1982 requires that the NRC submit an annual report to the US Congress on the status of the licence application. It also requires a final decision on the approval or disapproval of construction authorization within three years of submittal of the application. A one-year extension may be granted if warranted.

Should construction be authorized, the repository would be developed in stages, initially providing only limited operating capacity in 2010. Prior to start up of operations, a licence amendment would be submitted to the NRC to receive and possess nuclear waste.

4. THE PATH FORWARD TO LICENCE APPLICATION

Much work remains to be done in order to develop a technically defensible licence application by 2004. A synopsis follows of the work in progress which supports licence application.

The USDOE will continue pre-licensing interactions with the NRC to obtain closure on key technical issues prior to submitting a licence application. Documentation will be provided to the NRC for those issues which have been regarded as ‘closed pending’, and specific tests or analyses will be performed, as required, for those issues which remain open.

Scientific and engineering investigations will be continued. These investigations would be designed to address the concerns of the NWTRB regarding uncertainties in total system performance assessment projections, and in the long term performance of the repository and waste packages in a proposed high temperature repository environment.

Repository related work being conducted by the University of Nevada in Las Vegas and by Nye County, where the proposed repository is located, will continue to be supported. International collaboration on research which would enhance the nuclear waste management programme will also continue to be supported.

Key to a successful licence application is a strong quality assurance programme. The USDOE will ensure that appropriate quality assurance policies and procedures are implemented which will fully support the licensing process.

A definitive repository design will be developed for licence application. A preclosure safety analysis and a post-closure total system performance assessment would be conducted for this design in accordance with licensing requirements.

A performance confirmation programme, which was initiated during site characterization, will be expanded to incorporate additional testing and analyses. The additional tests and analyses would provide increased confidence that the repository system is functioning as expected.

A national transportation system will be developed for moving nuclear waste from civilian and government sites to the proposed repository. The transportation system would be integrated with the repository system in order to accommodate shipments upon arrival at the repository.

In co-ordination with affected USDOE organizations, the types, quantities and a schedule for acceptance will be developed for government owned nuclear waste. This will include consideration of the many types of USDOE spent nuclear fuel, some of which may require conditioning or stabilization before they can be accepted for disposal in the repository, as well as high level waste.

To facilitate the licensing process, an Internet based licensing support network will be developed. Such a network would allow interested parties to obtain access to key licensing documents for the legal purpose of discovery.

A total system life-cycle cost estimate and fee adequacy report will be prepared in support of the licence application. This would provide information to decision makers on the funding requirements and adequacy of the nuclear waste fund to carry the waste management programme through licensing, construction, operations and closure.

5. LONG TERM RESEARCH AND DEVELOPMENT

The USDOE plans to develop a long term science and technology programme at Yucca Mountain. The goal of such a programme would be to enhance confidence in the understanding and performance of the repository system; explore and develop new technologies which may be used in the construction, operation, closure and long term stewardship of the repository; and promote cost effectiveness in each phase of the waste management programme.

6. CONCLUSION

Formal characterization of the Yucca Mountain site in Nevada has been completed, and the site has been recommended to the US President for development as an underground repository for spent nuclear fuel and high level radioactive waste. The US President and the US Congress have approved the site for repository development. With site designation in effect, the USDOE plans to submit a licence application to the NRC in December 2004, for construction authorization in 2008. Given adequate funding and successful completion of the licensing process, nuclear waste could begin arriving at the repository by 2010.

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PANEL 1

WHAT ARE THE PRESENT AND FUTURE ISSUES AND CHALLENGES IN RELATION TO THE IMPLEMENTATION OF GEOLOGICAL DISPOSAL?

Chairperson: **M.S.Y. Chu** (United States of America)

Members: **S. Masuda** (Japan)
P. Zuidema (Switzerland)
Ju Wang (China)
V. Ryhänen (Finland)
C. McCombie (Switzerland)

Panel Discussion

V. RYHÄNEN (Finland): I should like to give a brief account of the Finnish programme for the final disposal of spent fuel.

The programme is based on a 1983 decision of the Finnish Government regarding the objectives of and the timetable for the programme. The period up to 1999 was a period of research and development work — with the development of technologies suitable for Finland's crystalline bedrock, with safety studies and safety analyses that we updated at regular intervals, with site investigations (which involved deep drilling) and with environmental impact assessments.

In 1999, we entered the first licensing phase, during which municipalities had a veto right. We applied to the Government for a licence in May 1999, and a hearing and review process started, with statements being requested from authorities and municipalities. Pursuant to our Nuclear Energy Law, both STUK (Finland's Radiation and Nuclear Safety Authority) and the municipality proposed as host of the final disposal facility had to submit a positive statement — otherwise the process would be broken off. In January 2000, STUK submitted a statement in support of siting the final disposal facility within the territory of the Eurajoki municipality (in western Finland) and the members of the Eurajoki municipal council voted (by 20 votes to 7) in favour.

In December 2000, the Finnish Government took a Decision in Principle in favour of locating the final disposal facility on Olkiluoto island in the Eurajoki municipality, where there are already power reactors. The Decision in Principle was ratified by the Finnish Parliament in May 2001 by 159 votes to 3.

We plan to start constructing an underground rock characterization facility in the summer of 2004, the idea being that the tunnels and shafts will become part of the final disposal facility, work on constructing the rest of which will start soon after 2010 and which will go into operation in 2020.

One could say that the decade 1990–2000 was a decade of mainly societal challenges, the principal challenge being to gain acceptance. The decade 2000–2010 will probably be a decade of technical challenges, but maintaining acceptance will be important, and the decade 2010–2020 will probably be a decade of industrial challenges, but with the maintenance of acceptance continuing to be important.

S. MASUDA (Japan): The process for the siting of a high level radioactive waste repository in Japan will start soon, with the circulation of an announcement to all Japanese municipalities (over 3000 of them).

The Nuclear Waste Management Organization of Japan (NUMO) will promote public involvement in decision making based on a stepwise decision making approach, voluntary participation by municipalities and transparency.

As announced in October 2002, municipalities will be invited to offer to host the envisaged repository. In the municipalities which volunteer, NUMO will carry out surveys for the purpose of identifying areas where preliminary, surface investigations may be carried out, with a view to selecting areas for detailed investigation, carried out both at the surface and underground.

We shall be sending to each municipality a package containing both information designed as a basis for discussion with stakeholders and the general public in the municipality, and instructions for applying to be considered a candidate municipality.

NUMO will also provide information about the criteria for being considered for preliminary investigation, for example, the absence of a record of significant tectonic movement, the absence of evidence of unconsolidated sediments and an absence of mineral resources.

There will be an outreach programme which takes into account the objections of local residents and arranges for volunteering municipalities to receive financial and other benefits.

One purpose of the stepwise decision making approach will be to help stakeholders and the general public to understand passive safety measures, which differ from the active safety engineering measures associated with surface storage.

Research and development will continue with a view to reducing the uncertainties associated with long term performance assessments, and thereby increasing the trust of stakeholders and the general public in passive safety.

M. AEBERSOLD (Switzerland): S. Masuda talked about helping stakeholders and the general public to understand passive safety measures. How will that be achieved?

S. MASUDA (Japan): Most stakeholders and most members of the general public are not familiar with the concept of passive safety. It will be necessary to familiarize them first with active safety.

P. METCALF (IAEA): You mentioned some of the criteria which will have to be met by an area in order to be considered for preliminary investigation. Will there also be national safety standards which will have to be complied with?

S. MASUDA (Japan): Compliance with such standards will become an issue at the licence application stage. At present, we are just starting the siting process.

JU WANG (China): I should first like to refer you to contributed paper IAEA-CN-90/20 entitled Progress on Deep Geological Disposal of High Level Radioactive Waste in China: 1999–2001.

The Chinese nuclear power programme is run by the China Atomic Energy Authority, with the China Environmental Protection Administration as the regulator. All activities relating to high level waste disposal are conducted by the China National Nuclear Corporation. It is estimated that there will be 1000 t of accumulated spent fuel from the Chinese nuclear power programme by 2010 and 2000 t by 2015, and that 1000 t of spent fuel will be produced each year thereafter.

China has plans to build, between 2030 and 2040, a national geological repository for high level waste (vitrified waste, transuranic waste and a small amount of CANDU spent fuel).

The Beishan area in Gansu Province, north-west China, has been selected as potentially the most suitable area, and a preliminary site evaluation has been carried out. However, possible areas in Inner Mongolia, south-west China, eastern China and southern China have also been identified. There are plans to build a site-specific underground research laboratory which could be developed into a repository.

It is expected that siting and site evaluation activities will have been completed by the end of 2015 and that the underground research laboratory will have been built by the end of 2030.

The IAEA has been involved in some of the activities directed towards the construction of a high level waste repository in China, through a technical co-operation project on siting and site evaluation, and research contracts for hydrogeological studies on low permeability granite and for natural analogue corrosion studies on bronzeware relics.

A.V. GIL (USA): Could J. Wang describe the regulatory arrangements in China?

JU WANG (China): Within the China Environmental Protection Administration, the regulator, is a nuclear safety administration which issues licences for nuclear facilities. The China Atomic Energy Authority develops policies for radioactive waste management and disposal.

J. GREEVES (USA): Could you describe China's licensing process?

JU WANG (China): The licensing process in China is broadly similar to that in the United States of America.

Procedures have not yet been established for high level waste disposal, but for low level waste there has to be a site evaluation and an environmental impact assessment, which is reviewed by the China Environmental Protection Agency.

P. ZUIDEMA (Switzerland): I should like to talk about the key lessons learned with regard to the concept, the scientific basis and societal views.

With regard to the concept, before you embark on a siting exercise, you should be very clear about your ultimate goal. Otherwise, you will soon be in difficulties.

In Switzerland, the concept has recently been re-evaluated by an independent group of experts — a group independent both of the implementers and of the regulators, so that it is perceived to be neutral.

The experts concluded that passive safety is the most important issue and agreed that one can probably have much more confidence in the stability of geological formations than in that of society — so that the ultimate aim should be geological disposal.

However, we have heard at this conference about the importance of societal views. Given the views of society, there is a need to provide for post-closure monitoring and for reversibility or retrievability. We have also heard about interim storage between the arising of the waste and final disposal — the only question being 'for how long?'

As regards the role of partitioning and transmutation, that is rather country specific. It is not very important in Switzerland.

When one engages in a siting exercise, one needs a sound scientific basis. At any given stage, the selected system must be promising enough for one to proceed to the next stage. That means that the level of confidence and safety must be sufficiently high.

The level of confidence and safety is based on the level of understanding, which depends on the existence of a sufficient data set that is understood.

It is very important to be able to indicate the possibilities for resolving open issues, which brings us to the question of robustness and flexibility. At least in the early stages, one must be prepared for the unexpected — prepared to fully accept the uncertainties. That means that the repository must be able to live with the uncertainties or one must have the flexibility necessary for taking appropriate measures.

For us in Switzerland, it is important to see what level of confidence we have at the point where we would say 'the major political decisions are taken before going on the ground'. What we want is a fairly high level of confidence that, after the burden of the political debate, we will not find that 'unfortunately it does not work' and the project 'goes down the drain'.

We have also heard that the final test is the views of society. There, the key issue is the decision making process. Is it clearly defined? Is it accepted? The interactions have to be clear. Who should say what, and when, and how does that person become involved? One thing we have learned is that it is difficult to deal with groups which have a hidden agenda — which are not interested in solving the problem but wish to use the radioactive waste management issue as a platform for something else.

What we see in Switzerland is the public's perception of the decision makers, which is very important for decision making. Of course, Switzerland is a special case because of the widespread use of referendums. We had, I think, six referendums, all of them positive, because we had established a personal relationship. There the people can perceive what you are doing and can say 'yes, it may be right to go ahead'.

It is much more difficult if you go to the intermediate level, where people are affected but do not have an opportunity to learn the facts behind it. They perceive it rather differently, and often the process is misused.

What I think is very important is that these three items be clearly and properly justified — or at least that we have the arguments as to why it is 'this' and not something else. So it brings us back to the concept, but also to the site and the design — why here and not somewhere else, and why now and not at some time in the future?

In this context, it is also important to clarify the alternatives so that if, with the stepwise approach, it turns out that the site is not suitable, one has alternatives and does not have to push ahead with something irresponsible.

C. McCOMBIE (Switzerland) I should like to say briefly why I — unlike P. Nygårds — think that international or regional deep geological repositories will inevitably have to be built.

All countries with nuclear power programmes — and also all other countries that produce long lived radioactive waste — are going to need access to a deep geological repository. Some of those countries will be able to build their own repositories. However, in Europe, for example, there are about 25 countries that will need access to a deep geological repository, which means that there would have to be 25 to 30 repositories in Europe — a territory of roughly the same size as the USA, which will have just two repositories. The situation is broadly similar in South America and Asia. So I think the advent of international or regional repositories is inevitable.

C. PESCATORE (OECD/NEA): I do not think that the advent of international or regional deep geological repositories is inevitable on safety grounds. Does C. McCombie believe that their advent is inevitable on financial grounds, because some countries do not have enough money or are not putting enough money aside?

C. McCOMBIE (Switzerland): A deep geological repository will cost $1 billion wherever and however it is built. Some countries will not have $1 billion to spend on one; some should not be spending $1 billion on one, because there are much better things that they could do with the money.

C. PESCATORE (OECD/NEA): So you are saying that the advent of international or regional repositories is inevitable on financial grounds.

C. McCOMBIE (Switzerland): There will simply not be dozens of $1 billion repositories around the world, and without international or regional repositories, some countries will be unable to dispose of their long lived waste, which they will also be unable to keep safe for the time it needs to be kept safe for.

HOW TO ACCOMMODATE NUCLEAR SAFEGUARDS REQUIREMENTS FOR SPENT FUEL IN A FINAL DISPOSAL FACILITY

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Abstract

Following the decision in 2001 to locate the spent nuclear fuel final disposal site in Olkiluoto, Finland, planning of the final disposal in Finland has been site specific. The Olkiluoto final disposal facility includes both the encapsulation plant above ground and the underground disposal area. Safeguards approaches are being developed for both. Even though the overall safeguards requirements, aiming at non-proliferation of nuclear materials, may be the same for the whole facility, implementation will differ. Different operational phases of the repository (pre-operational, operational and post-closure), also call for a different implementation of safeguards. The basis of national safeguards requirements is in Nuclear Energy Law. It stipulates that Finland's Radiation and Nuclear Safety Authority (STUK) shall be responsible for the necessary control of the use of nuclear energy to prevent the proliferation of nuclear weapons. In addition, the goal is to optimize their overall implementation in a way that satisfies the requirements of all parties, does not risk long term safety and does not cause an undue burden to any party or future generations. First safeguards measures including baseline mapping may need to be implemented as early as 2003 in Olkiluoto. Defining the safeguards requirements for a completely new facility type has proved not to be straightforward. In addition to the requirements of STUK, the requirements of the IAEA and the Euratom Safeguards Office (ESO) also need to be considered properly.

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1. INTRODUCTION

Spent nuclear fuel produced in Finland shall be disposed of in Finland. This is the only credible and known option at the moment. The requirement for nuclear waste management by the licence holders (power companies) was included in the Amendment to the Nuclear Energy Act, already in 1978. The Government Decision in Principle (DiP) in 1983 specified the objectives to be observed in carrying out research, surveys and planning in the field of nuclear waste management.

So far, the schedules outlined in the Government DiP in 1983 have been kept. The next phase, scheduled for 2001–2010, includes building underground facilities for rock characterization and site confirmation investigations. Construction of this research facility, ONKALO, is scheduled to start in 2004. According to the plans, the research facility may form a part of the final repository. A separate construction licence is required to start construction of the underground repository around 2010. Encapsulation and final disposal are scheduled to start in 2020 and will be based on a separate operating licence. According to the present understanding, the four operating nuclear power plants would be closed around 2020. If their operating time is extended and/or more reactor units will be built, operation of the repository may be extended beyond 2050.

The design of the final disposal facility and the beginning of the pre-operational phase, including the construction of ONKALO, call for defining the safeguards requirements on the level influencing the facility design and the planned investigation phase.

2. FINAL DISPOSAL OF SPENT FUEL IN OLKILUOTO

The site selection process was focused on Olkiluoto when the waste management company, Posiva Oy, applied the DiP from the Parliament to construct the final disposal facility specifically for one location, Olkiluoto. In the positive decision of the Government in December 2000, the final disposal facility was found to serve the overall good of society. The decision was ratified by the Parliament on 18 May 2001. The decision covered only the spent fuel produced by the existing reactors, however, in the DiP ratified by the Parliament on 24 May 2002 concerning construction of the fifth nuclear power reactor, it was decided that the planned repository was to include also the spent fuel from the fifth unit.

2.1. Spent fuel inventory

Production of nuclear power began in Finland in 1977, when the first power reactor, VVER-440 type Loviisa 1, was put into use. The second light water reactor (LWR) unit, Loviisa 2, was put into use in 1980. In the beginning, the fresh fuel supplier for both of these units was the Soviet Union. Since the Amendment to the Nuclear Energy Act in 1994, export and import of nuclear waste have been prohibited. Spent fuel of the Loviisa nuclear power plant (NPP) is being stored in storage pools of the interim storage located at the site. This decision contributed to establishing, in 1996, that the waste management company Posiva take care of the final disposal of spent fuel of both nuclear power companies, TVO Oy (Olkiluoto) and the Fortum Power and Heat Oy (Loviisa).

Nuclear power production was increased in 1978 and 1980 when the boiling water reactor (BWR) power reactors Olkiluoto 1 and 2 came into operation. The supplier of the reactors was Asea-Atom, Sweden. All spent BWR fuel produced in Finland will also be disposed of in Finland.

LWR fuel is imported into Finland as ready-made fresh fuel assemblies. No mixed oxide fuel has been used. The estimated operational lifespan for the present power plants units is 40 years, i.e. shutdown in around 2020. After this time, the expected total spent fuel inventory will be around 2600 tU. In the case where the lifespan is 60 years, the spent fuel inventory would be around 4000 tU. The spent fuel inventory of the present four power reactors is shown in Table I. During the annual reloadings of the four power reactors, in all about 70 t of spent fuel is replaced with fresh fuel. After initial cooling for a few years, fuel assemblies are moved to wet interim storages to await final disposal.

TABLE I. INVENTORY OF THE LWR SPENT FUEL IN FINLAND

Unit	Operating since	Spent fuel inventory (end of 2001)		Expected spent fuel inventory after 40 years of operation	
		tU	Assemblies	tU	Assemblies
Loviisa 1 Loviisa 2	1977 1980	267	2344	1000	6 500
Olkiluoto 1 Olkiluoto 2	1978 1980	897	5272	1600	10 000
Total		1164	7616	2600	16 500

Note: Planned operational lifespan of the present reactors is 40 years.

In addition to the power reactors, nuclear fuel of the FiR 1 research reactor includes about 60 kg of enriched uranium (EN 20%), partly in irradiated and partly in fresh fuel rods. The reactor was put into use in 1962. The future use of this reactor is open; the decision is expected around 2004. If the decision is to continue the operation, spent fuel needs to be disposed of in Finland in time. If the decision is made to close the reactor by May 2006, spent fuel may be returned to the United States of America.

2.2. Facility planning

For the time being, Posiva Oy has two basic options to construct the encapsulation plant in Olkiluoto. The primary option includes an independent plant and it is described in detail in Ref. [3]. The second option is to construct the encapsulation plant in connection with the existing AFR storage, TVO KPA store [4]. Both options will require spent fuel shipments, mainly from the Loviisa NPP. Figure 1 shows the location of the planned Olkiluoto underground repository, its conceptual draft design and the location of the independent encapsulation plant (option 1).

3. REGULATORY CONTROL OF FINAL DISPOSAL

3.1. Legislative basis

The national safeguards requirements in Finland are based on the national needs, legislation and international framework aiming at promoting the non-proliferation of nuclear weapons. The INFCIRC/153-type safeguards agreement entered into force on 9 February 1972 in Finland (INFCIRC/155). This agreement was suspended on 1 October 1995, on which date the agreement (INFCIRC/193) between Euratom, the non-nuclear-weapon States of Euratom, and the IAEA entered into force in Finland.

Responsibilities and rights of different parties involved in the production of nuclear energy are stipulated in the Nuclear Energy Act (990/1987, Amendment 1994 1§):

> "To keep the use of nuclear energy in line with the overall good of society, and in particular to ensure that the use of nuclear energy is safe for man and the environment and does not promote the proliferation of nuclear weapons, this Act prescribes general principles for the use of nuclear energy, the implementation of nuclear waste management, the licensing and control of the use of nuclear energy and the competent authorities."

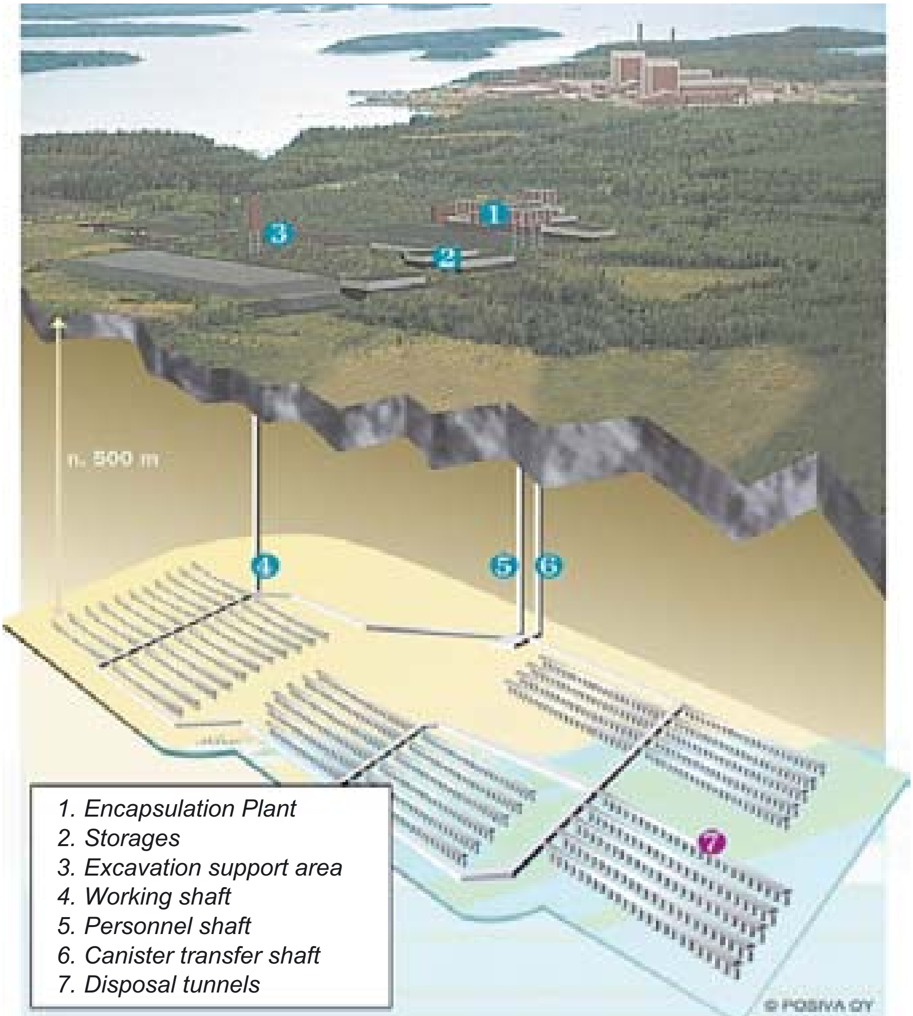

FIG. 1. The Olkiluoto final disposal facility will be located next to the existing NPPs, Olkiluoto 1 and 2, and the spent fuel interim storage TVO KPA store.

This is also the basis for developing safeguards for final disposal.

Safeguarding final disposal differs fundamentally from the existing nuclear fuel cycle and facilities. The final disposal facility in Finland includes an encapsulation plant and an underground repository. Both of them will be designed and constructed in parallel. The encapsulation plant looks more like a conventional facility, but its fuel handling processes differ clearly from conventional processes.

The repository, however, is completely different. It is planned to be under constant construction and operation several hundred metres below ground for decades. The final disposal process in Finland is meant to be irreversible. In addition, for safety reasons, the final disposal rooms need to be closed without needless delay. For specific reasons, however, the retrieval option has to be kept in mind. This complicates further the specification of the safeguards requirements. The repository is a facility that will be under constant change of design. It will be a challenge even for the national authorities to monitor the whole process and even more so to create knowledge and maintain it for decades. No experience of such facilities is available. Furthermore, there is no guarantee that the present requirements will also be the requirements of future society.

One of the key questions related to the final disposal safeguards will be the creation of knowledge about the nuclear material to be disposed of. Preliminary State system of accounting and control (SSAC) considerations, especially concerning the need for independent final verification, have already been presented [1]. Future planning of safeguards is guided by understanding the challenges related to the new facility type and the principle of not transferring undue burdens to future generations. Accordingly, the basic principle to be followed includes active creation of knowledge, enabling judgement over the correctness and completeness of the declared data before encapsulation, and assuring continuity of the knowledge during the future decades. This will allow and require the parties involved to settle conclusively and in a timely manner all open questions related to fulfilling the national and international safeguards commitments.

According to the IAEA policy paper [2], once the repository is backfilled and sealed, safeguards are maintained as long as safeguards agreements remain in force. The safeguards measures to be implemented after closing the repository will differ from the conventional measures applied when the nuclear material is accessible. In the future, only those methods can be applied which maintain the knowledge created earlier. In planning the safeguards for final disposal, the post-closure phase also has to be taken into account.

When operation of the final disposal facility is scheduled to start around 2020, implementation of the Integrated Safeguards (IS) is believed to offer new possibilities for the IAEA to create credible assurance of the absence of undeclared nuclear materials and activities in Finland. These methods include complementary access, increased information and State evaluations. Implementing practical safeguards measures will be more effective and efficient than before. Increased co-operation in safeguards between the State, the Euratom Safeguards Office (ESO) and the IAEA is possible and well motivated. Confidence building and national security will, however, remain one of the highest values guiding the implementation of the national responsibilities of Finland.

Reaching the goals discussed above is believed to satisfy all requirements related to nuclear material safeguards also in the future.

3.2. Regulatory guidance

The highest licensing authority concerning nuclear material safeguards in Finland is the Ministry of Trade and Industry. The regulatory authority, the Radiation and Nuclear Safety Authority (STUK), is maintaining the national central database of nuclear materials. STUK also develops the State system. It ensures that licence holders' activities are based on the legislation, regulations and guides related to safeguards.

The indisputable responsibility of safeguarding nuclear material is on the operator. This covers the fuel cycle of nuclear power production and also final disposal.

By virtue of acts and regulations, STUK issues detailed guidelines that apply to the safe use of nuclear energy, physical protection, emergency preparedness and safeguards. The following guides are related to safeguards:

— YVL Guide 6.1 Control of nuclear fuel and other nuclear materials required in the operation of nuclear power plants.
— YVL Guide 6.5 Regulatory control of nuclear fuel transports.
— YVL Guide 6.9 The national system of accounting for and control of nuclear material.
— YVL Guide 6.10 Reports to be submitted on nuclear materials.
— YVL Guide 8.4 Long-term safety of final disposal of spent fuel.
— YVL Guide 8.5 Operational safety of disposal of spent nuclear fuel (Draft).

The draft guide YVL 8.5 defines safeguards requirements on a rather general level. The basis is the Government Decision (478/1999 23 §). It stipulates that "the design, construction, operation and closure of a disposal facility shall be implemented so that control of nuclear materials can be arranged in accordance with pertinent regulations."

Accordingly, the transport and transfer routes, buffer stores, handling processes and control of nuclear material shall be designed and planned so that information generation, knowledge creation and continuation of knowledge is ensured at every step. There shall be a possibility to control material flows in and out of the underground rooms. The spent fuel canisters shall be identifiable.

The nuclear material data shall be verifiable by non-destructive methods to check the authenticity and completeness of information. Comprehensive verification of the nuclear material data can be carried out either at the encapsulation plant or before transfer to the encapsulation plant. In the latter case, the fuel assemblies shall be identifiable at the encapsulation plant.

Continuation of knowledge shall be confirmed including confirmation that transport canisters are not opened during transport. If continuation of knowledge is lost after verification, nuclear material data shall be reverified.

The aim of the control of the underground part of the disposal facility is to ensure that there are no rooms, materials or operations outside the area that is subject to nuclear material accounting and control, and that the spent fuel disposal canisters remain in their declared positions during operation and are not removed after closure of the facility.

The information on nuclide composition of the fuel assemblies inferred from safeguards measurements can also be used for the purposes of controlling criticality and heat production. The systems for monitoring radioactive discharges and the environment may be used to ensure that no undeclared operations are carried out at the final disposal facility.

In addition, the requirements of the national nuclear material accounting and reporting system shall be followed as applicable. In particular, it should be noted that the basic technical data required by the Commission Regulation 3227/76 (Euratom) shall be provided to STUK and to the European Commission not later than 200 days before the start of the construction of the disposal facility. More specific requirements will be made later on, as needed.

To support the development and implementation of the regulatory control of STUK, an independent national expert group, LOSKA, was established in April 2002. The expertise of the group includes those foreseen to play a role in implementing the IS measures in the future. The group includes five independent experts from the following disciplines:

- International agreements,
- Complementary access,
- Satellite monitoring and aerial photography,
- Environmental sampling (ES) and wide-area environmental sampling (WAES),
- Non-destructive assay (NDA) of nuclear material,
- Safeguards safety interface questions,
- Geophysical methods.

The LOSKA group will support STUK in developing technical safeguards requirements, in implementing safeguards and in evaluating the plans of the licence holders. In addition, the group may be used for R&D purposes, depending on future needs. The overall process of developing requirements and implementing safeguards by the STUK is shown in Fig. 2.

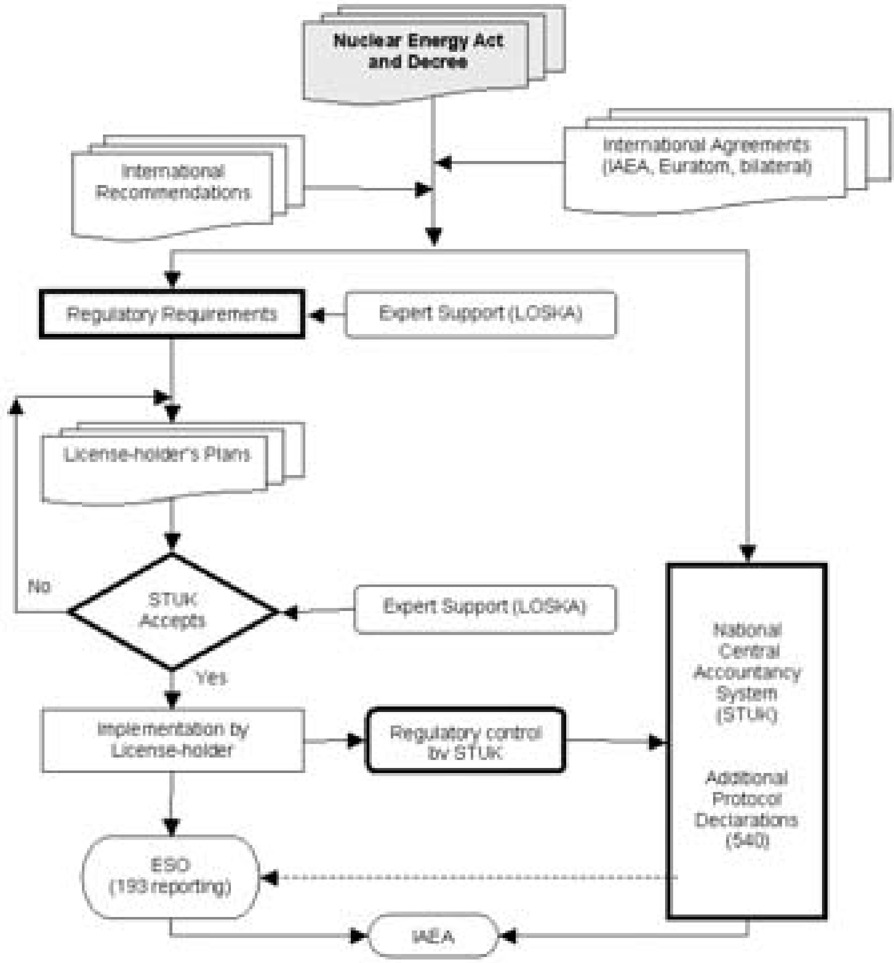

FIG. 2. The process of developing requirements and implementing safeguards related to final disposal in Finland.

4. SAFEGUARDS R&D AND PRELIMINARY IMPLEMENTATION PLANS

The final disposal facility, including the encapsulation plant and the final repository of spent fuel, will be located at Olkiluoto. The preliminary safeguards concept developed is based on having the encapsulation plant as an independent facility on the final disposal site [3]. The plant will receive spent fuel in casks from both nuclear power plants, Olkiluoto and Loviisa. The elements of the fuel cycle that are used as a basis for the development of this safeguards concept are schematically described below in Fig. 3.

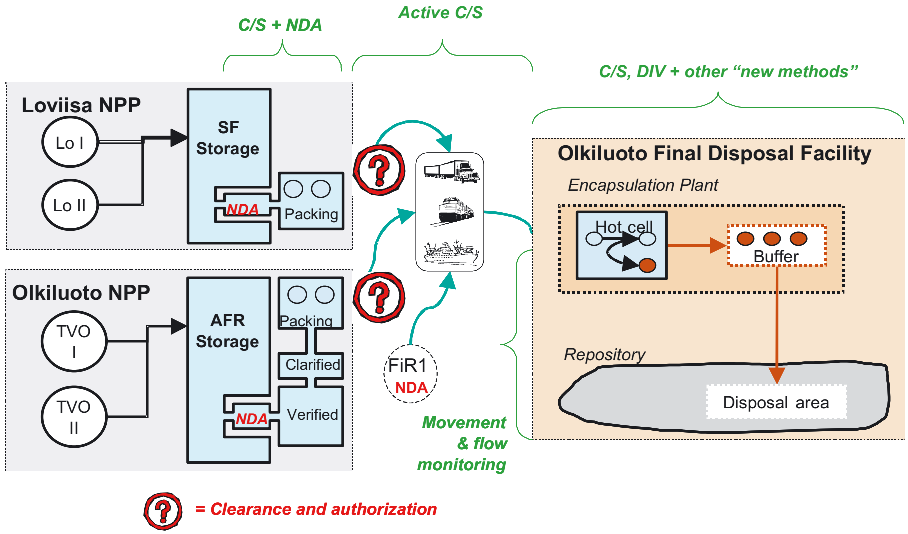

FIG. 3. A schematic picture of the planned safeguards measures related to final disposal of spent fuel in Finland.

According to the preliminary plans developed by STUK, the spent fuel assemblies would be measured and verified at the shipping facilities (NDA) to establish an accurate and correct factual basis for knowledge creation. The assemblies would be transported under instrumental safeguards monitoring, i.e. containment and surveillance, and received at the encapsulation plant using shipper's data. Nuclear material accountancy verification would no longer take place either at the encapsulation plant or thereafter in the final repository.

In the hot cell, the assemblies would be placed into the disposal canister, which will be closed, inspected and transferred down into the final repository. The encapsulation and transfer into the final repository will be continuous processes. The processes will be transparent, monitored and they will be accessible at least for visual observation. Minimum interference to the ongoing process is required. The preliminary safeguards concept is based on the establishment and maintenance of the continuity of knowledge through instrumental means and institutional action.

This means that the maintenance of the continuity of knowledge will play a central role in drawing safeguards conclusions. Authentic measurement results and other findings during storage, transportation and handling would be made available in a timely manner by the Finnish national system through secure communications to all parties who need to know. The continuity of knowledge about the identity and the content of the spent fuel in the assemblies and canisters disposed will be maintained. The optimum combination of inspections, use of monitoring, containment and surveillance technology as well as complementary access and design information verification (DIV) visits would be facilitated so as to make it possible for the parties to draw their respective conclusions with confidence. If needed, a special inspection may also be carried out by the IAEA.

The safeguards measures proposed can be carried out based on the existing technology; mainly facility specific implementation is required. The following features of the preliminary concept can be highlighted:

— Final disposal calls for enhanced knowledge creation and maintenance to allow responding to all present and future questions challenging the safe and secure disposal of spent fuel.
— In addition to active knowledge creation by the SSAC during interim storing, a final verification is proposed at the shipping MBA to show that all material data are correct and complete. Increased co-operation between national and international parties may offer cost effective implementation of Integrated Safeguards at the encapsulation plant.
— All parties involved (including the operator, STUK, ESO and the IAEA) shall clarify any open questions related to individual assemblies before they become difficult or impossible to access upon loading into the disposal canister in the hot cell of the encapsulation plant.
— Continuity of knowledge shall be maintained in a credible way throughout the final disposal phase lasting several decades.
— The encapsulation plant and process are designed to offer transparency for all parties involved (visual, containment and surveillance, complementary access).
— In addition to the DIV, environmental sampling may be used to reveal undeclared operations or materials.
— Safety and security measures implemented by the operator may offer additional information to satisfy safeguards requirements of parties involved.

The knowledge created before and upon encapsulation makes it possible to design a safeguards approach for the underground repository that is cost effective and does not risk the continuity of the final disposal process.

5. CONCLUSIONS

Development of safeguards for the final disposal in an early phase is in the interest of all parties involved. The Olkiluoto final disposal facility will have an important role in the future, forming one kind of model for safeguarding a final disposal facility in a non-nuclear-weapon State. As the competent State authority, STUK is responsible for specifying safeguards requirements for final disposal in a way that all national requirements and the requirements of the IAEA and the ESO will be covered. Due to its regulatory control rights, STUK is in a position to monitor all plans and activities related to regulatory safeguards and safety control.

Because no earlier experience is available, STUK is developing national system requirements based on the Nuclear Energy Act. In the implementation, the requirements of the IAEA and ESO will also be taken into account. The key requirement is to prevent the proliferation of nuclear weapons. Making sure that the declarations represent the actual reality, namely, that all nuclear material imported into the country is handled and used as declared, is stored in the interim as declared and is disposed of as declared, will allow the desired conclusion to be drawn with confidence. The knowledge created and maintained makes it possible to make available data and information to other parties for their analysis and evaluation in a way that independent and timely conclusions can be drawn. When conditions enable all parties to conclude at the encapsulation phase that there are no open questions related to the material subject to the disposal, the development of a safeguards concept and approach for the underground repository will be much easier to carry out.

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Discussion following paper by M.J. Tarvainen, J. Rautjärvi and A. Tiitta

P. METCALF (IAEA): Have you identified any potential conflicts between safeguards requirements, on one hand, and safety requirements, on the other?

M.J. TARVAINEN (Finland): We have tried to avoid such potential conflicts by being flexible.We did not start by asking ourselves what was necessary from the safeguards point of view. We started from the factual situation and the associated safety requirements, and then, using common sense, considered the safeguards requirements.

S.V. BARLOW (United Kingdom): In your presentation, you talked of continuity of knowledge being maintained throughout the final disposal phase. What would be done about continuity of knowledge after closure of the repository, given the fact that classical safeguards involve periodic physical reverification of the safeguarded nuclear material?

M.J. TARVAINEN (Finland): You have put your finger on a difficult issue. In classical safeguards, one ensures continuity of knowledge between periodic inspections for which the safeguarded nuclear material must be available. If, for example, the seal on the container with the nuclear material has not been tampered with, the inspectors do not have to look inside the container or take other steps to ensure that the nuclear material is still there. There is continuity of knowledge with periodic physical reverification through inspections which take place frequently enough to ensure that, if nuclear material were removed, its removal would be detected in time for action to be taken to prevent its use in the construction of a nuclear explosive device.

When nuclear material is deep underground in a repository which has been closed, it will not be available for periodic physical verification. This is an unmapped area which the IAEA and the rest of the international community will have to consider in detail.

PANEL 2

HOW WILL NUCLEAR SAFEGUARDS REQUIREMENTS AFFECT THE DESIGN AND POST-CLOSURE MANAGEMENT OF GEOLOGICAL REPOSITORIES? WHAT KNOWLEDGE IS REQUIRED FOR THE FUTURE AND HOW WILL IT BE RETAINED FROM SAFETY AND SAFEGUARDS PERSPECTIVES?

Chairperson: **M.S.Y. Chu** (United States of America)

Members:
A.J. Hooper (United Kingdom)
M.J. Tarvainen (Finland)
G. McCarthy (Australia)
C. Pescatore (OECD/NEA)
B.W. Moran (United States of America)
P. Button (Canada)

Panel Presentation

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1. PREFACE

Canada has not committed to building a geological repository for the disposal of spent fuel. A waste management organization has recently been formed to make recommendations to the Canadian Government. It is due to report in three years' time. The following comments do not pre-empt any decision by the Canadian Government.

2. SAFETY, SECURITY AND SAFEGUARDS

Besides the extensive work on safety, security and safeguards will be significant issues for a future repository. It is clear that safety is the highest priority, the others are also very important. Security will be a domestic concern. Safeguards are an obligation each State may have with the IAEA. From a safeguards perspective, we would prefer to see a geological repository used for disposal of spent fuel rather than any surface storage arrangement.

3. TIME-SCALE

It is important to note that safeguards agreements are indeterminate. They remain in force until terminated. In particular, we must expect them to be in force after repository closure.

4. CONCEPT

For safeguards purposes, we plan to consider the repository as one large underground enclosure. We plan to monitor accurately the nuclear material that enters and verify that no material leaves. We will be particularly concerned about monitoring exits, checking for illegal openings and illegal excavations.

5. MONITORING

It is clear that we cannot violate any containment determined for safety purposes. Indeed, in our view, this should not be necessary. Monitoring for safeguards need not be intrusive. Indeed, it is the view of most safeguards experts that they would prefer not to put instrumentation into a working area. We envisage portal and surface monitoring.

6. RETRIEVABILITY

The possibility of retrieval certainly makes safeguards more complicated.

Personally, I would prefer to see drifts backfilled when complete. Note that backfilled material (hard rock repository) could be retrieved if necessary.

7. DESIGN INFORMATION

Safeguards will be very interested in the planned and as built design of the repository.

We will need to determine all possible paths for removal of material. We will also be interested in site characterization data (including data from before the site was disturbed) and any information on pre-existing boreholes and excavations.

8. CLOSE

Thank you for inviting the safeguards community to your meeting. I belive we can and must work together to ensure optimal use of resources and avoidance of potential conflicts.

Panel Discussion

B.W. MORAN (USA): I shall try to allay some of the fears of radiation safety people about the impact of IAEA safeguards on a geological repository.

The objective of the IAEA's comprehensive (INFCIRC/153-type) safeguards is "the timely detection of diversion of significant quantities of nuclear material from peaceful nuclear activities to the manufacture of nuclear weapons or of other nuclear explosive devices or for purposes unknown, and deterrence of such diversion by risk of early detection." That means that, as long as the uranium and plutonium in spent fuel is considered to be usable for the manufacture of a nuclear weapon or another nuclear explosive device, there needs to be active monitoring in order to detect any diversion.

An INFCIRC/153-type safeguards agreement between a State and the IAEA should contain "an undertaking by the State to accept safeguards ... on all source or special fissionable material in all peaceful nuclear activities within its territory ... for the exclusive purpose of verifying that such material is not diverted to nuclear weapons or other nuclear explosive devices."

Against that background, in 1998 the following IAEA safeguards policy statement was formulated by a group consisting of, among others, safeguards experts, nuclear regulators and nuclear waste management specialists from 15 States: "Spent fuel disposed in geological repositories is subject to safeguards in accordance with the applicable safeguards agreement. Safeguards for such material are maintained after the repository has been backfilled and sealed, and for as long as the safeguards agreement remains in force. The safeguards applied should provide a credible assurance of non-diversion." So there was a significant international consensus that IAEA safeguards on spent fuel in a geological repository would not be terminated when the repository was closed.

The safeguards measures would depend on the level of activity at the repository and on the accessibility of the spent fuel. An operating repository would have spent fuel being moved about and fairly accessible. It would therefore be necessary to verify the repository design and to keep track of the spent fuel movements and of other activities in order to know what material goes into the repository, and to be sure that no material leaves the repository — and that there is no clandestine reprocessing plant inside the repository.

In a passive repository (a repository where operations have stopped but which has not been closed and sealed), there would be no spent fuel movements but the spent fuel would remain potentially accessible. In that case, the safeguards would consist just of verifying the repository design and monitoring in order to detect any removals of material.

In the case of a backfilled closed repository, the safeguards would consist merely of verifying the absence of activities carried out for the purpose of gaining access to the repository.

In the safety area, the design basis threat is the release of radioactive material to the environment as a result of natural processes taking place over long time periods. In the area of domestic security or domestic safeguards, the design basis threat is radiological sabotage, or the theft of material for explosive or radiological devices by terrorists, criminals or other individuals. In the area of IAEA safeguards, the design basis threat is the diversion of nuclear material by States for the manufacture of nuclear weapons or other explosive devices. The threat in the safety area is a longer term one than the threats in the other two areas but, thanks to our knowledge of natural processes, more predictable, so that monitoring for safety purposes can be more passive. As long as the threat in the IAEA safeguards area remains credible, monitoring by the IAEA must be relatively active.

T. FLÜELER (Switzerland): Could B.W. Moran say something about his views regarding accessibility in the case of disposal and in that of storage?

B.W. MORAN (USA): If spent fuel is placed in a repository that remains open (which is what will happen in the United States of America), I regard that repository as a passive repository. With above ground storage, there will be much greater accessibility, but the concept level is the same as long as there are no shipments into or out of the facility; there is no need to verify inventory changes, but there is a need to verify that all items are still present and that no removal of spent fuel has occurred.

The IAEA is already implementing safeguards based on this thinking at the spent fuel storage facility at Ahaus, Germany.

T. FLÜELER (Switzerland): Is a distinction made between various security levels, for example, those attributed to above ground storage facilities, underground storage facilities, deep underground storage facilities, non-sealed repositories and sealed repositories?

B.W. MORAN (USA): The IAEA's international safeguards concepts are based on credible diversion paths. For domestic safeguards and physical protection, the design of the physical protection system will depend also on the most credible threats of terrorist action involving the spent fuel at each particular location.

P. BUTTON (Canada): Canada has not committed itself to building a geological repository for the disposal of spent fuel. A nuclear waste management organization has recently been formed, and it is due to report — with recommendations — to the Government in three years' time.

Safety will clearly be the highest priority if a repository is built, but security and safeguards will also be important issues. Security will be a domestic issue, whereas safeguards will be based on obligations which Canada has vis-à-vis the IAEA under an agreement which we expect will still be in force after repository closure.

For safeguards purposes, we plan to regard the repository as one large underground enclosure. We shall accurately monitor the nuclear material that enters the repository and verify that no nuclear material leaves it. In particular, we shall check for illegal openings and illegal excavations.

Clearly, we in the safeguards area would not violate any containment installed for safety purposes, but we do not think that would be necessary. Monitoring for safeguards purposes need not be intrusive; we envisage portal and surface monitoring.

The possibility of retrieval makes safeguards more complicated, and I would prefer to see drifts backfilled when complete. However, it should be borne in mind that, in a hard rock repository, nuclear material in a backfilled drift could be retrieved.

We will be very interested in the repository design, as we will have to identify all possible paths for the removal of nuclear material. We will also be interested in data about the site (including data from the time before the site was first disturbed) and in information about pre-existing boreholes and excavations.

A.J. HOOPER (United Kingdom): I am representing what one might call the 'deep geological repository community', particularly those of its members who are concerned with long term safety, and I know very little about safeguards. However, I have in the past noted that there are potential conflicts between safety and safeguards requirements, but I have been somewhat reassured by what I have heard at this conference — especially what I consider to be quite a powerful message regarding the intention to ultimately place nuclear waste deep underground so that major industrial activities would be necessary in order to bring that material back to the surface.

In my view, much of what we in the deep geological repository community are calling for will be important for safeguards, for example, the unique identification of waste packages, with markings that will be durable under repository conditions. For long term safety reasons, we are ensuring that repositories will be designed in such a way that there will be no ready release routes — also important for safeguards, since ready release routes could facilitate the clandestine removal of nuclear material.

The people in charge of some deep geological repository programmes are considering the idea of what we in the United Kingdom call 'phased disposal', which in effect means underground storage for a potentially very long period. Then there is the rather interesting idea of gradually reducing the level of reversibility of disposal. However, this would necessitate institutional controls and record-keeping over long periods, especially in order to prevent accidental intrusion into so-called ‘passive repositories’.

C. PESCATORE (OECD/NEA): Coming from the safety side, I have been heartened by things which A.J. Hooper and others have said at this conference about extended periods of institutional control and retrievability and about the need for continuity of knowledge.

I should like to start by posing two questions:

— How will nuclear safeguards requirements affect the design and post-closure management of geological repositories?
— What knowledge is required for future safety and safeguards purposes, and how will it be retained?

For me, it is important to bear in mind that safety is an intrinsic property of a system. It does not depend on records; if a licence to close a repository has been granted following due process, passive safety is not predicated on the existence of records, and a licence is granted on the basis that no lingering technical or societal doubts exist.

Thus, the maintenance of records is an option — a kind of further reassurance for those who were not involved in the decision to close the repository. From the safety point of view, it is an option just like monitoring, long term institutional controls and retrievability.

In my view, a link to safety exists if retrievability is still required by law even after closure; with this option, knowledge must be preserved in order to facilitate retrieval and protect those carrying out the retrieval operation.

The information to be preserved may be of various kinds, for example, written information such as the safety case documentation; specimen materials (such as metals that were used, or rocks that were found during excavation of different parts of the repository); information about how to determine things like temperature and radiation levels; information about the machinery used (perhaps the actual machinery itself); and information about the organizational arrangements necessary in order to check whether the retrievability option can be exercised.

If the retrievability option is maintained by law, a great deal of information necessary also for safeguards purposes will have to be preserved. Conversely, if safeguards are required, a great deal of the information needed for retrievability will be available.

As regards the very long term, there is probably no sense in talking about safeguards, which presuppose the existence of States and institutions. One has to think perhaps in terms of markers — a form of information — designed to protect possible intruders. Archived information may still exist, but will probably not be of any use.

One last question: can safeguards impinge negatively on safety? From what I have heard, people working in the safeguards area are doing all they can to ensure that they do not. At all events, I believe that this question must be addressed at the time of licensing.

G. McCARTHY (Australia): The radioactive waste management industry is in some respects an archivist's dream. There is a need to create, maintain, preserve and continuously review records, monitor their use and make them widely accessible during the complete life of the industry and during its associated processes — from conception, design, construction, commissioning, implementation and decommissioning to post-closure. The records created are of critical scientific, technical, societal, political and environmental importance. The management of the records cannot be left to chance; they must be managed professionally, to the highest internationally accepted standards of the time.

Traditionally, the funds available for archival work have been very limited. However, the radioactive waste management industry cannot afford not to make sufficient funds available for ensuring that record-keeping and archiving are at the highest level.

Maintaining records as evidence that will be acceptable to licensing bodies and therefore to society at large is no trivial exercise. However, it is only in the past decade, with the development of affordable computing and database technology, that systems have been built that start to approach the ideal.

Since the 1980s, the records management and archival communities at the international level have produced three standards, and Australia has played a significant role in the development of all three. The three standards, which are currently going through processes of planned review, are: ISO 15489 (2001) — Records Management Standard; ICA ISAD(G) (2000) — International Council on Archives, International Standard on Archival Description (General); and ICA ISAAR(CPF) — International Council on Archives, International Standard on Archival Authority Records for Corporations, Persons and Families.

Of particular interest to the IAEA is the last of the three standards, which has been developed with a view to achieving comprehensive interconnectedness of records and archival information all around the world.

However, it will take decades for archival practice around the world to be transformed in the light of these standards. There are numerous entrenched procedures that will ultimately have to change, but this will have to happen voluntarily; it cannot be mandated.

The radioactive waste management industry is going to have to get its records and archives to work much harder in the future. Some significant failures of record-keeping in the past have led to significant costs to the current generation. Such failures cannot be tolerated today, but the standards and processes for preventing them are available. With these standards and processes, one can add value to records during archival documentation. This will permit the systematic and structured capture of contextual information (or metadata) dealing with the creation and management of records, which will be critical to meaningful interpretation of the records in the future.

Given the enormous time-scales with which the radioactive waste management industry is working, it is critical that its records management and archival programmes be well funded. The goals of evidence based accountability, transparency and public accessibility can be achieved with current technology. If they are, the industry will be significantly closer to engendering the societal trust that it requires.

P. METCALF (IAEA): Could the potential diversion concerns associated with nuclear material in geological repositories not be eliminated simply by vitrifying the material or by diluting or dispersing it in some other way?

B.W. MORAN (USA): The IAEA has agreed to the termination of safeguards on vitrified high level waste, but some countries have political problems with the chemical processes necessary for making spent fuel irrecoverable.

A. NIES (Germany): I would be interested in hearing the reactions of Panel members to the idea that the earlier radioactive waste is placed deep underground in a backfilled, sealed, passively inaccessible, safe repository the better as regards both safety and safeguards.

A.J. HOOPER (United Kingdom): I subscribe to that idea from a technological perspective, but, as we all know, there are also other perspectives. This is an issue which should be discussed in such a way that the public understands.

P. BUTTON (Canada): I believe that underground disposal is the right solution as regards safeguards. Nuclear material will be easier to safeguard in an underground repository than on the surface.

C. PESCATORE (OECD/NEA): If one implication of the idea put forward by A. Nies is that there would be no retrievability, I think one would have to think about the effect of early inaccessible disposal.

A. NIES (Germany): There are several aspects to the manner of disposal which I described, for example, the public acceptance aspect. If it were agreed that that manner of disposal was the recommended one as regards safety and safeguards, one could then consider the other aspects.

P. ZUIDEMA (Switzerland): I am not a safeguards expert, but in my view one could never say that nuclear material is completely irretrievable; some form of safeguards would always be necessary.

A.L. RODNA (Romania): I not only favour deep underground disposal on safety and safeguards grounds, I also favour, partly on cost grounds, having fewer rather than more deep underground repositories.

A. SUZUKI (Japan): In my view, if it is generally accepted in the radioactive waste management community that geological disposal is better than above ground interim storage from a safeguards perspective, some international body, for example, the IAEA, should inform the global community. That might provide an incentive for the construction of deep underground repositories.

B.W. MORAN (USA): Regarding A.L. Rodna's comment, there are obvious benefits in a country's having one repository for the spent fuel from all of its reactors rather than having a spent fuel store at every reactor site, for example, lower safeguards costs and a smaller number of possible system failures.

I see the idea of building international repositories as an extension of building single centralized repositories in countries with large nuclear power programmes, with the IAEA applying safeguards at just a few international repositories instead of at a much larger number of repositories in countries with relatively small nuclear power programmes.

Regarding A. Nies's comments, the less active a safeguards approach is, the lower the possibility of failures; the safeguards measures at a surface facility have to be active, with electronic systems which will ultimately fail. Moreover, the time necessary to retrieve spent fuel from a surface facility will be relatively short, which could be critical from the point of view of preventing diversion.

C. McCOMBIE (Switzerland): What is the role of the IAEA with regard to the physical security of radioactive waste? This is an important issue at a time when there is a great deal of concern about terrorism.

B.W. MORAN (USA): Physical security — not only of radioactive waste but also of nuclear facilities — is a responsibility of the State. The IAEA's role is to offer technical guidance, helping States to increase their physical protection capabilities, and to co-ordinate the support being provided by certain States to certain other States in the physical security area.

P. METCALF (IAEA): In the area of physical security, there are a number of initiatives currently under way within the IAEA, for example, the development of guidance for self assessment of the adequacy of physical protection arrangements at nuclear facilities and the development of guidance relating to the physical security of radiation sources and radioactive waste, including disused radiation sources. We realize that there may be gaps in the guidance being developed, so we are also carrying out a 'gap analysis'.

M.J. TARVAINEN (Finland): Regarding spent fuel in interim storage, it should be borne in mind that the diversion of old spent fuel is easier than that of fresh spent fuel owing to the gradual decay of the fission products in the spent fuel. Consequently, the safeguards measures at an interim storage facility have to become more rigorous with time.

In Finland, where we expect to build our underground repository in crystalline bedrock, we believe that disposal in a repository that is then closed is preferable to interim storage from the safeguards point of view.

P. KAYSER (Luxembourg): Regarding the question of physical security, I would recall that the Convention on the Physical Protection of Nuclear Material is currently being examined with a view to its scope being extended to cover the physical protection of nuclear facilities — including repositories — against sabotage. The IAEA is supporting this exercise.

THE MANAGEMENT OF DISUSED RADIOACTIVE SOURCES

(Session 5)

Chairperson

N.K. BANSAL
India

OVERVIEW OF THE INTERNATIONAL SITUATION AND THE MANAGEMENT OPTIONS FOR SPENT RADIOACTIVE SOURCES

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Abstract

The number of sealed radioactive sources worldwide is estimated to be much higher than existing registries indicate. The activity of a disused source may still be in the order of GBq or TBq. The incidents and accidents that have occured with a wide range of consequences showed the risk associated with spent radioactive sources, if continuity of regulatory control and technically sound management was not ensured. At the international level, the IAEA issued a technical document on the Categorization of Radiation Sources and a Code of Conduct on the Safety and Security of Radioactive Sources, both being revised currently. The European Commission is proposing a Council Directive on the control of high activity sealed radioactive sources which is under discussion at present. There are sound technical options for the management of disused sealed radioactive sources. At present, however, disused sources are stored for longer periods at the users' site and for the long term at waste processing and storage facilities in many countries. This is not an ideal situation and leads to increased risk of degradation of physical integrity of the sources and of loss of control. The eventual solution for the final management of spent sources should be conditioning and disposal.

1. INTRODUCTION

Sealed radioactive sources are extensively used in agriculture, industry, medicine and various research fields in both developed and developing countries. The number of sealed radioactive sources worldwide is estimated to be in the millions, although the existing registries indicate a much smaller number. If a source is no longer needed (if it has been replaced by a different technique, for example) or has become unfit for the intended application (for example, if the activity has become too weak, the equipment malfunctions or is obsolete, or there is a damaged or leaking source) it is classified as a spent or disused source. The activity of a disused source may still be in the order of GBq or TBq. The incidents and accidents that have occurred with a wide range of consequences, including widespread contamination and deterministic health effects, showed the risk associated with spent radioactive sources if continuity of regulatory control and technically sound management was not ensured.

The status of regulatory control of sealed radioactive sources varies from country to country depending on the national legal and regulatory infrastructure and the extent of use of sealed sources. Special regulations on certain aspects of sealed radioactive sources exist in a few industrialized countries but in most developing countries only general statements are included in the legislation and regulation on radiation protection. At the international level, the IAEA issued a technical document on the Categorization of Radiation Sources [1] and a Code of Conduct on the Safety and Security of Radioactive Sources [2], both being revised currently. The European Commission is proposing a Council Directive on the control of high activity sealed radioactive sources [3] which is under discussion at present.

The management options for disused sealed radioactive sources from a user's point of view are the following:

— Short term storage for decay for a limited number of short lived sources (not typical);
— Transfer to another user;
— Transfer to a waste management organization for processing and long term storage or disposal;
— Return to the supplier for further management (which may be recycle and reuse). At present, disused sources are stored for longer periods at the users' site and for the long term at waste processing and storage facilities in many countries, which is not an ideal situation and leads to increased risk of degradation of physical integrity of the sources (corrosion, damage of the encapsulation or packaging, etc.), and to loss of control (abandoned and orphaned sources, theft, misuse, etc.). Therefore, the eventual solution for the final management of spent sources should be conditioning and disposal.

2. RADIOACTIVE SOURCE INVENTORY

There is a significant discrepancy between the estimated number of radioactive sources existing worldwide and the number of sources actually registered. The following are among the reasons for this discrepancy:

— There are missing records of sources manufactured and distributed a long time (decades) ago;

— There is a lack of comparison between records and physical inventories (verification of data);
— There is a lack of continuity of regulatory control (for example, in the case of transferring sources to another user or illegal disposition of disused sources).

The number of radioactive sources being out of control virtually does not depend on the level of industrial development of countries. However, the reasons for not having or losing control over sources is different in developing and developed countries. In developing countries, the origin of the problem is that radioactive sources had been imported before proper national legislation and control were introduced, and their technical infrastructure and expertise is still limited. In developed countries, though both the regulatory and technical infrastructure is in place, there are such a large number of sources in use and stored that if even a small percentage of them is lost or unaccounted for, it can nevertheless amount to a significant number. For example, according to a recent study prepared for the European Commission [4], about 500 000 ‘significant’ sources have been distributed in the present 15 member states of the European Union during the past 50 years. Of these, 110 000 are still in use, 30 000 are stored with the users and up to 70 sources may go out of control every year. A second similar study made about the situation in some of the candidate countries in central and eastern Europe [5] showed similar numbers for the same categories.

3. SOURCE LIFE-CYCLE AND THE WEAK POINTS

In order to identify when sources are most vulnerable, it is necessary to analyse the whole life-cycle of the sources. The main phases of the life-cycle of sources are:

— Manufacturing (production of radionuclide, encapsulation, equipment manufacturing),
— Distribution to users (transportation, storage),
— Application period (medical therapy, industry, etc),
— Transition period(s),
— Disused/spent sources.

It is in the interest of manufacturers, distributors and users (at least, as long as the source is in use) not to lose control of the sources, therefore, these phases are not so critical from the source control point of view. The weak points of the life-cycle are when the sources are in the transition phase and when they become disused.

3.1. Sources in transition

Sources are typically in transition when they are the following:

— Transported,
— Temporarily out of use,
— Waiting for another application/user,
— Taken out of service but not declared as waste.

The transportation of radioactive materials, including sources, is usually under proper regulatory control and it is also in the interest of the carrier that the consignment reaches its destination. If a source is temporarily out of use but the user intends to use it again for the original purpose, proper control is usually ensured. The level of control, however, may degrade when the source is not intended to be used for the original purpose any longer, but is stored with the aim of using it in another application or transferring it to another user. The same applies when the source is finally taken out of service (because, for instance, the activity is not sufficient), but is not declared as waste (possibly for financial reasons), just stored for an indefinite period of time.

3.2. Disused/spent sources

The main causes for sources becoming disused are the following:

— Radioactive decay (the activity is not enough for the original purpose),
— Leaking or damage,
— Obsolete equipment,
— Alternative technology,
— Changes in priority.

The most frequent case is when, due to radioactive decay, the source cannot be used for the original purpose. The activity of the disused source, however, may still be in the order of GBq or TBq. It is important, therefore, that control of the source is maintained at the same level by the user until the source is removed from its facility. The same applies in cases when the equipment containing the sources or the whole application becomes obsolete and/or changed. If the equipment or the source is damaged or leaking, immediate action is to be taken to isolate the area and to remove the source from the user's facility by a qualified and authorized organization.

3.3. Orphan sources

Radioactive sources become orphaned if regulatory and physical control is lost over the source. A typical scenario of losing control is when a source becomes disused for any of the reasons listed in the previous section, it is put in a store without notifying the regulatory authority, then it is moved in another store with less physical control. Knowledge about the source degrades in time, and finally it lands in scrap storage and leaves the facility as scrap metal. Once it is mixed with scrap metal of another origin, it is almost impossible to track where it originated from.

Some typical problems with orphan sources are:

— Appearance at an unexpected location and time (usually in a public area and the environment);
— Unknown owner (need for an organization for rendering the source safe);
— No technical documentation (need for technical capability to identify, transport, further manage);
— Lack of financial resources (for collection and further management).

4. MANAGEMENT OF DISUSED/SPENT SOURCES

The first place where disused sources must be dealt with is the user's facility. The user should have a designated area where disused sources are stored and where there are specially trained staff who are responsible for the proper management of disused sources. Except for a few types of short lived sources, which can be stored for decay under appropriate conditions, *the storage at the user's facility should be as short as possible*. If no further use at the facility or by another user is foreseen, the source has to be returned to the supplier or manufacturer, or declared as waste and should be transferred to a waste management organization.

The waste management organization should have a designated and licensed facility and trained staff for processing, long term storage and/or disposal of spent radioactive sources. Spent sources should be stored and/or disposed of in conditioned form. There are special techniques available for conditioning of disused sources (such as immobilization, typically in a cement matrix, and packaging). The applicable conditioning process as well as the storage and/or disposal technique (near surface or geological disposal) will depend on the characteristics of the sources (such as activity and half-life). The IAEA has issued technical documents describing available techniques for the management of smaller [6] and high activity [7] sources. While the final solution should be the disposal of spent sources, there are some concerns about the long term safety of disposal of high activity/long lived sources in near surface repositories. The concerns are associated with the probability of intrusion in the disposal volume and eventual recovery of sources. This is the reason why, for example, most of the European Union member countries, which operate near surface repositories for low level radioactive waste, do not dispose of sources but store them for the long term.

If a country does not have the proper waste management infrastructure, the preferred option for the management of disused sources should be *the return to the supplier* or manufacturer. Preferably, the purchase contract should include the supplier's agreement to take back the spent source. This option is more difficult to realize if the source is old, if no valid special form certificate is available and if reuse of the source is not feasible. The legal aspects (such as import authorization) and financial aspects (such as transport and disposal costs) of source return are also to be resolved.

5. ECONOMIC ASPECTS

Significant costs are associated with all steps of the management of disused sources. If the owner of the source is known, the *prime responsibility* for the proper management is with that owner. In many countries, the (last) owner pays the waste management organization when the disused source is transferred for final management. However, in many cases, they (especially in developing countries where users such as hospitals are government owned) do not have sufficient funds for this purpose. In such cases, the government should ensure that financial resources are available for the management of disused sources, otherwise the sources will be stored by the last user for the long term, which may cause safety and security problems as mentioned in Section 3.3.

It is also the responsibility of the government to ensure that in the case of orphan sources and emergency situations, sufficient funds are available to deal with the sources and to mitigate the consequences of accidents. The government may take direct financial responsibility or oblige manufacturers and users to allocate funds for this purpose. In some countries, the costs of the management of disused sources are included in the purchase price of the new sources. There are also examples of funds raised by stakeholders (including manufacturers, distributors and users) for managing orphan sources and emergency situations. The solution depends on the legal and economic infrastructure of the country.

6. REGULATORY SITUATION

At the national level, usually there is no specific regulation or regulatory body for radioactive sources. Certain aspects, such as radiation protection and transport, are addressed in the general legislation related to radioactive materials and/or protection against ionizing radiation. Some important aspects, however, such as security of sources, management of disused and orphan sources, are typically not addressed.

At the international level, the IAEA issued Safety Series publications, where radiation safety and transport safety aspects of radioactive sources have been specifically addressed [8, 9]. The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management addresses some aspects of the return of sources to the country of origin [10]. More recently, the IAEA issued a technical document on the Categorization of Radiation Sources [1] and a Code of Conduct on the Safety and Security of Radioactive Sources [2] which are being revised at present in order to categorize sources more quantitatively, based on the risk associated with them if control is lost, and to address some new concerns, such as security. The European Commission is proposing a new Council Directive on the Control of High Activity Sealed Radioactive Sources [3]. The Directive proposes a simple definition of high activity sources (dose rate at 1 m > 1 mSv/h), definition, regulatory, technical and financial provisions for orphan sources as well as financial provision for the management of disused sources. This Directive, if promulgated, would be the first internationally binding legislation specific to radioactive sources.

7. CONCLUSION

The number of sealed radioactive sources worldwide is estimated to be in the millions, although the existing registries indicate a much smaller number. There is a significant discrepancy between the estimated number of radioactive sources existing worldwide and the number of sources actually registered. Among the reasons for this discrepancy are the following:

- There are missing records of sources manufactured and distributed long time (decades) ago;

— There is a lack of comparison between records and physical inventories (verification of data);
— There is a lack of continuity of regulatory control (for example, in the case of transferring sources to another user or illegal disposition of disused sources).

The weak points in the life-cycle of a radioactive source are when the source is in transition and when it becomes disused. The result of weakening and finally loss of control is that the source becomes orphaned. Orphan sources appear at unexpected locations and times, and may cause serious accidents. Weak or missing control may also lead to theft and the malevolent use of sources.

Options for the proper management of disused and spent sources are to store them for decay at the user's facility (exceptionally, only for some short lived sources), conditioning and long term storage at a waste management organization. The ultimate solution should be disposal. Although technical options for all steps are available, some discussion on the safety of near surface disposal results in long term storage in most countries at present. International guidance and national regulations regarding legal and economic aspects of the management of disused sources are still needed.

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PANEL

THE WAY FORWARD IN MANAGING DISUSED RADIOACTIVE SOURCES

Chairperson: **N.K. Bansal** (India)

Members: **J.C. Benítez** (Cuba)
V. Friedrich (Hungary)
E. Martell (Canada)
R. Heard (South Africa)

Panel Discussion

E. MARTELL (Canada): A large fraction of disused radioactive sources (possibly most) are returned to the manufacturer and then sometimes recycled. For example, old teletherapy cobalt sources and industrial radiography sources are taken back by the manufacturer as part of the source replacement transaction.

However, problems arise with, for example, the final disused source in a piece of equipment that is being decommissioned, possibly 30 to 40 years after being installed. The final disused source is more likely to be taken back by the manufacturer if the manufacturer can reuse the source or the active material in it, if the manufacturer has a shipping container licensed for the type of source in question, if the manufacturer has expertise regarding the type of source (with source holder) in question, if the manufacturer has facilities for consolidating the source material for disposal and if the manufacturer has access to a radioactive waste disposal site. On the other hand, for example, the manufacturer may not be identified on the equipment or may have gone out of business; or the shipping container may no longer be approved owing to changes in regulations; or the price asked by the manufacturer for taking back the source may be — or just may be perceived to be — too high.

Nowadays, someone purchasing equipment in which there is a radioactive source normally has to make advance financial arrangements for disposal of the final source when the equipment is ultimately decommissioned unless, for example, the source manufacturer guarantees disposal of the final source at no cost or is prepared to lease the sources that will be used in the equipment, or the manufacturer's State is prepared to guarantee disposal. All such possibilities, however, involve complications relating to, for example, responsibility over long periods of time which limit their usefulness. Other possibilities include:

— The decommissioning approach, whereby one thinks of the source as being in a piece of equipment at a facility that is in effect a radiation facility for whose ultimate decommissioning financial provision should be made;
— The use of disposal bonds to guarantee funding — still at the experimental stage;
— The construction of interim storage facilities, for which there is undoubtedly a need.

It would help if manufacturers promoted the return of sources by making their 'take back' services as affordable as possible. Where the return of sources to the manufacturer is simply impossible, source owners with very limited financial resources need local or international assistance. Also, efforts need to be made to prevent the costs and the administrative burdens associated with things like the transport of sources from getting out of hand.

J. GREEVES (USA): I should like to see the introduction of an incentive that would induce the users of sources to return them to the manufacturer when they stop using them — a kind of 'bottle deposit', which all source manufacturers would have to demand in order that there be no distortion of the competition among them. What does E. Martell think about that idea?

E. MARTELL (Canada): There are various schemes for promoting the return of disused sources to the manufacturer, for example, I believe that in the United States of America, there is a decommissioning financing guarantee requirement.

The introduction of a 'bottle deposit' scheme would involve a lot of discussion about the practical business modalities among source manufacturers.

G. CSULLOG (IAEA): Nuclear power generation is under attack by anti-nuclear groups, so there is a strong incentive for the nuclear industry to try to ensure that nuclear waste management is effective — to avoid providing the anti-nuclear groups with additional 'ammunition'. However, nobody is demanding the closure of hospitals, universities and other establishments where radioactive sources are used, so there does not appear to be an incentive for source manufacturers to try to ensure the effective management of disused sources.

V. FRIEDRICH (Hungary): I believe that regulators could provide an incentive for source manufacturers to agree to take back disused sources. When licensing a practice, the regulator could include in the licence a clear statement about how the source is to be managed after use, thereby inducing the prospective purchaser of the source to insist that the purchase contract contain a clause providing for the return of the disused source to the manufacturer. If a manufacturer refused to accept such a clause, the prospective purchaser could turn to another manufacturer. Those manufacturers who were prepared to accept such a clause would have a competitive advantage over the rest.

While I have the floor, I would like to say a few words about the cost of managing disused sources properly. It may be considered to be very high by many users of sources, but they should think about the much higher cost of mitigating the consequences of an accident involving a disused source. Regulators should impress on the users of radiation sources how expensive such an accident can be.

J. TAMBORINI (France): I agree with what V. Friedrich just said about regulators helping to ensure that disused sources are returned to the manufacturer. I believe that it is now impossible to import sources into France without an agreement providing for their ultimate return to the manufacturer.

While I have the floor, I would mention that the users of radiation sources in France have established an association for the purpose of ensuring that disused sources are properly managed if the manufacturer does not take them back; also, the association provides funds for the management of recovered orphan sources.

L. JOVA SED (IAEA): A problem for many developing countries regarding the importation of radiation sources is that the transactions are conducted through a local company that receives a percentage of the purchase price for acting as the manufacturer's representative. Such companies normally do not have any real technical expertise in the relevant field, and many of them do not remain in business very long.

E. MARTELL (Canada): In a case where there is an independent operator in a country, if that independent operator contracts with a licensee to take ownership of a source, that party becomes — or should become — a licensee, so that all the obligations attaching to source ownership are transferred to that party. Thus, it is a matter of how well one knows these companies and whether one can make sure, when a source changes ownership, that the receiving party has a valid licence to own and possess it and that the receiving party is regulated in such a manner that it will act responsibly as far as that source is concerned.

R. HEARD (South Africa): A problem in many countries, particularly developing ones, is that radiation sources are regulated not by a nuclear regulator but by the ministry of health, which has more urgent matters to deal with than the regulation of radiation sources.

While I have the floor, I should like to ask how many countries are actually disposing of disused sources; in South Africa we are certainly not disposing of such sources. I think that when people talk about the 'disposal' of disused sources, they usually mean 'long term storage'.

E. MARTELL (Canada): Yes, the word 'disposal' is being used too loosely in some contexts. Many licensees believe that, when they have transferred the ownership of a source to someone else, they have 'disposed of' the source.

At present, disused sources end up — if all goes well — in an interim storage facility in the country of the manufacturer or of the licensee.

P. METCALF (IAEA): Regarding this question of 'disposal', I would mention that the IAEA recently launched a co-ordinated research project on the application of safety assessment methodologies for near surface waste disposal facilities. One of the aims of this project is to explore the extent to which such facilities can be used for the disposal of disused sources.

A. SIMCOCK (OSPAR Commission): A recently adopted convention that people concerned about the problems associated with the export of radiation sources from developed to developing countries might find it useful to consult is the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade. This convention provides for the establishment of a system for ensuring that substances which are hazardous because of their toxicity are sent from developed to developing countries only if the receiving country has given its consent.

M.V. FEDERLINE (USA): Are there types of radiation source to which we should be paying particular attention on security grounds?

V. FRIEDRICH (Hungary): Security issues are being taken into account in the current work on revising the IAEA's Categorization of Radiation Sources (IAEA-TECDOC-1191), a revised version of which will — I hope — be appearing soon.

J.C. BENÍTEZ (Cuba): I should like to say a few words about options for the management of disused sealed radioactive sources in developing countries, basing myself on a number of internationally recommended management options. Three of these options are, in my view, relatively unproblematic.

The first option is 'transfer to another user' if there is a plan for utilization of the source. The existence of such a plan should mean that there are good arrangements for keeping the source under control. However, this option is likely to be feasible only in the case of a few sources.

The second option, 'storage for decay', is feasible for only a few source types, for example, sources containing iodine-131, iodine-125 or iridium-192.

The third option, 'transfer of the conditioned source to a disposal facility', is not problematic if the developing country has good facilities for the conditioning of sources and also a disposal facility.

Now a few words about the other internationally recommended options.

The option 'conditioning and interim storage of the source at the user's premises' is unsuitable for most developing countries. I have encountered many examples of very bad conditioning at user premises in developing countries.

As regards the option 'return to the manufacturer/supplier', I believe that developing countries should think in terms of renting sources.

The option 'transfer to a central conditioning facility followed by interim storage' is of interest in situations where a developing country has a lot of very old disused sources, but very few developing countries have central conditioning facilities. In that connection, I was interested to learn from contributed paper IAEA-CN-90/37 that a central waste processing and storage facility is being constructed in Ghana.

Finally, there is the option 'transfer to a central facility for interim storage until a conditioning facility is available'. Unfortunately, most developing countries do not have central interim storage facilities, and in many of those countries, the disused sources are being stored on user premises under very bad conditions.

R. HEARD (South Africa): In 1995, at a meeting of representatives of several African countries, it was concluded that disused radiation sources posed a major problem in Africa, where the radioactive waste management infrastructure was generally poor, the necessary legislation was in many cases lacking and the continuity of knowledge regarding some radioactive waste had been interrupted.

The IAEA, which has been promoting the use of nuclear techniques in Africa (for example, in medicine) and arranging for radiation sources to be supplied to African countries, has a regional technical co-operation project under way for strengthening radioactive management infrastructure in Africa. Within the framework of that project, work is being done on the technical and economic feasibility of the disposal of radiation sources in boreholes and on the pre-disposal conditioning of sources by international expert teams, which have so far conditioned sources in ten countries. The project falls under the heading of AFRA, the IAEA supported African Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology. A question which arises in that connection is what to do about the disused sources in African countries which are not parties to AFRA.

We who are working on the feasibility of borehole disposal in Africa are co-operating closely with people engaged in work on high level waste management, and there is a great deal of synergy in dealing with shared problems like 'what is the best material: copper, stainless steel...for the containers?' We have reached the container design stage and expect that the overall borehole feasibility study will have been completed by the end of 2003.

M. VESELIC (Slovenia): Having some 30 years' experience in borehole drilling, I feel that there will be major technical problems in drilling boreholes for the disposal of radioactive sources.

R. HEARD (South Africa): We envisage using normal drilling equipment (standard water drills), and we believe that the radiation sources can be conditioned in such a way that the boreholes will meet the criteria applied in a standard safety assessment.

THE MANAGEMENT OF LARGE AMOUNTS OF LOW ACTIVITY RADIOACTIVE WASTE

(Session 6)

Chairperson

J. HULKA
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MANAGEMENT OF NORM
An international overview

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Abstract

Naturally occurring radioactive materials (NORM) may be present in several industrial activities and may lead to exposures of workers and members of the general public at some stage of the operational process and (re)use of products, residues or wastes. The present paper aims at reviewing the international accepted methodologies generally used in the management of NORM wastes. It also discusses issues such as regulatory aspects in NORM waste management and mathematical modelling to assess the waste impacts. A study case on wastes generated by a niobium industry is also discussed.

1. INTRODUCTION

Naturally occurring radioactive materials (NORM) are generated by a wide variety of industrial activities which in principle are not associated with radiological problems. As a result, many members of the public and workers can be exposed to radiation from NORM wastes/residues. If these wastes/residues or products containing natural radionuclides are not managed properly and safely, large contaminated areas associated with different exposure pathways can take place. This situation has two important components:

— Large amounts of such NORM containing wastes and other materials;
— Potential long term hazards resulting from the fact that NORM comprise long life radionuclides with relatively high radiotoxicities.

A key step concerning NORM wastes/residues is to understand when and where these wastes can occur within a given process and also to identify the locations where their concentrations can be greatest.

Another issue refers to the fact that relevant national and international policies (regulations) should be developed for the appropriate management of these materials. Care must be taken with respect to the potential impacts that these regulations may cause on a wide variety of industries. That is to say; depending on the adopted approach, some inconsistencies caused by the variations in the definition and scooping of NORM waste issues can take place. Such facts reinforce the need for an international agreement (harmonization) on different issues, for example, acceptable dose (risk) associated with NORM wastes/residues, clearence levels, etc.

In 1996, the European Council adopted the revised Basic Safety Standards (BSS) in which radionuclide specific exemption levels are submitted (Council Directive 11701/1/95).

These regulations (indirectly) involve also NORM. As a consequence, new and large volumes of waste materials will have to be treated as radioactive material.

The available studies on NORM indicate that, for example, several wastes from oil and gas industry and slags from, for instance, steel production and the phosphate industry exceed the new European Union exemption levels. Furthermore, there is growing awareness on this subject by both regulators and the industry. As a consequence, new types of industries are identified with significant volumes of NORM in their process [1].

2. STRATEGIES OF WASTE MANAGEMENT

The development of the waste management strategy is usually a complex process that aims to achieve a reasonable balance between two often conflicting goals, that is, maximizing risk reduction versus minimizing financial expenditure. The process is one of optimization of protection in which the available alternatives for sorting, design and construction, operation, managing waste streams, and closure are evaluated and compared, taking into account all associated benefits, detriments and any constraints that may be imposed. The characteristics of the alternatives (or options) that should be considered include [2]:

— The radiological and non-radiological impacts on human health and the environment during operation and in the future;
— The requirements for monitoring, maintenance and controls during operation and after closure;
— Any restrictions on the future use of property or water resources;
— The financial costs of the various alternatives;
— The volumes of the various waste to be managed;
— The socio-economic impacts, including public acceptance;
— Good engineering practices.

The purpose of applying any management technology, or combination of technologies, is to reduce the level of public exposure to radioactivity on-site or via radionuclide migration, off-site. In order to determine the requirement for remediation, and the options most likely to prove cost effective, it is necessary to develop a common approach to categorizing sites and types of remediation approaches [2].

Among the technologies which are well established and have been successfully applied to treat radioactive waste sites, or show considerable promise in laboratory and/or field trials, are those depicted in Table I.

TABLE I. MAIN APPROACHES IN WASTE MANAGEMENT

Removal of sources	Bulk removal Surface scraping Turf cutting
Containment	Capping Subsurface barriers
Immobilization	Cement-based solidification (in situ and ex situ)
Separation	Chemical immobilization (in situ and ex situ) Soil washing Flotation Chemical/solvent extraction

Source: See Ref. [1].

In determining the viability of applying any of the above technologies for a particular contaminated site, a number of factors must be taken into account, including:
— Characteristics of the site;
— Risk to the public;

— Performance and cost of the technique to be applied;
— Exposure of the workforce during remediation work.

The impact of the different categories of remediation technologies may be described as follows [1]:

— Removal of sources and separation technologies reduce the input of radionuclides into groundwater pathways and reduce the level of radon exhalation by removing the parent nuclides with a proportionate decrease in the magnitude of all exposure pathways.
— Immobilization and containment (except capping) technologies reduce input to groundwater, and therefore have a significant impact on the off-site terrestrial and aquatic exposure pathways (ingestion and external irradiation), but have little impact on radon exhalation. Immobilization can be seen as a precondition to store the material in alternative repositories for low radioactive wastes. The moment immobilization in the matrix is assured and the radionuclides can never reach the environment, even reuse of the material is an option.
— Capping reduces the input of radionuclides into groundwater and also reduces radon exhalation in a manner proportional to the thickness of the surface barrier.
— Separation technologies can be either physical or chemical. If the radionuclides can be associated with some specific physical properties of the solid, such as the particle size, a specific physical treatment, such as screening, could be used for separation. If the nuclides are bound within special chemical compounds, a chemical separation technique could be a possibility for separation. Separation techniques can be considered if:
  • The concentration of radionuclides is within the order of a few times the exemption value of the BSS;
  • The radionuclides are heterogeneously divided in the material;
  • The activity is linked with specific material properties.

After separation, the reduced amount of waste with the enhanced content of radionuclide should then be immobilized and stored in an alternative disposal facility. The separated fraction, which is ‘radionuclide free’, can be either recycled or disposed of using standard treatments.

Removal of source material and capping of the waste area reduce external irradiation both on-site and off-site: in the case of capping, this presumes that the covering material remains in situ. For extreme intrusion scenarios, where penetration of the cap may be assumed, the on-site external radiation pathway will not be reduced. Immobilization and containment approaches, other than capping, tend to reduce off-site irradiation, but may have little effect on-site.

An additional 'institutional' approach is available in principle, through placing restrictions on the use of the site. However, it is commonly accepted that such restrictions would be effective only over relatively short time-scales.

Under some circumstances, a combination of technologies may be used to restrict exposure from the waste, especially where a number of pathways exist. Such a combination of technologies can, at times, be considerably more cost effective than applying a single, more costly technique. However, only certain combinations of technologies are logical. Similarly, the order in which different technologies are applied is important [2].

3. SELECTION OF REMEDIATION TECHNOLOGIES FOR A CONTAMINATED SITE

The selection of appropriate remediation techniques will depend on the characteristics of the contaminated waste and the potential exposure pathways. Consequently, the choice is generally site specific. However, it can be assumed that some sites are sufficiently similar that some general considerations, such as the following, may be applied to the selection of remediation technologies:

— *Volume:* High volumes of contaminated waste will favour in situ remediation technologies;
— *Accessibility:* Inaccessible wastes, and waste sites, will favour in situ technologies;
— *Local populations:* The presence of a large population near the site will favour removal of contaminant material from the site to a more secure location;
— *Exposure pathways:*
  - Sites where radon and dust emissions are high will be best treated by either removal of material from the site or the installation of a surface barrier above the waste;
  - Sites where leaching and off-site migration of radionuclides is important will be best treated by technologies which reduce groundwater infiltration through the waste;
  - Sites with high external irradiation levels will be best treated by surface barriers or removal of the radioactive material.

A comment is in order regarding the fate of the large volumes of wastes containing natural radionuclides, which may be generated during remediation action. Deep geological disposal is not a feasible option on cost grounds and sea dumping is not feasible on political grounds, leaving surface/shallow land disposal as the only viable option.

4. TYPE OF NORM RESIDUES AND ADOPTED MANAGEMENT STRATEGIES

Most of the information in this section is drawn from an IAEA document that is still in preparation [3].

4.1. Oil and gas

Oilfield equipment can contain hard radioactive scales and softer scale bearing sludges which appear as coatings or sediments. The scale is typically a mixture of carbonate and sulphate minerals. One of these sulphate minerals is barite ($BaSO_4$), which is known to readily incorporate radium in its structure. It is estimated that more than 140 000 drums (roughly 28 000 m^3) of technically enhanced NORMs containing residues (>3300 Bq/kg) accumulate on an annual basis in the United States of America. Estimates for the North Sea suggest a lower value of 20 t of scale per well each year. Another residue is the formation water that has been separated from an oil, gas and water mixture. Studies of the large quantities of water produced from wells at oil and natural gas drilling and production sites have indicated that a number of the wells yielded water with an average radium concentration in excess of 1.85 Bq/l. Other data suggest that average radium concentration in water from some wells can be as high as 111 Bq/l. The separated water is often re-injected into the oil bearing formation, which is a sound waste management approach posing minimal potential impacts on human health. However, in many cases, the water is discharged to the ground surface in the case of a land-based well or discharged directly into the sea in the case of an offshore well.

Disposal alternatives for these wastes include the following:

- Surface spreading,
- Surface spreading with dilution,
- Burial,
- Industrial landfill,
- Licensed NORM disposal facility,
- Low level waste facility,
- Surface mine,
- Injection well,

— Plugged and abandoned well,
— Hydraulic fracture,
— Deep geological repository.

Surface spreading and dilution of low activity NORMs is a past practice that is now disallowed by most states in the USA with NORM regulations. An additional method of disposal of scales that have been ground to a small size is direct discharge into the sea. Land farming or other approaches involving the mixing of NORM containing residues in surface soils are used for management of lower activity sludges and some scales. In this approach, the concentration of NORM is diluted in the soil to a level considered acceptable based on applicable regulations.

4.2. Coal

Most of the waste from a typical coal fired power plant is generated as fly-ash, which is entrained with the hot flue gases of the combustion process. The remainder of the ash is heavier and settles to the bottom of the boiler to form what is referred to as bottom ash. It has been calculated, in fact, that global coal burning (2800 million t/a) releases around 9000 t of thorium and 3600 t of uranium [4]. Thus, the release of nuclear components from coal combustion far exceeds the consumption of nuclear fuel by the nuclear industry. It is also pointed out that the nuclear fuel released by the burning coal contains one and a half times more energy than the coal itself.

Given the extent of solid fossil burning and the amount of residues resulting from any given power plant, the amount of residues in countries with many coal power plants can be very large. Atmospheric dispersal of fly-ashes can take place in some situations where the absence of adequate flue gas filtering and scrubbing is observed. Other solid residues are either destined for disposal in engineered surface impoundments and landfills, or backfilled into

TABLE II. TYPICAL ACTIVITY (Bq/kg) OF FLY-ASH COMPARED WITH COAL

	^{40}K	^{238}U	^{226}Ra	^{210}Pb	^{210}Po	^{232}Th	^{228}Th	^{228}Ra
Coal	50	20	20	20	20	20	20	20
Fly-ash	265	200	240	930	1700	70	110	130

Source: See Ref. [4].

the mines. To a degree, fly-ash and gypsum are recycled as building materials, for instance, as additive to concrete or in lightweight building materials. This use in house construction can lead to undue exposures of dwellers to radiation (external exposure and radon inhalation).

4.3. Phosphate mining and fertilizer production

The phosphate in minable quantities is concentrated by sedimentary, igneous, weathering and biological processes. Uranium may be incorporated in sedimentary phosphorite ores through ionic substitution into the carbonate-fluoroapatite crystals. Igneous phosphorite contains less uranium but more thorium. High phosphate contents usually correspond to high uranium contents (50–300 mg/kg). The mean uranium content in the ore from Moroccan origin is 125 mg/kg (1500–1700 Bq/kg ^{238}U; 1500–1700 Bq/kg ^{226}Ra; 10–200 Bq/kg) ^{232}Th.

The apatite ores are particularly insoluble and the primary process for the production of phosphoric acid is by leaching the phosphate from the rock with strong acids. In 90% of the cases, ore is treated with sulphuric acid to produce phosphoric acid and gypsum. The gypsum precipitates and is filtered out, washed and, if necessary, neutralized for disposal. The obtained phosphoric acid is very impure (30% P_2O_5) and further processing is generally carried out to obtain a concentration of 50% and more. Uranium and thorium become enriched in the fertilizer to about 150% of their original concentration and radium reduced to 10% of the original concentration. About 80% of the ^{226}Ra, 30% of the ^{232}Th and 14% of the ^{238}U is left in the phosphogypsum.

It can be assumed that the production of 1 t of phosphate requires the extraction of 3 t of ore. When processed, this results in the generation of 4–5 t of phosphogypsum. A reference 1000 t ore·d^{-1} plant produces about 240 000 t of phosphogypsum per year with a mean ^{226}Ra content of 800–1250 Bq/kg. The local dump sites, containing TBq of radium, are often unprotected from rainfall and are hydraulically connected to surface waters and to the shallow aquifers. The ^{226}Ra present is fairly insoluble but, given the concentration of calcium, it can be solubilized.

The major environmental hazards from phosphogypsum waste may be summarized as follows:

- The potential for releasing radium and non-radioactive contaminants into the environment;
- The radon exhalation into the atmosphere;
- The potential reuse of materials due to the loss of institutional control.

There are several properties of these wastes that long term management options have to cope with, as follows:

— The large volumes of wastes;
— The long time persistence of the potential hazards due to the long half-lives of the relevant radionuclides;
— The solubility of the wastes in water.

Options for remedial action on phosphogypsum piles can be guided by the state-of-the-art in remediation of wastes from uranium mining and milling, because the various hazards and requirements are quite similar.

4.4. Metal ore mining and processing

Metals mined and processed in bulk for industrial application include aluminium, copper, iron, lead, zinc and precious metals such as gold and silver.

The mining and processing of metal ores may also generate large quantities of NORM wastes. These wastes include ore tailings and smelter slags, some of which contain elevated concentrations of uranium, thorium and radium, and their decay products that were originally part of the process feed ore. Tailings are the solid materials remaining after physical and chemical beneficiation has removed the valuable metal constituents from the ore. Slag is the vitreous residue mass left from the smelting of metal for extraction and purification.

The distribution of radionuclides and radioactivity fluxes along the operational process of two different niobium mining and milling industries in Brazil was assessed [5]. They are located at two different geological settings. Table III shows the radionuclide activity concentrations in samples from the operational processing step of both industries.

It can be seen that the waste compositions will depend very much on the original composition of the ore and on the kind of ore processing as well. The physical process steps did not alter significantly the waste radionuclide concentrations if compared to the original radionuclide concentrations present in the ore. The most significant activity concentration increases were observed in the barium sulphate waste and in the metallurgical slags. In one of the examined industries, ^{232}Th activity concentration is one order of magnitude higher than that of ^{238}U. As a result, the type and extent of exposure to radiation contained in these wastes will vary. This will also occur in different remedial action tasks to be achieved, as will be discussed later.

Another issue arising from these data is the fact that smart waste management strategies, for example, waste segregation, shall be applied during the operational phase. This will avoid large future expenditures in site cleanup

TABLE III. RADIONUCLIDE ACTIVITY CONCENTRATIONS IN SAMPLES FROM THE OPERATIONAL PROCESSING STEP OF TWO DIFFERENT NIOBIUM INDUSTRIES IN BRAZIL

Operational step	Activity concentration (kBq/kg)									
	^{238}U		^{226}Ra		^{210}Pb		^{232}Th		^{228}Ra	
Ore	0.9	4.5	0.8	3.4	1.3	8.0	6.4	0.9	5.2	2
Magnetic separation waste	1.1	0.8	0.3	0.9	0.7	1.7	0.9	0.3	0.8	0.3
Desliming waste	1.3	6.7	1.4	6.9	2.0	6.2	9.0	1.7	5.3	3.0
Flotation waste	0.8	5.0	1.0	3.4	2.4	7.5	3.1	1.0	1.4	1.8
Barium sulphate waste	0.04		26		7.4		0.04		197	
Metallurgical slag	23	35	3.3	5.0	2.4	0.4	118	17	20	6.4

Source: See Ref. [5].

and remediation works. This issue becomes clearer if mass balance calculations are taken into account. Keeping that in mind, one may verify that the amount of highly radioactive wastes is less than those of less disturbed ones. As a result, they can be contained in cells of relatively small size.

It can be concluded that the level of NORM found in metal ores depends more on the geological formation or region than on the particular mineral being mined. The mining techniques and its selectivity can be an important variable that controls the NORM content in wastes.

The goal of waste management strategies for mining and milling may be assumed as identical to those related to uranium mining and milling. Of the different waste streams produced by mining and milling, tailings represent the greatest challenge, particularly in terms of long term management, because of the large volumes produced and their constituent of very long lived radionuclides. The preferred management option for achieving the protection goals will depend on the specific conditions at the site, the ore body characteristics, specifics of the mining and milling process and the characteristics of the tailings themselves.

To conform to the principles for managing radioactive waste, access to and dispersion into the environment of the hazardous constituents of the mining tailings need to be restricted for long periods into the future. The key issues, which should be considered in the design of a tailings management facility include:

- — The stability of the pit, underground mine void or surface impoundment considering natural processes such as earthquakes, floods and erosion, etc.;
- — Hydrology, hydrogeology and geochemistry;
- — The chemical and physical characteristics of the tailings as they relate to the potential for contaminant and transport;
- — The use of neutralization agents, radium precipitating additives, artificial or natural liners, radon barriers and evaporation circuits.

The design of a tailings management facility should include drainage systems to consolidate the tailings before closure and eliminate excess pore water pressure. In the case of a surface impoundment or a pit, this could be achieved through the installation of an under drainage system prior to tailings emplacement, or the use of wicks that are driven into the tailings after emplacement. The addition of a stabilizing agent (i.e. cement) to the tailings immediately prior to its deposition has the potential to significantly reduce the permeability of the tailings mass, thus retarding contaminant transport and binding any pore water. In the case of underground mine disposal, the increased integrity using concrete with the tailings mass may allow the continued mining immediately adjacent to the tailings. Prior to adopting this strategy, the possible chemical interactions between the stabilizing agent, tailings and host rock should be carefully investigated to ensure that contaminant transport would not be enhanced at some time in the future.

In addition to disposal of tailings in above ground impoundments, open pits and underground mine voids, other waste management options, such as deposition into lakes, exist. However, these options are not likely to be accepted by some regulators and the public.

Finally, waste rock can contain significant amounts of NORM that can be mobilized by means of acid rock drainage. This is the case when pyritic material is present. Options for managing waste rock and mineralized rock include using it as backfill material in open pits, in underground mines, and for construction purposes on the mine site. The need to cover mineralized rock with inert rock or clay material should be considered.

5. REGULATORY ASPECTS

In September 2002, the IAEA held a technical meeting to discuss relevant regulatory approaches for the control of environmental residues containing

NORM. The meeting covered the regulation of NORM and NORM industries in Member States, with particular emphasis on potential public exposure and residual waste arising from these activities. The Member States representatives reported a wide range of waste disposal methods and statutory and regulatory controls.

In general, the radiation protection principles for practices may be used prospectively for the licensing of new installations. However, in situations such as contaminated areas due to past practices with NORM dose limits should not apply and the intervention principle should be taken into consideration. However, the degree to which the remediation will take place may (and, in fact, will) vary from country to country. It will not solely be a matter of technical feasibility assessment but will have to encompass socio-economic and political issues. The level of the additional risk acceptance by society is also a key issue. This is especially important in societies where public participation in such a decision is very active.

A complicating factor associated with NORM wastes is the fact that some of this material may be reused in certain applications, for example, red mud and coal burning ashes in brick production; gypsum in wall board application; and as fertilizer in agriculture. The use of NORM wastes will depend very much on economic, social and technological factors. This introduces a dual classification of these materials as waste and/or commodity.

Broadly, one can say that people would like to have two clear recommendations: first, at what level of individual total dose (i.e. extant residual dose) protective actions should be undertaken under almost any circumstances; and at what level of dose one can say that the situation is basically safe for the individual.

Whether the international community will reach a final consensus about this issue is a question to be answered, but the present criteria seem to be a rather reasonable approach: if the extant dose is above 100 mSv/a, there is no doubt that an intervention is required. If it is below 10 mSv/a, intervention is normally not required. In the middle range, there undoubtedly is an area of concern, which requires a detailed assessment to decide whether or not to intervene.

5.1. An overview of regulatory aspects in different countries

A brief overview concerning NORM wastes regulatory aspects in different countries is provided in this section. It is not intended to be comprehensive. Rather, it is aimed at pointing out the fact that international harmonization is needed.

5.1.1. USA

5.1.1.1. Federal sites

Most federal sites (mainly USDOE) are now listed on the National Priorities List (NPL) which places them directly under the jurisdiction of the Environmental Protection Agency and the states through the Comprehensive Environmental Restoration, Compensation and Liability Act (CERCLA, also known as Superfund). CERCLA has developed general criteria that apply to all carcinogens, including radiation. In simplified form, those criteria provide that:

— Sites should be cleaned up to a lifetime risk (for all reasonably plausible use scenarios) of no greater than approximately 10^{-4} (interpreted as $<3 \times 10^{-4}$), and in the case of radiation this upper limit is defined to be 0.15 mSv/a (based on 5×10^{-2} Sv^{-1} and an assumed 30 years typical exposure period, based on anticipated maximum residence times) or ^{226}Ra, U and Th combined activity concentrations of 0.2 Bq/g above background for site cleanup of contaminated soils.

— Sites that cannot satisfy that criterion cannot be released for unrestricted use, but may be released under enforceable use restrictions that lead to satisfying the same risk criteria for a more circumscribed set of uses (i.e. an industrial or park site, under effective zoning restrictions, would not have to satisfy 0.15 mSv/a for permanent occupancy under residential use). There is an additional requirement that groundwater which is an actual or potential drinking water source be cleaned up to satisfy drinking water standards, based on national groundwater policy.

5.1.1.2. Non-federal sites

The situation for non-federal sites varies. For sites not licensed by the Nuclear Regulatory Commission (NRC), CERCLA applies if the site gets listed on the National Priorities List (NPL), and the states have jurisdiction if it does not. This is the situation for all the radium, uranium mining and phosphate sites, some of which are on the NPL and some not (depending on the degree of contamination).

The NRC standard specifies 0.25 mSv/a with provisions permitting exceptions (release for unrestricted use) of up to 1 mSv/a. It also makes no provision for satisfying national groundwater protection policy.

5.1.2. Canada

The guideline recommends that NORM may be released with no radiological restrictions when the associated dose is no more than 0.3 mSv/a. The radioactive hazard associated with this dose is considered insignificant, and no further control on the material is necessary on radiological protection grounds.

5.1.3. Malaysia

The Atomic Energy Licensing Board (AELB) spells out the need for a Radiological Impact Assessment (RIA) to be carried out for the disposal of waste from oil and gas industry. If the RIA shows that an additional radiation dose to members of the public is less than 1 mSv/a, then the disposal by landfill will be exempt from control. In practice, the AELB is using a constraint limit of 0.3 mSv/a. With regard to treatment of wastes, dose assessment is required prior to approval from the AELB. In some cases, radiological monitoring are required to be carried out during the treatment. As for NORM wastes from the processing of minerals and ores, there is no specific guideline for its management. However, the AELB usually licenses with conditions to be fulfilled by the licensees. An RIA is also needed for the landfill disposal management of NORM wastes from processing of minerals and ores.

5.1.4. European Union countries

Title VII of the revised European Union Basic Safety Standards (BSS) Directive has, for the first time, set down a framework for controlling exposures to natural radiation sources arising from work activities. In Article 40 (Applications), it is stated that work activities involving operations with, and storage of, materials not usually regarded as radioactive but which contain naturally occurring radionuclides, causing a significant increase in the exposure of workers and, where appropriate, members of the public, shall be identified. In the relevant situations, the requirements of the Directive shall be applied. The BSS allow each member state a degree of discretion in this area.

Concepts such as ‘clearance’ or ‘exemption’ levels are used by some European Union countries. In the Netherlands, NORM regulations are based on a pragmatic approach, i.e. 300 μSv dose criterion; exemption level being the same as clearance level, both being based on realistic scenarios. However, the final fate of residues and wastes is still unclear for some industries. For example, the disposal of sludge from the oil and gas industry into abandoned wells is forbidden, and a final solution for the problem is not available. In Greece, for the phosphogypsum disposal in the environment in the form of stacks, a relevant radiological study is required. The study must be approved by the Greek Atomic Energy Commission (GAEC) and a licence must be issued. The use of phosphogypsum in agriculture may also be authorized if a set of requirements is satisfied.

6. IMPACT ASSESSMENT

6.1. General overview

There are a number of approaches to modelling the impact of waste disposal sites, each of which may be equally valid and which may have specific advantages for different types of sites. Some computer-based assessment models, developed to deal with radiological impacts of contaminated waste disposal sites are listed below:

— Environmental Contamination from Surface Repositories (ECOSR) [6];
— GEOS/ABRICOT [6];
— Integrated Model for the Probabilistic Assessment of Containment Transport (IMPACT) [7];
— INTAKE [8];
— Japan Atomic Energy Research Institute Model (JAERI) [9];
— Multimedia Environmental Pollutant Assessment System (MEPAS) [10];
— Residual Radioactive Material Model (RESRAD) [11];
— Safety Assessment Comparison (SACO) [12];
— State Office for Nuclear Safety Model (SONS) [13].

In each case, the models address radiological assessments of sites and determine the impact of the radioactive waste inventory on the population. The following factors are common to all models:

— The composition of the waste;
— The locations of the waste;
— The nature of the surrounding environment;
— The mechanism and pathways through which radionuclides from the waste are released into the environment;
— The off-site locations where migrating radionuclides may accumulate to form secondary sources of contamination;
— Uptake into the food chain;
— The habits of the population.

Clearly, many of these factors will be specific to individual sites. However, the underlying approach to quantifying these factors is often common to a number of sites. Key points of commonality may be expressed as follows:

- Waste is treated as a point source;
- The migration of radionuclides through the atmosphere is modelled assuming a Gaussian plume dispersion;
- Groundwater is modelled using a one dimensional advection-dispersion equation;
- The biosphere incorporates compartments to describe the distribution of radionuclides in soil, livestock, vegetables and aquatic foods, and is modelled by assuming that transfers within the system are in equilibrium.

In all cases, standard dose conversion factors are assumed. In most cases, radioactive decay and in-growth daughters are included. This is considered essential where the time periods of interest are relatively long by comparison with the physical processes involved.

6.2. Study case

As an example of the possible doses associated with the disposal of NORM wastes into the environment; the consequences of spreading slags from two niobium industries in Brazil and further use as landfill for house construction was examined. The assessment of the potential radiological impact was performed using the computational code RESRAD [11]. The pathways selected were as follows: external gamma irradiation; inhalation and ingestion of soil; radon exposure; and water ingestion due to an eventual aquifer contamination. Rounded values of average ^{238}U, ^{226}Ra, ^{210}Pb, ^{232}Th and ^{228}Ra activity concentrations of the solid waste were used as input. These values are shown in Table III. (See Ref. [5] for a detailed description of all parameters used in the calculations.)

In both cases, the exposure to radon and the external gamma irradiation represents the main contributions to the total dose. In the case of one of the examined industries, the exposure to radon is responsible for approximately 70% of the total dose immediately after the cessation of activities. In the long term, the radon contribution increases drastically owing to the in-growth of ^{230}Th. In both cases, the estimated doses are very high, above 100 mSv/a. It was also concluded that parameters related to the extension of the contaminated zone and annual precipitation rate could significantly affect calculations.

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Discussion following paper by H. Fernandes, M.R. Franklin and M.A. Pires do Rio

G. COLLARD (Belgium): I believe that in Brazil, as in Belgium, the regulation of radioactive substances is a federal matter, whereas the regulation of non-radioactive hazardous substances is a regional matter. Does this situation cause problems in Brazil as well?

H. FERNANDES (Brazil): Yes, it does. There is often a lack of close liaison between, on one hand, the institutions concerned with the radioactive contamination due to some industrial activity (for example, uranium mining) and, on the other, the institutions concerned with the chemical contamination due to that activity. Political decisions designed to bring about a holistic approach are necessary.

J. HULKA (Czech Republic): It seems to me that in many countries, as in the Czech Republic, non-radiological hazards represent a bigger problem than radiological hazards.

PANEL

HOW SHOULD POLICIES BE DEVELOPED IN THIS AREA AND CAN THEY BE CONSISTENT WITH POLICIES IN OTHER AREAS OF RADIOACTIVE WASTE MANAGEMENT?

Chairperson: **J. Hulka** (Czech Republic)

Members: **J. Avérous** (France)
A.W. van Weers (Netherlands)
H. Fernandes (Brazil)
P. Metcalf (IAEA)

Panel Discussion

P. METCALF (IAEA): A question often asked is whether large volumes of materials containing elevated levels of naturally occurring radionuclides should be regarded as radioactive waste. The BSS are explicit about the application of radiation protection principles to such materials, recommending the adoption of an intervention approach to controlling the associated exposures. However, if the materials containing naturally occurring radionuclides arise as the result of a practice, the principles for controlling exposures from practices should be applied. Either approach clearly indicates that the materials pose a radiological hazard warranting control and that they must therefore be managed as radioactive waste.

It is clear that the definition of 'radioactive waste' in the Joint Convention does not exclude waste containing natural radionuclides, but the Joint Convention allows countries to decide whether they will include such waste within the scope of the Joint Convention. The Contracting Parties will hold their first review meeting in 2003, when it will be seen what they report. It would seem that quite a lot of countries are drawing up inventories of waste containing natural materials.

So, it would appear that in international legal instruments and safety standards, large volumes of materials containing elevated levels of naturally occurring radionuclides are regarded as radioactive waste.

Applying radiation protection principles to the management of these types of waste gives rise to a number of difficulties, particularly in respect of radon exposure and how to deal with background levels. The management of these waste types was discussed at the Cordoba Conference and — together with disused radiation sources — was identified as an area where more work was needed.

It seemed that there were difficulties in rationalizing the waste management and disposal options for these particular waste types. So one action arising out of the Cordoba Conference was "to establish a common framework for the disposal of different types of radioactive waste". The IAEA has been working on the establishment of such a framework during the past two years. All the different waste types have been described and been divided into a number of categories based on the characteristics — volume, half-life and specific activity — which seem to be the controlling parameters. This has led to the identification of a number of limitations in the present classification scheme.

The various waste types have been linked to different waste disposal options in a manner that is compatible with the 'waste safety fundamental principles', together with the ICRP 81 recommendations for disposing of solid waste.

The different disposal options have been considered in order to determine which would be acceptable, for example, low level waste in a near surface facility is acceptable while high level waste in near surface disposal facilities is unacceptable. Also, there are 'inappropriate' options, for example, it would be inappropriate to dispose of low level waste in a geological disposal facility because it simply would not be worth the effort.

If we use the ICRP 81 recommendations, there arises the issue of what would not be acceptable in a near surface facility. This relates to waste that could give rise to the intervention levels specified in ICRP 82 being exceeded: 10 mSv to 100 mSv. From the figures that H. Fernandes showed, it is clear that you do not need very high concentrations of naturally occurring radionuclides in such waste in order to exceed 100 mSv. The average level of radium in the ground is about 30 Bq/kg. That gives rise on average to about 1.5 mSv/a. If you multiply that by a hundred (3 Bq/g), you exceed 100 mSv/a quite easily. In South Africa, there are 109 t of residues that exceed that level. These are enormous amounts of material.

As regards the disposal options available, stabilization in situ, which is basically what happens to mine tailings, is the only option for large amounts of such residues. The problem is that there are no good engineering techniques for stabilizing them in situ for time periods compatible with their radioactive half-lives. In the United States of America, the UMTRA project came up with very good engineering for stabilization, but with a design lifetime of, I think, 500 to 1000 years. In the case of materials with half-lives of millions of years, one needs to ask whether that is an appropriate approach. It implies that you must have institutional controls at the facilities essentially in perpetuity. This is a fact that we shall never be able to get away from. Whether it is uranium mine tailings, copper mine tailings, or phosphate mine tailings — the situations are exactly the same.

The common framework has also identified smaller amounts of waste — scales and concentrates — which can have up to tens of thousands of Bq of radium per g. These are above the waste acceptance criteria that are generally adopted for near surface disposal facilities. So, what disposal options are there for these materials? Can the generators of such waste afford geological disposal? Possibly not, but maybe a disposal option which is somewhat deeper than the so-called 'normal intrusion zone' that we talk about in the case of near surface disposal would be a solution. Or maybe we have to disperse these materials within an existing near surface facility.

How do we go about assessing the safety of these disposal options? It is a difficult issue. If you look at the radon pathway, there are still a number of issues related to the risks associated with exposure to radon. The epidemiological approaches involve considerable uncertainty. The lung dosimetry models were abandoned when it was a question of trying to cope with radon daughter exposures. So, there are still big question marks about the actual dose and the actual risk associated with exposure to radon daughter products.

Thus, there are a number of challenges. It is necessary to develop approaches to safety assessments of disposal facilities for these waste types in which people can be confident. Regarding the disposal options, there would appear to be two: stabilization on the surface, or some sort of subsurface disposal for the more concentrated waste. But we still have to do a lot of work in demonstrating the safety of these disposal options, and we have maybe to look closely at the criteria for exposure to radon.

A.W. van WEERS (Netherlands): Residues exist in very large amounts from a wide variety of NORM industries, for example, phosphogypsum production, titanium dioxide pigment production and even primary steel production. The residues from NORM industries are to be found all over the world.

Also, there is a tendency for the processing activities involved in NORM industries to ‘migrate’ from technologically advanced countries to countries where the ores are found. For example, that is happening in the case of the processing of phosphate rock and of tin ore.

A further internationally important phenomenon associated with NORM industries is the fact that the residues from particular NORM industries are becoming raw materials for other industries and are being moved around the world for that reason, for example, tin slag is being used in the extraction of tantalum, rare earth concentrates are being used instead of rare earth ores in the production of catalysts, and zinc concentrate is being used instead of zinc ore.

In the phosphoric acid industry and the titanium dioxide industry, the discharges have been reduced (not because of the radioactivity, but because of [discharges of] the cadmium, zinc, chromium and other contaminants present), and as a result there are large amounts of solid waste containing not only radionuclides but also other contaminants.

With globalization, NORM industries are increasingly in the hands of internationally operating companies, and one would expect these companies to exercise the same environmental care in one country as they are required to exercise in another country.

Is there a need to regulate the management of large amounts of low activity radioactive waste? As far as the countries of the European Union are concerned, there is no choice. Title 7 of the European Directive on Basic Radiation Protection Standards (96/29/EURATOM) requires them all to assess whether the residues from their NORM industries could give rise to radiation exposures which cannot be disregarded from a radiological protection point of view — and then to take appropriate regulatory measures, including the creation of exemption and clearance mechanisms. The compliance of those countries with that requirement is currently being evaluated.

J. AVEROUS (France): I should like to talk briefly about the detection of hazard situations associated with NORM and TENORM, and about the principles which one should apply in dealing with such situations.

As regards the detection of such situations, I think it is dangerous to rely on predetermined limits or levels, but you must of course have some guidance. You know usually that when you are milling uranium, you will produce TENORM, and it is also the case with phosphorgypsum, but I think that the inventiveness of people is very great (usually greater than the inventiveness of regulators), and you can always find some case where you have a problem which escapes regulation. So it is, in my view, very important not to underestimate the need for a general environmental monitoring system for harmful substances that is capable of detecting unexpected uses of radioactive substances. There is a very good example in the field of radiation protection relating to radon: when you are looking for radon in dwellings, you must have an environmental monitoring system, and this system must have some random components in order to detect such unexpected uses.

As regards the principles which one should apply, I think one should apply the general philosophy of radiation protection — above some level you have to intervene, and below that level you have to apply optimization and justification principles. These principles can only be applied on a case by case basis, with the involvement of stakeholders and the general public.

In my view, therefore, with NORM and TENORM you have to apply the normal principles of radiation protection. However, I do not like the idea of trying to predetermine action plans or cases that have to be tackled using reference levels, because you have two choices. If you want to be sure that you will not have any problems, you set very low reference levels — afterwards, you cannot do anything. Then, if you still want to, say, engage in trade, you have to set somewhat higher reference levels, but you will really have problems in some cases.

So, I would advocate a case by case approach involving the stakeholders, particularly the people who are living close to the facilities where you have problems and who are aware of the nearby dangers, since involving those people is, in my view, the best way of ensuring regulatory control over a long period.

A. WALLO (USA): J. Avérous expressed concern about the use of reference levels and said that we should do things on a case by case basis, involving stakeholders in the optimization process — that is clearly a good strategy. But why does he advocate that strategy only for NORM and TENORM, and why does one need reference levels with that strategy?

J. AVEROUS (France): One needs some reference levels as guidance, but I do not like levels expressed in becquerels per gram, as you have to carry out a case by case impact study in order to establish the relationship between dose and activity concentration. Of course, you have to apply the general principles to all cases, but in the case of NORM and TENORM, where it is usually difficult to distinguish between natural background activity and the additional radioactivity due to NORM and TENORM, you have to apply optimization and justification, talking with stakeholders.

H. FERNANDES (Brazil): I should like to make a comment regarding this issue.

When thinking about the principles of radiation protection, you should distinguish between a practice and an intervention. When licensing a nuclear facility, you allow for a dose increase that should not exceed the primary levels and should be under some kind of constraint. So you are being proactive.

As regards NORM and TENORM industries, so far they have not been licensed; the problem is already there. In this particular situation, it is recommended that you not apply any kind of limit. In ICRP 82, the ICRP recommends ranges that should be thought about. However, it can be difficult because, for example, you may have a situation in which, when you talk about optimization, the stakeholders may wish that the environment be completely clean. That is what happened after the Goiânia accident in Brazil; the local population did not want to have any residues of caesium in the area, and a lot of money had to be spent because it was impossible to convince the local population that the residual contamination would not appreciably increase the risk.

I agree with J. Avérous that setting limits is dangerous. On the other hand, people tend to find it easier to deal with fixed numbers than with an approach based on what would be acceptable — what would represent a consensus.

The key point, however, is that reference levels do not apply to intervention situations. That is the case with NORM and TENORM when the contamination is already there.

A. WALLO (USA): There appears to be an — at least perceived — inconsistency here. I would say that an operating phosphate industry or an operating zinc processing facility is a practice rather than an intervention situation, so that it would be somewhat illogical to intervene. It is difficult to understand why you say ‘dose limits are good here but not there’. There are a lot of reasons, largely cost-benefit ones, but maybe we ought to be honest and say what the real reason is for not applying dose limits here: that the cost is too high, and the impact is too great.

P. METCALF (IAEA): When I was working in South Africa, we decided about 20 years ago to regulate the mining industry, mainly because of the occupational exposures being incurred — there were some 100 000 workers receiving doses in excess of 20 mSv/a, about 1000 receiving doses in excess of 50 mSv/a and several tens receiving doses in excess of 10 mSv per month.

As the basis for the regulations, we took the normal radiation protection requirements for new practices.

We did not encounter many difficulties. The difficulties which we did encounter related to land which had mill tailings on it and which people wanted to use for some purpose or another. In such cases, we determined the background for the area and decontaminated to a level corresponding to that background. Essentially, that meant removing all the waste, but that did not prove to be very difficult.

Similarly, if you do not remove mine tailings but stabilize them in situ, the doses due to radon emanation are not very high 50 to 60 m away, so you can build there. If you allow any of the waste to get into building material or to contaminate land, however, you have big problems.

So, with an existing situation you may perhaps consider intervening, but if you are going to release the land for some use or other, that is a practice.

I. SIMÓN (Spain): Regarding the argument about intervention versus practice, I understand that a recommendation which is soon to be made by the ICRP, and in which the distinction is ignored, will be in terms of protective action levels for use on a case by case basis and that for NORM there will be a protective action level of 0.3 Bq/g below which no action would be called for.

We are applying the BSS, which will presumably have to be revised in the light of the ICRP recommendation. What is happening within the IAEA framework?

P. METCALF (IAEA): The recommendation, which is actually for a protective action level of 0.5 Bq/g, is currently being reviewed by IAEA Member States, which will decide in March 2003 whether to accept it.

H. FERNANDES (Brazil): Regarding what I. Simón just said, I should like to recall that ICRP recommendations are just recommendations — not decisions about what is going to be done. Let me explain why I say that.

In Brazil, we are having problems with a phosphorgypsum dump near the city of Sao Paulo. The environmental protection agency realized that it might represent a radiological hazard and asked us what to do. The advisers who were sent in consulted Brazil's regulations and concluded that the material was, because of its total activity (not the activity concentration), radioactive waste. Does that mean that the facility where the dump is located is radioactive? Of course not!

In my view, playing with numbers can be dangerous; we need a pragmatic approach. Like J. Avérous, I should like to see discussions on a case by case basis, with the direct involvement of the affected communities, because, if you make general assumptions on a broad basis, you may find that every industry has to be regulated — at great expense.

A.W. van WEERS (Netherlands): I should like to point out that a reference level expressed in terms of concentration (Bq/g) is a derived level. The primary level is expressed, as a dose criterion or dose constraint, in terms of exposure (mSv/a or μSv/a).

With regard to NORM industries, within the European Union a clear distinction is made between, on one hand, practices and on the other, activities involving natural sources, which are referred to as 'work activities'. However, there is a problem in both cases. When you have materials/residues in practices or work activities and you want to clear them for reuse, recycling or disposal, you need a dose criterion and derived levels. As regards work activities, the general opinion is that the dose criterion for clearance should be about 300 μSv/a — very different from the 10 μSv/a for the exemption and clearance of materials from practices. On the basis of this, you have a series of numbers in becquerels per gram below which you can unconditionally clear materials from NORM industries.

M. VESELIC (Slovenia): I agree with what J. Averous and H. Fernandes said. In my view, one must be realistic and consider problems on a case by case basis.

Within the European Union, a new directive on mine waste is currently being prepared, and I would recommend to the IAEA that it contact those who are preparing it in order to ensure that NORM issues are taken into account.

J. AVEROUS (France): Regarding P. Metcalf's reference to a recommended protective action level of 0.5 Bq/g, I do not see why I should not authorize an activity involving material which is above that level if an impact study has shown that there is no problem. For example, I would have no objection to the recycling of metal parts from a dismantled phosphorgypsum plant if an impact study has shown that there is no problem, even though they are above the 0.5 Bq/g level — provided, of course, that everything has been done in a transparent manner and the stakeholders have been consulted.

I am simply uncomfortable with Bq/g limits.

A.W. van WEERS (Netherlands): I agree with J. Avérous, but what he said underlines the fact that the primary criterion should be a dose criterion — what is a reasonable dose constraint for exposure to NORM? When you have agreed on that, there is still much to do in order to arrive at acceptable options for disposal and so on.

P. METCALF (IAEA): I should like to mention that the IAEA is now thinking in terms of 'exclusion levels' below which one should simply not be concerned at all, but above which exemption is still possible or one can start introducing controls gradually.

A point which has not received much attention here is the fact that a near surface disposal option for long lived waste implies institutional control in perpetuity, which might be regarded as placing an undue burden on future generations. In my view, the point merits thorough discussion.

A. WALLO (USA): I have a feeling that the Panel members are trying to harmonize their positions by relating the case by case approach to the fact that it is all a question of dose limitation. In my view, that is not harmony. I think the point was made that the case by case approach requires optimization, but I do not understand how the dose criterion that gives rise to a Bq/g number satisfies the optimization requirement.

Do the Panel members think they really are in harmony just because there is a dose derived concentration? In my view, the issue of optimization has not been addressed.

J. AVEROUS (France): I think that what is usually being done with uranium mine tailings is a good example of optimization. The tailings are being left on the surface and protective measures are being taken, for example, institutional controls are being set up. This is not a very satisfactory solution, but it is what is being done because of the justification and optimization principles, because it would be too costly to build an underground repository.

I do not agree with dose constraints. Clearly, you have to intervene if the dose is above a certain level, but I think that otherwise you should discuss matters on a case by case basis, looking at all the problems involved.

H. FERNANDES (Brazil): There are situations where, from the point of view of radiation protection scientists, the doses do not justify action but the public calls for action regardless of what the scientists say. How clean is ‘clean’? The public sometimes even demands decontamination down to the original background levels. So there is a societal dimension, and optimization is not just a matter of cost-benefit analysis.

D. BONSER (United Kingdom): The view has been put forward that, in many cases, the chemical hazards associated with radioactive waste are more serious than the radiological hazards. Is there any agreement on how to compare chemical and radiological hazards — a kind of ‘common currency’?

A.W. van WEERS (Netherlands): I’m afraid not. However, there is a need to develop a common approach to residues from, for example, oil and gas production, which are radioactive and contain mobile heavy metals.

H. FERNANDES (Brazil): A difficulty in carrying out comparative assessments is that the effects of radiation at low doses are stochastic, whereas the effects of the heavy metals which we have in mind are deterministic.

In an assessment which we carried out at a uranium mine tailings dump, we found that the ^{210}Pb with its short half-life decayed before reaching the groundwater; the uranium, because of the distribution coefficient, was retained in the bedrock, but the sulphate migrated easily.

The risk assessment methodology used in the USA at the Superfund sites could, I think, be used for comparative assessments.

A problem vis-à-vis the public is that the levels of radioactive pollutant releases from nuclear facilities may not exceed 1 mSv, whereas a phosphoric acid production plant may leave a site radioactively contaminated to the extent that you have doses higher than 10 mSv. How do you explain that to the public?

J. AVEROUS (France): That is a problem which we technical people, having carried out the impact/risk assessment to the best of our abilities, should place before the politicians. We should not spend too much time discussing it among ourselves.

L.R. SCHNEIDER (Germany): I think we need a consistent strategy for dealing with — if we take Germany as an example — uranium mines, centuries-old silver mines, and oil industry facilities. Because of different approaches to radioactivity, we were not allowed to move radioactive crud from oil industry facilities to the Morsleben repository for low and intermediate level waste.

J. AVEROUS (France): In my view, we do not need unified dose criteria for polluted sites or for very large amounts of NORM. These do not move about, so that in each case the problem is a local one. If the dose levels are below the intervention level, a political solution has to be found to the problem.

It might be reasonable, in the light of an impact assessment, to dispose of very low level waste contaminated with artificial radionuclides and of NORM and TENORM at a conventional waste disposal site, but disposal of the waste contaminated with artificial radionuclides would most likely not be permitted on political grounds. At some point, the issue ceases to be a technical one and becomes a political one.

A.W. van WEERS (Netherlands) [in reply to a comment made with respect to NORM industries, where the points made included that NORM industries were not regulated properly in the past, that the resulting problem is to a large extent unmanageable, that if the old approach continues today the result will be a worse problem, and that the NORM industries operating today should be regulated as practices]: I agree. We should make a clear distinction between intervention in order to deal with the consequences of unregulated past activities and regulating a work activity. In the former case, there are no dose constraints/limits; in the latter case, there are dose constraints/limits, and one has to operate in accordance with the principles of radiation protection.

H. FERNANDES (Brazil): We have assessed the impact of liquid and gaseous discharges from many mining facilities in Brazil and have found the doses to the public to be below the 10 μSv exemption level.

From the point of view of exposure of the workforce, radon in mine galleries was an issue. We measured concentrations in the air of 20 kBq/m^3, which is quite high, but it is easy to achieve reductions.

The most important thing, however, was the residues. As long as the residues are within the site, there is probably no risk of exposure of the public. When they are disposed of outside the site and the operator no longer has any control over them, you have contaminated areas and the principles of intervention apply.

How far one should go with remediation is a matter for debate; as A.J. González said, it is a question of optimization. Besides that, there are complications in treating such mining operations as practices, as they were not intended to produce or to process nuclear material. This is a philosophical issue; if we regulate them as practices, in some cases we will not be able to keep them under observation properly. So, we are thinking of an intermediate framework within which we can have a situation where some kind of self-declaration arrangements or whatever could be put in place, and we are formulating recommendations or guidelines to help operators to deal with the main issue — the residues or wastes which they produce.

Finally, there is the question of international trade. Some products from Brazil are being rejected by European Union countries. In my view, if the wrong decisions are taken now, the problem will become a time bomb.

J. AVEROUS (France): NORM and TENORM waste can arise in the most unexpected processes. In France, for example, there have been high activity concentrations in the sand filters at the beginning of the drinking water treatment process. I would not like to have to regulate this process as a practice.

THE MANAGEMENT OF RADIOACTIVE WASTE FROM PAST ACTIVITIES AND EVENTS

(Session 7)

Chairperson

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THE CONTACT EXPERT GROUP FOR INTERNATIONAL RADIOACTIVE WASTE PROJECTS IN THE RUSSIAN FEDERATION

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Abstract

The Contact Expert Group (CEG) was formed in 1995 following an international conference at the IAEA on radioactive waste management in the Russian Federation. The purpose of the CEG is to collect information on radioactive waste and spent nuclear fuel problems in the Russian Federation and to present recommendations for their elimination.

1. INTRODUCTION

The end of the Cold War has left behind a legacy of radioactive waste and spent nuclear fuel as well as a great number of decommissioned nuclear powered submarines and other vessels. Today they represent a source of concern from both an environmental and a proliferation point of view. They need to be taken care of with some degree of urgency.

2. ESTABLISHMENT OF THE CONTACT EXPERT GROUP

The Russian Federation is experiencing many problems related to the management of its Cold War nuclear legacy. The Nordic countries became aware of this situation at an early stage and offered their assistance. They also wanted to engage the international community to assist in solving the problems related to radioactive waste management in the Russian Federation. They approached the IAEA, which in May 1995 organized an international conference entitled 'International Co-operation on Nuclear Waste Management in the Russian Federation'. The conference was financially supported by Nordic countries and attended by 18 countries and international organizations. Presentations at the conference revealed a number of urgent challenges regarding management of radioactive waste in the Russian Federation related to past activities in the military and civilian fields.

A number of international organizations and countries began co-operating with the Russian Federation in order to deal with its problems emanating from the accumulated amounts of spent nuclear fuel and radioactive waste. The IAEA conference identified the need to establish a mechanism for co-ordination and information exchange among those international organizations and countries that were co-operating with the Russian Federation in dealing with these issues.

In September 1995, a meeting was held in Stockholm where it was decided that the Contact Expert Group (CEG) would be set up for this purpose. The IAEA was requested to provide the executive secretariat and the CEG was set up under the auspices of the IAEA.

3. MEMBERSHIP OF THE CEG

All countries and international organizations interested in contributing resources within the objective and scope of the CEG are eligible for membership of the CEG. Presently, the membership of the CEG is as follows:

— Ten member countries: Belgium, Finland, France, Germany, the Netherlands, Norway, the Russian Federation, Sweden, the United Kingdom and the United States of America;
— Four international organizations: the European Commission, the IAEA, the International Institute for Applied Systems Analysis (IIASA) and the International Science and Technology Center (ISTC);
— Observers are Japan and the Nordic Environment Finance Corporation (NEFCO).

4. OBJECTIVES OF THE CEG

The main objective of the CEG is to offer information and guidance about the radioactive waste situation in the Russian Federation and promote international project co-operation to enhance the safety of spent nuclear fuel and radioactive waste management in the Russian Federation.

5. ORGANIZATION OF THE CEG

The CEG has a chairperson, a vice-chairperson and an executive secretary. The secretariat is located within the IAEA premises. Plenary meetings of the CEG have been arranged twice yearly in alternating members' cities, organized by the respective national representative. The plenary meetings provide a forum for assessing and preparing activities within the CEG.

6. ACTIVITIES OF THE CEG

The CEG serves as a forum for discussion and exchange of information and presents recommendations on specific co-operation projects with the Russian Federation.

The CEG arranges ad hoc meetings and workshops on specific topics. It collects information and presents reports related to its main areas of activity, formulates ideas for project co-operation and seeks to attract financial support from interested contributors to implement projects that have received approval by the CEG. The secretariat maintains a database on co-operative activities in the Russian Federation, which includes over 200 projects.

At one stage, the CEG established a special working group of experts to draw up a general strategy for managing spent nuclear fuel and radioactive waste in the Russian Federation and to identify high priority areas for future international co-operation. The work of this group was supported by the European Commission. It was recognized that current radiological problems in the Russian Federation are caused mainly by the Cold War legacy, and in particular by the massive decommissioning of the Russian Federation's nuclear submarines, which has been initiated recently. The following three high priority areas for future co-operation were identified and approved by the CEG (in the given order of priority):

— Remediation of naval bases in the north-western part of the Russian Federation (especially Andreeva Bay and Gremikha).
— Recovery and safe interim storage of spent nuclear fuel from decommissioned nuclear submarines and service vessels.
— Conditioning and containment of high level liquid radioactive waste and sludges in fuel cycle facilities (especially Mayak, Krasnoyarsk and Tomsk).

6.1. Andreeva Bay

It was recognized that the remediation of the former naval base at Andreeva Bay is one of the most demanding challenges with regard to conditioning and safe storage of spent nuclear fuel and radioactive waste. This facility was used by the Northern Fleet of the former Soviet Union for more than 30 years as the main storage for spent nuclear fuel from submarines and all types of radioactive waste. It is located in the Litsa Fjord on the northern side of the Kola Peninsula, approximately 50 kilometres from the Norwegian border. The Ministry of Atomic Energy (Minatom) of the Russian Federation has been given the responsibility to clean up the site. A substantial amount of spent nuclear fuel (about 100 submarine reactor cores) and different radioactive wastes have accumulated there. They are stored under conditions which reportedly fail to meet current safety requirements, thereby posing a substantial risk to the Arctic marine environment.

In order to initiate international co-operation for remediation of this facility, a specially dedicated CEG workshop was organized and successfully conducted in October 2001 in Idaho Falls, Idaho, USA, under the sponsorship of the United States Department of Energy (USDOE), the Department of Defense (DOD), the Idaho International Engineering and Environmental Laboratory (INEEL), and several other US organizations. As a result of the discussion based on detailed technical information presented by representatives of the Russian Federation at the workshop, several projects were proposed for immediate initiation under the sponsorship of Western nations. The 13th CEG Meeting in Oskarshamn, Sweden in November 2001 fully endorsed the conclusions and proposals made at the CEG workshop. Shortly thereafter, negotiations on several specific projects aimed at establishing the necessary infrastructure at that site were initiated. Further preparatory activities in the area of spent nuclear fuel and solid radioactive waste management at Andreeva Bay were discussed at the second CEG workshop on Andreeva Bay remediation, which took place in March 2002, in Moscow. The workshop was organized with the support of the Minatom of the Russian Federation.

The status of international projects on Andreeva Bay was reviewed at the 14th CEG Meeting which took place at the IAEA in Vienna in April 2002, and the 15th CEG Meeting which took place in Brussels in October 2002. The current situation is as follows:

— The Russian Federation performs the most urgent activities at the site, including security measures, fragmentation and storage of solid radioactive waste (presently stored on open pads), treatment and removal of liquid waste from the site.
— Norway is rebuilding the infrastructure at the site, including the construction of an administrative building, repair of the access road and supply of water, sewers and electricity.
— Sweden has volunteered to lead activities related to the management of solid radioactive waste. Detailed surveys and feasibility studies will be

conducted at the beginning of this project. Preparatory activities are under way.

— The UK will lead activities on the management of spent nuclear fuel. Feasibility studies and detailed surveys are planned for the initial stage.
— The UK will conduct investigations and studies on the level of radioactive contamination of Building 5 where spent nuclear fuel was previously stored in pools. However, practical work on these projects will require a bilateral agreement between the UK and the Russian Federation on issues such as liability, taxation, etc.
— Norway will carry out a project to improve the physical protection and access control to the site.
— Norway is supporting a project to map radiological contamination of the site, improve radiation protection of personnel and upgrade the radiation monitoring system.

6.2. Gremikha

The Gremikha naval base is another storage for spent naval nuclear fuel. It is situated on the north-east of the Kola Peninsula. It can be reached only by sea and air. At this site, a good deal of spent nuclear fuel has been stored outdoors for more than 30 years in obsolete containers. There are also substantial amounts of solid and liquid radioactive waste. A number of decommissioned nuclear submarines are moored in the area. The bulk of them will need to be transported to shipyards elsewhere on the Kola Peninsula for dismantlement. This can be accomplished only with the help of floating devices, pontoons or a floating dock, as the submarines' capacity to float is endangered because of age and degradation. Gremikha is the service base for the submarines with liquid metal cooled reactors. Three such submarines are still awaiting defuelling. In order to carry out this operation, the defuelling facility will need to be refurbished and some infrastructure provided. Their nuclear fuel is highly enriched uranium which represents a proliferation threat.

The CEG is planning to arrange a workshop in 2003 on the Gremikha naval base in order to draw up a picture of the radiological situation at the base and identify the amounts of spent nuclear fuel and radioactive waste stored at the site. On this basis, projects suitable for international co-operation may be formulated.

6.3. Dismantlement of nuclear powered submarines

The former Soviet Union had more nuclear powered submarines than any other nation. Most of those submarines are now obsolete and decommissioned; they await their final dismantlement and disposal. In all, approximately 250 submarines from either the former Soviet Union or the Russian Federation have been built. According to sources from the Russian Federation, 190 submarines have been taken out of service, of which 68 have been partly dismantled. This means that they have been defuelled and stored floating as three compartment units with the reactor section in the middle. The remaining 122 submarines await dismantlement, 93 of which have not yet been defuelled. Roughly two thirds of the nuclear submarines belonging to the Russian Federation were located in the north-west, with the remaining one third in the furthest eastern parts of the Russian Federation. Today, 55 submarines in the east and 67 submarines in the north-west of the Russian Federation await dismantlement. In addition, there are 41 contaminated service vessels that have been used for transporting and storage of spent nuclear fuel and radioactive waste. They will need to be dismantled, and radioactive parts conditioned and stored.

7. ORGANIZATION OF THE DISMANTLEMENT OF NUCLEAR SUBMARINES

The Russian Federation was not prepared for this massive dismantlement of nuclear submarines. Organization and infrastructure had to be put in place; shipyards had to be refitted; transport, storage and reprocessing capacity had to be increased. By an order of the Government of the Russian Federation, the Minatom was commissioned to organize the dismantlement of the submarines and the cleaning up of nuclear sites where spent nuclear fuel and radioactive waste had accumulated from the naval operation of nuclear powered vessels, mainly submarines. The Minatom set up two separate organizations to deal with these issues. One for the north-west of the Russian Federation, the SevRAO (referring to the Northern Federal Unitary Enterprise on Radioactive Waste Treatment), and one for the far east, the DalRAO (referring to the Far Eastern Federal Enterprise for Handling Radioactive Wastes), both subordinate to and reporting to the Minatom. The activities of the two organizations are financed by national budget appropriations through the Minatom, and to some extent through foreign contributions.

8. FOREIGN ASSISTANCE TO THE DISMANTLEMENT PROCESS

A few countries have offered assistance to the Russian Federation to speed up the process of dismantling submarines and cleaning up nuclear sites.

The USA, under its Cooperative Threat Reduction programme, is financing the dismantlement of approximately 30 strategic nuclear submarines. The programme includes management of spent nuclear fuel and radioactive waste resulting from the dismantlement process. The USA has also provided important infrastructure including cutting equipment, defuelling stations, and treatment plants for solid and liquid waste. Japan has delivered a treatment plant for liquid waste which is in operation in the far eastern parts of the Russian Federation and has conducted negotiations for additional projects. Norway has supplied infrastructure such as railway cars for transporting containers with spent nuclear fuel, a storage plant for liquid waste from scrapping of submarines, and is in the process of rebuilding the infrastructure at Andreeva Bay. Norway and the USA together have:

— Built a storage pad for containers with spent nuclear fuel at a shipyard near Murmansk;
— Provided casks for storing and transporting solid radioactive waste;
— Developed a cask for storing and transporting spent nuclear fuel.

Given the complexity and the costs involved in dealing with the nuclear legacy of the former Soviet Union, however, it has been recognized that a wider multinational effort is required in order to eliminate the most urgent problems in the near future. Recent international developments are rather promising and a couple of intitiatives have been taken that could provide substantial financial support. One is the setting up of a fund under the Northern Dimension Environmental Partnership (NDEP) financed by the European Commission and five European countries. The fund will support nuclear as well as environmental projects within the NDEP region. The European Bank for Reconstruction and Development (EBRD) is managing the fund.

In addition, the G8 has undertaken a commitment to assist the Russian Federation in dealing with its nuclear problems. The Global Partnership initiative was launched during the G8 Summit in Canada in June 2002. It obliges the USA on one side, and its other members on the other, to spend US $10 billion each over the next 10 years to assist the Russian Federation, among other things, to dismantle nuclear submarines. States that are not members of the G8 are invited to join the Global Partnership.

9. THE WAY AHEAD

A substantial improvement of the situation for spent nuclear fuel and radioactive waste in the Russian Federation will require large financial means.

It is likely that such amounts may be accumulated only through multinational joint undertakings. In addition to multinational initiatives, a number of countries will continue to operate bilateral programmes with the Russian Federation. Bilateral and multilateral programmes should be directed towards the most pressing needs, which from today's perspective seem to be the dismantlement of decommissioned nuclear submarines, including the provision of necessary infrastructure and equipment for this activity. The cleaning up and decontamination of nuclear sites, the handling and conditioning of stored spent nuclear fuel and radioactive waste at such sites is another urgent issue. The various programmes and activities ought to be co-ordinated to avoid overlapping and achieve the maximum benefit from the investments. The CEG is well placed and able to carry out such a function, as is shown by its current performance.

SAFETY UPGRADING OF THE PÜSPÖKSZILÁGY DISPOSAL FACILITY

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Abstract

Although for more than 20 years it has been operated safely, the near surface repository at Püspökszilágy is now considered to be unsuitable for some of the waste formerly placed in the facility. The results of the safety assessments clearly indicate that the spent sealed radiation sources could both result in high doses of radiation to individuals who intrude into the facility, and lead to high doses following any future disruption of the facility by natural processes. Based on the findings of the safety assessments, consideration will be given to possible developments at the site, which could include retrieving certain waste types from the site and putting them into interim store, pending final disposal in a geological repository; remedial measures to improve safety of the wastes that are currently disposed; and disposal of further wastes by providing free capacity within the existing facility. The future decisions about the Püspökszilágy repository will be based on optimization studies. The present paper provides a detailed review of the current situation and highlights the possible future alternative scenarios to improve the overall safety of the site.

1. HISTORICAL BACKGROUND

In Hungary, the application of open and sealed sources of radioactivity on a larger scale began in the latter half of the 1950s. A research reactor was commissioned in 1959 for the Central Research Institute for Physics in Budapest. The first nuclear power plant unit went into operation in 1982.

Currently, there are two main groups of institutions which generate low level waste (LLW) and intermediate level radioactive waste (ILW). The first group, involving small scale or non-fuel cycle producers, includes hospitals, laboratories and industrial companies. The other main waste producer is the Paks nuclear power plant with its four WWER-440 reactors.

At the beginning of the 1990s, there were approximately 2000 workplaces licensed for the application of isotopes, mainly working with sealed sources. Their number has been continuously decreasing, and has dropped recently to between 500 and 600 because of the structural changes in the Hungarian economy.

Producers of the first group generate yearly between 10 m^3 and 30 m^3 LLW/ILW. This amount includes between 10 m^3 and 25 m^3 of solid waste, between 4 m^3 and 5 m^3 of liquid waste, between 1 m^3 and 2 m^3 of biological waste, and 500 to 1000 pieces of spent radiation sources (SRS).

A major source of waste awaiting to be disposed of now and in the future is in the form of spent radioisotopes and sources. It is estimated that only 0.5% of the sealed sources in Hungary have been collected and disposed of. In addition, Hungary is a significant exporter of sealed sources and recent licences have included a commitment to accept repatriation of spent sources originating from Hungary.

In 1960, a temporary waste disposal facility was set up at Solymár in the north-western outskirts of Budapest. About 900 m^3 of LLW was stored there in concrete wells 3–4 m deep. As the site proved to be inadequate, the Hungarian Atomic Energy Commission (HAEC) decided on establishing a new radioactive waste disposal facility for institutional wastes close to the main production centre (Budapest). In December 1976, the Radioactive Waste Treatment and Disposal Facility has been commissioned some 40 km north-east of Budapest, near the village of Püspökszilágy. In 1980, the Solymár site was cleaned up and closed by transferring all waste to the new facility.

The repository was commissioned in 1976 and was formerly operated by the Budapest Branch of the State Public Health and Medical Officer Services. Since 2 July 1998, the newly formed Public Agency for Radioactive Waste Management (PURAM) has taken over the operational tasks.

In 1983, the site was licensed to dispose of low level solid radioactive wastes from the Paks nuclear power plant until the expected opening of the power station's own disposal facility. Unlike other waste producers, the power plant was charged for this service and was compelled to build as much new disposal capacity as it would occupy. The shipments from the nuclear power plant continued until 1996.

The Püspökszilágy disposal facility was responsible for taking over institutional radioactive waste from the producers, and treating and disposing of them properly. However, neither the original licence nor the licensing of the extension dealt with waste acceptance criteria. On the request of producers, SRS have been accepted for disposal. There were two important exemptions to the overall take over responsibility. Radium sources (needles, capsules, etc.) of medical applications had been collected and stored at the National Institute of Oncology. In the early years, the Püspökszilágy repository accepted ^{238}Pu and ^{239}Pu sources for disposal, and these cases were discussed and agreed upon with the HAEC and the Institute of Isotopes of the Hungarian Academy of Sciences to comply with safeguard requirements. At present, however, this practice has been terminated and plutonium sources are collected and stored in the Institute of Isotopes.

To date, approximately 4900 m^3 of solid and solidified waste has been placed — 1580 m^3 of it came from the Paks nuclear power plant, which took up some 2500 m^3 repository volume — in the disposal site and about 3000 m^3 has been sealed and temporarily covered. More than 80% of the disposed waste is classified as LLW and the available record data show that the current total activity placed is approximately 800 TBq.

The site was extended in the late 1980s. The Hungarian Geological Survey, one of the authorities participating in the licensing procedure, has not consented to the issue of the permanent licence during the licensing procedure of the new vaults. The new vault extension has been granted a limited operating licence.

The radioactive waste disposal facility at Püspökszilágy is currently the only site for disposal of radioactive waste in Hungary.

2. DESCRIPTION OF THE FACILITY

The disposal site is located on the ridge of a hill near Püspökszilágy village (Fig. 1). The facility is a near surface engineered type repository (on typically shallow land), with concrete vaults and shallow (6 m) wells for waste disposal purposes.

The disposal units are categorized into four classes, abbreviated by letters:

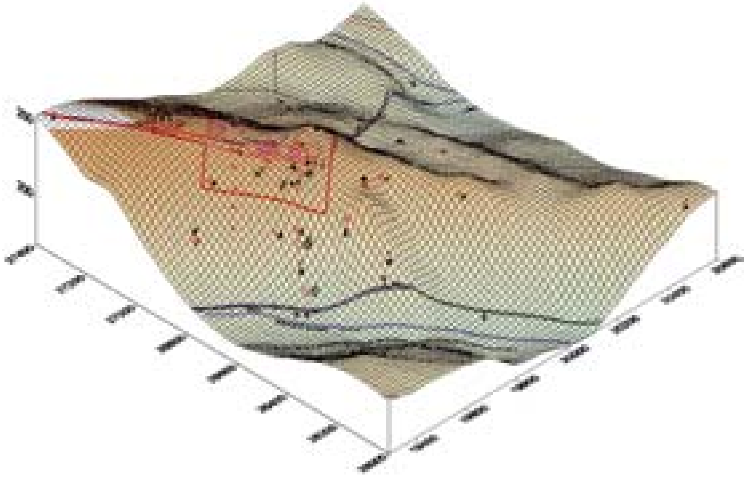

FIG. 1. Disposal site at Püspökszilágy.

— The ‘A’ type disposal system consists of the original 48 vaults, 70 m^3 each and the extension: 6 vaults, 140 m^3 each plus 12 vaults with 70 m^3 volume (see Fig. 2).
— The ‘B’ type disposal system consists of 16 wells with a diameter of 40 mm, and 16 wells with a diameter of 100 mm. The wells are stainless steel lined and 6 m long, located inside a concrete monolith structure (Fig. 3).
— The ‘C’ type disposal system consists of 8 vaults, 1.5 m^3 each proposed and used for disposal of solidified organic solvent (Fig. 4).

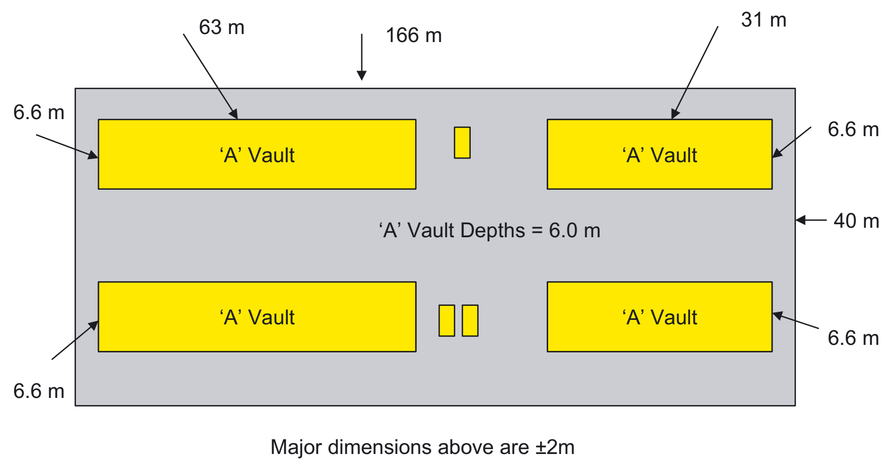

FIG. 2. Layout and dimensions of the ‘A’ vaults.

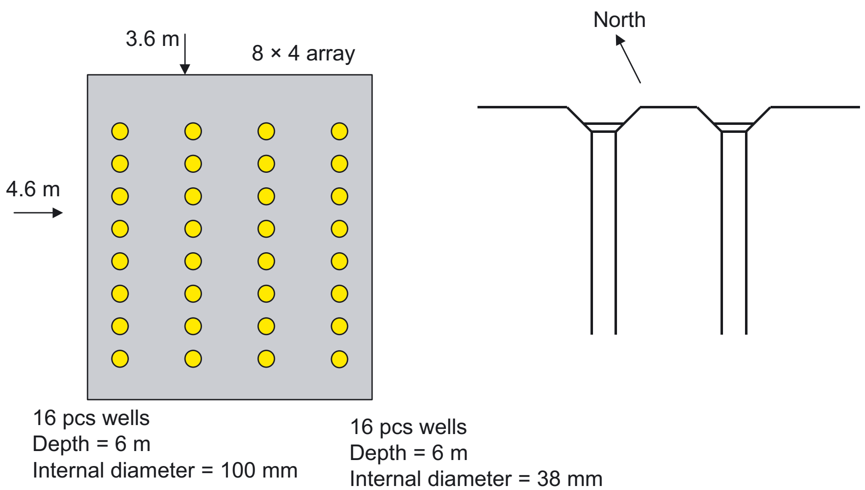

FIG. 3. Layout and dimensions of the ‘B’ wells.

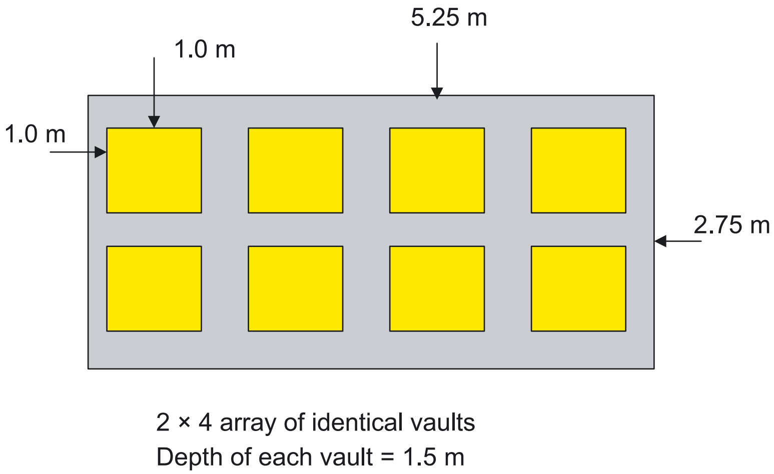

FIG. 4. Layout and dimensions of the 'C' vaults.

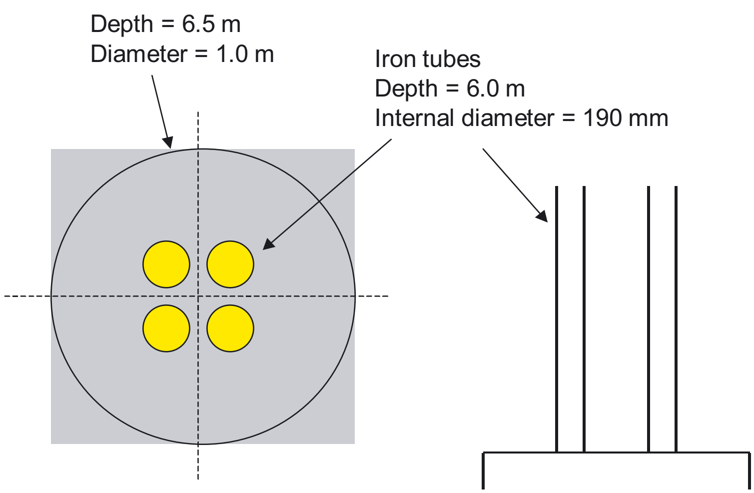

FIG. 5. Layout and dimensions of the 'D' wells.

— The 'D' type disposal system consists of 4 wells with a diameter of 200 mm. The wells are stainless steel lined and 6 m long (Fig. 5).

The solid waste is packaged into drums (formerly plastic bags were also used), the spent sealed sources are handled with a shielding container. Solid waste put in plastic bags by the producer is repackaged into drums at the disposal facility. The liquid waste is sponged up with siliceous marl or cemented. In earlier days, the biological waste was filled with bitumen in drums; at present, it is also cemented.

At the beginning of the site operation, both unconditioned and conditioned waste, packaged in plastic bags or metal drums, was placed in layers in the vault, and each vault was backfilled with concrete (disposal phase): the corresponding volume of radwaste is about 2800 m^3. A few years ago, the authorities required the retrievability of the newly emplaced waste until confirmation was received of the post-closure safety. Since that time, no backfilling has been allowed and the site must be considered an interim storage site (storage phase). Two vaults have already been sealed and temporarily covered.

Steel lined concrete wells are used for the disposal of high activity waste. This waste comes from isotope users and is regarded as high level waste (HLW) based on the Hungarian National Standard for the Classification of Radioactive Wastes. (HLW is defined as having a dose rate at the surface higher than 10 mGy/h.)

Large activity gamma sources are usually put and sealed afterwards into a special disposal container (called a 'disposal torpedo', owing to its shape) by the Institute of Isotopes. Gamma sources having no surface contamination are not packaged; lead containers are used for their safe transportation. Alpha and beta sources have to be packaged into polyethylene casings.

Gamma sources are not conditioned prior to disposal into the stainless steel lined boreholes. Usually twice a year, the boreholes are partially filled by cement grouting up to the level of sources. Spent alpha and beta sources have to be embedded into cement prior to disposal into the 'A' type vaults.

The disposal wells of 'B' and 'D' types had been designed basically for the radiation protection requirements of the 1970s, for disposal of gamma emitting sources. These wells have a 5 m long active length because the upper 1 m long part has to be cemented in case of closing the individual well. It was envisaged to provide the necessary radiation protection at the surface. The conical guidance part is protected during the operational phase by a lead plug.

A particular feature of the site is that — because neither the original licence nor the licensing of the extension dealt with waste acceptance criteria — high activity sources and SRS consisting of a long half-life and alpha emitting materials have also been disposed of, and not only in the wells but also in the vaults. The lack of defined waste acceptance criteria means that an acceptable benchmark is not established against which the type of waste received can be judged to conform or not conform with a required standard other than the external dose rate. The operators of the facility recognized that inconsistencies existed in the recording of waste that has been stored historically at the site. Proposals have been made to establish a comprehensive quality assessment/quality control (QA/QC) system as part of the review of the operation of Püspökszilágy.

There are more than 80 isotopes usually accepted by the facility for storage or disposal. The main radioisotopes in the waste disposed of are ^{3}H, ^{14}C, ^{60}Co, ^{90}Sr, ^{99}Tc, ^{137}Cs, ^{192}Ir, ^{226}Ra, $^{238/239}Pu$ and ^{241}Am.

The currently remaining unused capacity at the site has been reduced to 100 m^3, which is sufficient for the coming five or six years to accommodate the annual volume of waste stemming from non-power generation activities. Due to the reduction in usable disposal volume, the future development of the facility was unclear. A firm basis was required to support decisions concerning its future management. The legal and regulatory changes also necessitated a safety re-evaluation of the repository. That is why safety assessments were carried out to work out the long term effect of the disposed waste and to develop an understanding of the overall 'disposal capacity' of the site as a basis for decision making.

3. REFURBISHMENT ACTIVITIES

The repository operated for more than 30 years without any accident or release of radioactivity to the environment, but also without any investment in upgrading. As a consequence, the equipment became obsolete and the physical conditions of the operating systems impaired. In 1998, PURAM started systematic work on the safety upgrading of the Püspökszilágy repository. During 1998 and 2002, the safety re-evaluation of the repository was the primary focus, to include some basic modernization and refurbishment measures.

One of the objectives with regard to the development of the Püspökszilágy repository has been to upgrade the physical state of the facility and to provide better conditions for its continuing operation. The main areas of the upgrading activities were as follows:

- Physical protection (new fence system, new access control, new equipment for the security guard), radiation protection (replacement of the obsolete measurement devices, enhanced environmental monitoring), data acquisition (new data recording system, waste characterization capability, new meteorological station), transportation (new transport vehicle and containers).
- Repair and improvement of the buildings, entire refurbishment of the electrical supply and reserve electrical supply, water supply, specialized sump water collection and ventilation systems, decontamination facility,

improvement of the firefighting system together make the modernization activities complete.

The other main objective of development at the repository site is to make preparations for conversion of the existing treatment building (the ‘active building’) into a centralized interim store for institutional radioactive waste which is not meant for near surface disposal. Two main categories include radium sources of medical applications formerly stored at the National Institute of Oncology, and plutonium sources being stored in the Institute of Isotopes. The ‘active building’ was designed in the 1970s to treat and condition raw low level and intermediate level radioactive waste (liquid and solid) from isotope applications, but the building remained unused. The centralized interim store can also serve as a ‘buffer storage’ especially in cases when an urgent need may arise to receive a larger amount of waste at the repository site. The ‘active building’ contains laboratories and a waste sorting area with storage tanks for the collection of liquid wastes. The sorting facility is not in use and the liquid storage tanks are empty and may be dismantled to provide an additional storage space.

4. SAFETY REASSESSMENT OF THE REPOSITORY

A number of near surface disposal facilities exist, where the safety of the existing facility has not yet been demonstrated, no safety assessment has been performed, safety of the facility has been questioned because revisions to the operating conditions have been proposed or a periodic review and update of the safety assessment is required by the regulator. At some of these facilities, disposal practices have been conducted that may not meet modern concepts of safety, and consideration must be given to corrective measures. The Hungarian near surface repository at Püspökszilágy belongs to the latter category.

Previously, the safety of the facility had not been the subject of any comprehensive assessment. As the temporary licence of the extended part of the repository expired on 31 December 2000, the regulatory body set the following condition for issuing the permanent licence: that a comprehensive safety assessment be conducted. Two safety analyses were completed: one was performed by the Hungarian ETV-Erőterv, while the other one was made by the United Kingdom Atomic Energy Authority in a project funded by the Phare programme of the European Commission [1, 2]. Safety assessments attempted to answer the question whether the site would remain safe in the future, or if corrective measures were needed, through which the required safety could be guaranteed. The work was carried out in the period between September 1999 and March 2001, and was based on data and research commissioned by PURAM.

As part of the supporting studies for the safety assessment, in March 2000, an uncemented and a cemented compartment in an 'A' vault were opened in order to check on the condition of the disposed wastes. The basic objective of the investigations was to check on and evaluate the condition of the disposed waste as well as the conditions of the concrete and metal structures which were more than 20 years old. The vaults were found to be dry and the vaults, cap and wastes were found to be in good condition with little apparent degradation of either concrete or waste packaging. Having finished the investigations, the compartments were closed and sealed again. (See Table I for a summary of the results of the safety assessment.)

From the results of the safety analyses undertaken, it could be stated that present operational and environmental safety up to the end of the passive institutional control of the facility is properly guaranteed. The repository as a whole is suitable for safe disposal of low level and intermediate level waste and short lived wastes. Beyond the passive institutional control, mostly because of the significant amount of long lived components yet disposed of (^{14}C, ^{226}Ra, ^{232}Th, $^{234, 235, 238}$U, ^{239}Pu and ^{241}Am), inadvertent human intrusion — or any other scenario resulting in the surfacing of waste after the deterioration of concrete barriers — could cause both the dose constraint and dose limit to be exceeded. A Phare preliminary assessment indicated long term doses of around 100 mSv/a in the case of inadvertent human intrusion, and a credible hazard of larger scale aerial contamination at between 500 and 800 years after closure owing to the presence of large ^{137}Cs sources. The national assessment estimates human intrusion doses around 35 mSv/a and recognizes an additional hazard associated with ^{226}Ra, ^{137}Cs and ^{232}Th sources.

There are existing international recommendations (ICRP, IAEA) covering such situations, i.e. criteria to be applied and action to be taken in the case of exposure resulting from past practices [3]. These recommendations call for obligatory intervention above 100 mSv/a and a more optimized intervention (efforts and compliance) where doses of between 10 and 100 mSv/a are forecast. The basis for optimization is the real dose associated with intervention activities versus the reduction of the potential dose in the future. Such an optimization has never before been performed in Hungary.

5. THE WAY FORWARD

The estimates of dose suggest that for certain components of the repository, remedial actions are required and that, for other components, the requirement for remedial actions should be further considered.

TABLE I. SUMMARY OF THE RESULTS OF THE SAFETY ASSESSMENT

Scenario	Critical group	Highest individual dose	Exposure pathway	Critical nuclides	Date of exposure (a)
Normal evolution					
Natural discharge	adults infants	0.1–1 μSv/a 1–10 μSv/a	Use and consumption of water from the wells	^{99}Tc, ^{232}Th, ^{14}C	1000[a]
Well on the hillside[b]	adults infants	10–30 μS/a 100	Consumption of water only from the well	^{99}Tc, ^{232}Th	3000
Alternative evolution					
More rapid natural discharge[c]	adults infants	1 mSv/a 100 μSv/a	Consumption of fish	^{14}C	1000
Well on the hillside	adults infants	1–2 mSv/a 1–2.5 mSv/a	Consumption of water only from the well		500–600
Exposure of the waste packages[d]					
Slope slide[e]			Accelerated transport in the saturated zone		
Inadvertent human intrusion					
Immediate intrusion after the passive institutional control		0.1–0.4 mSv/a	Groundwater transport	^{99}Tc, ^{14}C, ^{238,234,235}U	500

TABLE I. (cont.)

Scenario	Critical group	Highest individual dose	Exposure pathway	Critical nuclides	Date of exposure (a)
Deferred intrusion		15 mSv 18 mSv 1–2 mSv	Other exposure routes	^{225}Ra ^{232}Th ^{99}Tc, ^{14}C	2000
Road construction					
Normal activities	Construction workers	10 μSv/a max. 72 μSv/a	Dust inhalation		500 1000
Handling of found sources	Construction workers	23–24 mSv/a	Keeping home the source/external exposure	^{226}Ra	500–600
			Contamination of a larger area	^{137}Cs (TBq)	500–600

[a] After the closure of the repository.

[b] It is assumed that the well would be present close to the boundary of the site in the direction of the highest concentration gradient.

[c] Early degradation of the concrete structures and bad chemistry in the near field.

[d] Consequences are similar to those associated with the human intrusion.

[e] Consequences are similar to those associated with the ‘well on the hillside’ alternative scenario.

Key recommendations relating to the future management of the site are:

- Certain long lived and high activity spent sources should be removed from the facility;
- The repository cap should be carefully designed (this is a key element of the system from the safety perspective);
- The scope for long term settlement within the vaults should be minimized and at an appropriate time, the vaults should be completely backfilled;
- Steps should be made to minimize the chances of future human disturbance by recording information about the facility and by an extensive period of administrative control over the site.

Consideration will be given to possible developments at the site which could include:

- Remedial measures to improve safety of the wastes that are currently disposed;
- The retrieval of certain waste types from the site and putting them into interim store pending final disposal in a geological repository.

The modifications might include, for instance, the introduction of grout into the vaults to provide an additional chemical and physical barrier to migration and potential intrusion. Alternatively, the modifications might specify an additional period for institutional control to be ensured, to prevent inadvertent intrusion for a specified period of time. The benefits, in terms of risk or dose averted, should be balanced against cost for any proposed intervention.

Based on the assessments, it would be sensible to remove as many of the spent sources from the facility as possible before closure. Steps should also be taken to minimize the probability and consequences of human intrusion by any of the following measures: good cap design, cementing the wastes in a monolithic block, administrative control and promoting the memory of the location of the facility for as long as possible.

Recovery of wastes and disposal elsewhere may reduce the possibility of high radiation doses from certain components of disposed inventories, e.g. SRS. Recovery operations necessitate treatment and storage of the recovered waste as well as long term waste management solution for wastes not planned for near surface disposal. Certain components of the inventory still need to be identified. To avoid accidents or exposures during recovery requires very careful planning and preparation.

Reconditioning and repackaging may improve local physical containment, may provide a chemical barrier and may also give the possibility of volume reduction. There is a need for a waste conditioning and packaging facility. Difficulties may arise from a lack of understanding about what has been disposed of. It may be difficult to quantify benefit.

Alternatively, steps can be made to minimize the chances of future human disturbance by recording information about the facility and by an extensive period of administrative control over the site.

The arguments may be different in the case of the wastes that have not been backfilled with cement, where retrieval would be relatively easy, compared with the backfilled wastes, where safe retrieval of SRS would be considerably more onerous.

A systematic review of all the spent sources in the facility is planned, to determine which sources should be retrieved and placed in interim storage, and which could be reasonably left in the repository. Such a review should be based in part on considerations relating to post-closure safety. It is feasible to take appropriate remedial actions in order to obtain an acceptable performance.

Removal of SRS from the 6 m deep disposal wells is a separate task for intervention activities.

PURAM has set out a programme of remedial activities which should be funded by the Central Nuclear Financial Fund. Due to the rather large number of parameters involved, an optimized intervention programme should be established on the basis of a feasibility study [4].

An assessment will be made that retrieval of some wastes is advisable. This judgement should be based on an assessment of the long term impact of existing disposals but, in addition, risk estimates should be produced for workers and members of the public from exposure associated with the retrieval operations. The benefits, in terms of risk or dose averted, should be balanced against cost, both dosimetric and monetary, for any proposed intervention. To do this, the assessment must have an estimate of the projected impact from current disposals, an estimate of the remaining inventory following the intervention, from the two previous items a differential long term impact between the two situations should be identified, on-site exposure to workers, and potential off-site exposure to members of the public as a result of the intervention, should be estimated.

In addition to the work on safety assessment, it will be necessary to develop short term and long term plans for providing disposal capacity for all the waste types intended for the site. The first task is to develop and implement technical approaches to conduct analyses in these areas.

Providing free capacity within some existing vaults appears not to be very difficult. In the beginning, for disposal purposes, 50 L plastic bags, 200 L metal drums and boxes made of paper or wood, were used equally. The packages within the vaults were positioned fairly loosely, consequently, by use of volume reduction technology (e.g. compaction) following the waste recovery, a considerable amount of space can be provided for further disposal. This observation was confirmed during the vault opening operation in March 2000, as mentioned earlier. In order to make a judgement on which disposal unit was to be opened for waste retrieval, a detailed analysis of the individual waste disposal units was performed.

It is important to note that two actions — freeing space for disposal of additional institutional radioactive waste in vaults, and retrieval of specific radioactive waste packages that are giving radiological concern — are interconnected. Both types of operations would require the opening of the vaults that are already temporarily sealed and covered with protective layers of bitumen, clay and grass. For obvious safety reasons, it would not be appropriate to open several times the vaults either to reduce the volumes of waste packages or to retrieve some specific items.

Having identified the key issues and uncertainties in the assessment, further work will be undertaken to resolve these issues and uncertainties, leading eventually to a position in which full assurance of the post-closure safety of the repository can be provided. This further work is likely to involve changes in the characteristics of the facility, updating of plans for its closure and enhancements of the methods used to evaluate its post-closure radiological impact.

A middle term programme has recently been set up by PURAM, which designates in detail the tasks to be performed. It was recognized that additional iterations of the safety assessment process are very important, since past assessments have been relatively simple and have not used all of the available data. The purpose of the repeated assessment is to:

- Assess the level of safety using currently available information;
- Identify the most important uncertainties;
- Suggest further data collection and/or alternative conceptual models that may be the subject of future safety assessment iterations;
- Increase confidence that the site and facility design will be suitable for waste disposal and that future investment in site characterization and other activities will be worthwhile. This would prepare the way for an application for facility construction and, ultimately, permission to commence disposal operations.

The safety assessment will illustrate progress towards demonstrating adequate safety (i.e. compliance with the regulatory requirements) but it is too early in the assessment cycle to demonstrate complete compliance with the set of regulatory requirements for the authorization of disposals.

Further work is required to determine the geological and hydrogeological properties of the site. Further focused hydrogeological testing will be undertaken and consideration will be given to acquiring geological and hydrogeological data at greater distances from the facility. Effort will be put into the development of a more integrated understanding of the geology and hydrogeology based on a review of all available data. An improved understanding of the controls on possible slope failure is also needed.

6. INTERNATIONAL ASSISTANCE

When performing the safety enhancing and modernization activities, besides using its own resources and expertise, Hungary has been relying on external assistance and collaborations. Besides the Hungarian part and the planned IAEA support, the third 'pillar' of technical co-operation in the safety enhancement programme is the European Commission's Phare project. The aim of the Phare project is to decide on the most appropriate and acceptable method of safety upgrading. The project, to take place in 2003, should provide a consistent scheme for analysing the problem situations and for ensuring that all factors essential for successful implementation are addressed. The intervention logic should be sufficiently prepared.

Having identified the key issues in the safety assessment, further work can be undertaken to resolve these issues, leading eventually to a position in which full assurance of the post-closure safety of the repository can be provided. It is emphasized that this further work is likely to involve changes in the characteristics of the facility, updating of plans for its closure and enhancements of the methods used to evaluate its post-closure radiological impact.

Important work has already been performed in the context of two recent Phare feasibility studies on the conversion of the treatment building on the site and the assessment of volume reduction and characterization of the recoverable low level solid waste packages deposited in the repository.

In 2001, the IAEA prepared a new Co-ordinating Research Programme on the Application of Safety Assessment Methodologies for Near Surface Waste Disposal Facilities (ASAM), which is now being implemented. It will build on the experience of the Improvement of Safety Assessment Methodologies for Near Surface Disposal Facilities for Radioactive Waste (ISAM) project, with special emphasis on the application of the ISAM methodology to address practical problems of interest. The Püspökszilágy repository has been offered to be a test case for the ASAM project.

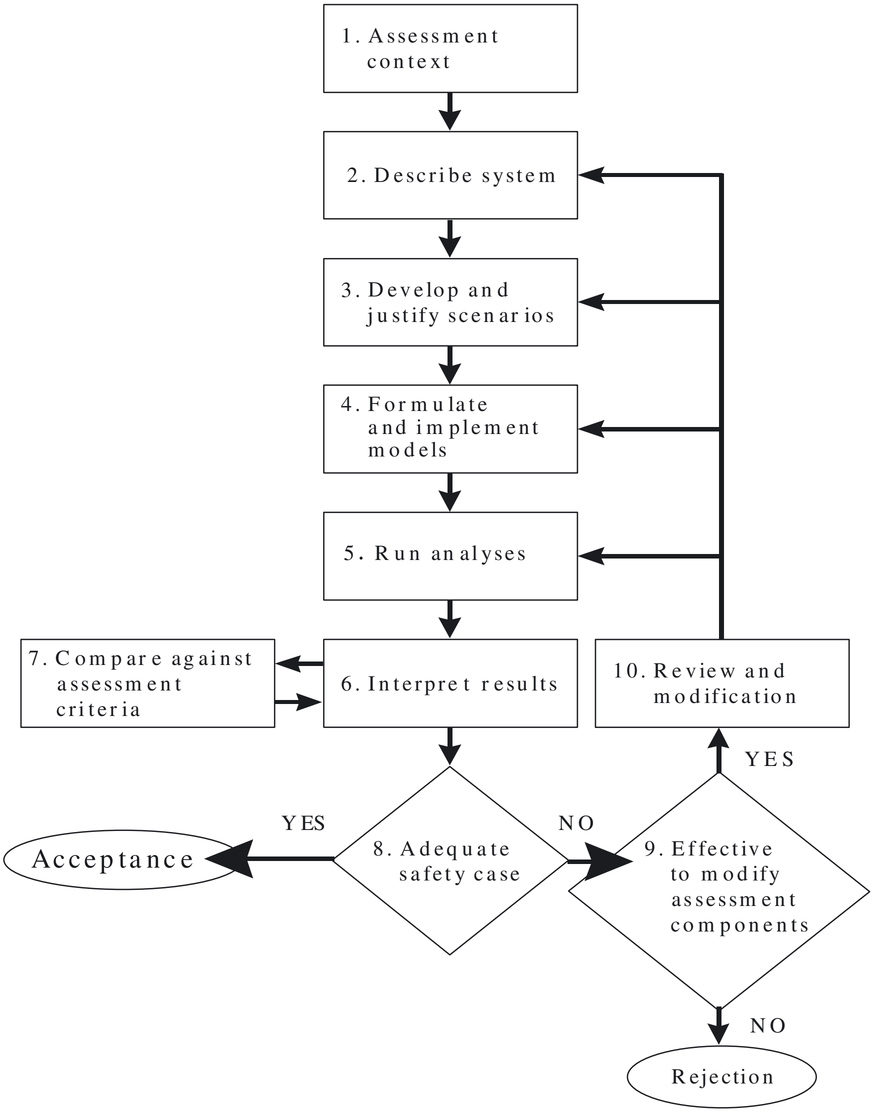

FIG. 6. The ISAM safety assessment process, adapted from the IAEA (1997).

In ISAM, a methodology was applied to an initial assessment of past practice disposal facilities (the Radon type safety case). While this was not a rigorous application of the decision diagram to this situation, the basic concepts appear to be applicable to the assessment in most regards (see Fig. 6).

A number of existing near surface disposal facilities exist, for which adequate safety assessments do not yet exist. These situations do not fall within the current ICRP framework for radiation protection, in that they are neither a justified practice nor a clear intervention. This situation can be called a ‘mixed practice intervention situation’ [5]. This name reflects the reality that such sites may be appropriate for continued use as a justifiable practice, or they may require intervention, after which they may be appropriate for continued use as a justified practice. These situations are generally reflected by ageing waste disposal facilities.

The ICRP framework for intervention is based on the recognition of an imminent risk. The trade off between public risk and worker risk during the intervention is therefore relatively straightforward. One conducts a straightforward justification of risk reduction, including potential consequences to workers. For waste disposal sites, the situation is less clear. Risks associated with waste disposal are potential future risks. When assessing the advisability of an intervention, the decision maker must therefore balance these potential future risks against certain risks (both radiological and non-radiological) to workers during the intervention. In addition, risks to the environment or to the public associated with some remediation technologies may also need to be factored into the decision.

For ASAM, a proposed draft diagram for the mixed practice intervention situation is shown in Fig. 7. In this situation, a large number of options may need to be assessed.

The Püspökszilágy disposal facility is currently in the first decision block of the flow chart, having conducted initial safety assessments which suggest that the facility may not be adequately safe in the distant future.

The concept of the use of Fig. 7 is that at each decision stage, an appropriate safety assessment would be undertaken using the ISAM safety assessment methodology. In support of these decisions, special considerations are expected to be implemented in components of the ISAM methodology.

The activities within the ASAM reassessment working group will form a bridge between the technical approaches used in implementation of corrective actions/interventions and those used in safety assessments of radioactive waste disposal practices. It is anticipated that they will also:

— Provide a practical demonstration of the ISAM safety assessment methodology to address this real problem;
— Support the review and judgement of the acceptability of differing options by providing a quantitative comparison of the different options;
— Support decision making in the selection of alternatives for corrective actions.

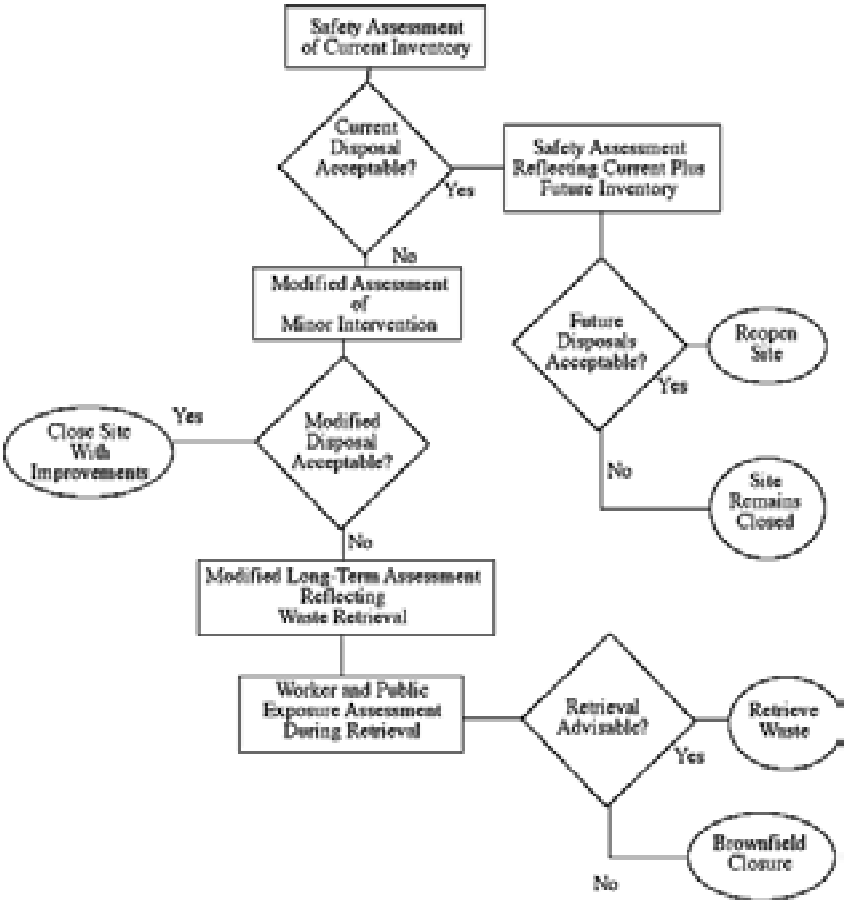

FIG. 7. Draft decision flow chart for mixed practice interventon situations [5].

7. SUMMARY

A number of near surface disposal facilities have been developed during the last 40 years. These facilities have been constructed, operated, upgraded or closed according to different safety standards, requirements and criteria during this period. Some existing facilities are either in operation, or closed (temporarily or finally), for which safety assessments have been conducted at varying levels of completeness and quality.

For some facilities, safety assessments have recently been conducted for different reasons including the following:

— The need to demonstrate compliance with current standards;
— New regulatory requirements for reassessment of safety as part of routine regulatory programmes;
— The need for revisions to be made to the operating conditions (e.g. waste acceptance criteria) that have been proposed since licensing or the previous licence review;
— The need for evaluating the possibility of disposing of new waste types (e.g. decommissioning waste) not considered previously.

Other, often older, facilities may have had assessments conducted that are no longer considered adequate by present day standards. Furthermore, at some of these facilities, disposal practices have been conducted that may not meet modern concepts of safety, and consideration must be given to corrective measures and future use of these facilities, especially in countries where no other disposal option is envisaged in the short term.

The topic is very timely, as the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, under Article 12 (Existing Facilities and Past Practices) states:

“Each Contracting Party shall in due course take the appropriate steps to review:

i. ...
ii. the results of past practices in order to determine whether any intervention is needed for reasons of radiation protection bearing in mind that the reduction in detriment resulting from the reduction in dose should be sufficient to justify the harm and the costs, including the social costs, of the intervention.”

The Püspökszilagy repository is considered to be unsuitable for some of the waste formerly placed in the facility. Based on the safety assessments conducted, a judgement has been made that long term safety of the Püspökszilágy repository may be ensured, but only with some technical or administrative modifications to the facility.

In 1998, Hungary started systematic work on the safety upgrading of the Püspökszilagy repository. During 1998 and 2002, the safety re-evaluation of the repository was the primary focus with some basic modernization and refurbishment measures (replacing the obsolete equipment, supplementary site investigations, ‘re-inventorization’, ‘near field’ and ‘far field’ studies).

In 2003, a project was launched to decide on the most appropriate and acceptable methods for enhancing safety and making the necessary preparations for remedial measures. Important elements of this phase include the construction of the central interim store, an inventory re-evaluation, undertaking a feasibility study, producing a detailed work programme, licence preparations and preparing an application for international assistance.

The final step is the implementation of safety measures which are envisaged to be accomplished in 2004 and would last for years depending upon the measures selected.

The project must take into consideration all relevant Hungarian regulations, European Commission directives, IAEA Safety Series documents, recommendations, as well as other international recommendations regarding current best practice in this field.

When planning the forward programme, it should be recognized that the safety assessment process is an iterative cycle and further work is required to enhance and improve the Safety Analyses Report, which will be periodically updated and reissued during the operational phase. Decisions are required on which subject areas require more work and which are lower priority for the next iteration, and hence what tasks need to be done and the appropriate level of investment for each.

Based on the safety assessments carried out so far, some key recommendations relating to the improvement of the site can be formulated. Doses from future human disturbance vary according to the part of the facility that is assessed. It should be noted, however, that certain spent sealed sources are present, which would give rise to very serious radiological consequences if they were ever handled.

A judgement can be made that long term safety of the repository may be ensured, but only with some technical or administrative modifications to the facility. These modifications might include, for instance, the introduction of grout into the vaults to provide an additional chemical and physical barrier to migration and potential intrusion. Alternatively, the modifications might specify an additional period for institutional control to be ensured, to prevent inadvertent intrusion for a specified period of time.

For any proposed intervention, the benefits, in terms of risk or dose averted, should be balanced against cost. In addition to the work on safety reassessments, it is necessary to develop short term and long term plans for providing disposal and storage capacity for all the waste types currently disposed at the site.

It is emphasized that there are many issues which still need to be addressed subsequent to the safety assessments. The safety assessments should not be regarded as final assessments of the performance of the facility, rather, as initial assessments which are the first of a series. Having identified the key issues and uncertainties in this assessment, further work can be undertaken to resolve these issues and uncertainties which will provide a good basis for the development of a more certain view in subsequent assessments. The results of the safety assessment may be used to focus the subsequent research programme and to identify issues that require further consideration.

According to PURAM's plan, the repository will be operational for an additional 40 to 50 years, by receiving the radioactive waste from the small scale producers of the country. By the end of this period, a deep geological repository should be available to receive those long lived wastes which are temporarily stored in the Püspökszilágy facility, and which are not amenable to disposal in a near surface repository. Bearing this approach in mind, the first measure to be taken is to provide additional disposal capacity within the site.

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Discussion following paper by P. Ormai

L. KONECNY (Slovakia): Do you know about the conditions in the boreholes and vaults?

P. ORMAI (Hungary): The safety assessment highlighted that human intrusion into the vaults, if it occurred, could result in high doses. However, as it is relatively easy to remove all the waste, there is no need for urgency, because the safety assessment suggested that the facility is safe as long as it is under control. So we should act before the closure of the site — before the removal of the institutional controls. In principle, we have plenty of time to treat the boreholes, and the good news is that for that part, there was backfilling only at the very beginning of the operations. Most of the spent sources can easily be retrieved. But it is not only a technical question — it is also a moral one: we do not want to leave a burden for future generations. But it is not an urgent task. The urgent task is to provide additional space and also to recover (on the basis of the feasibility study) certain waste types, mainly the long lived component and the high activity sources.

J. GREEVES (USA): Without knowing what is there, how will you decide which sources to retrieve?

P. ORMAI (Hungary): So far, no decision has been taken. I should underline again that we are in the stage of considering what would be the best option for intervention. We are lucky in the sense that not all of the vaults have been backfilled. There are cells where the long lived components and the high activity sources are not backfilled and are quite easy to recover. So our approach is to recover the easily recoverable sources.

We have quite a good knowledge of the source inventory. 'Inventorization' took a year or so. We examined all the takeover protocols electronically. So now we have a fairly good knowledge of the inventory and the distribution of the sources.

A. WALLO (USA): If the possibility of human intrusion is your main concern, why not consider improved intrusion barriers and stronger institutional control rather than removal of certain waste types for the near surface repository?

P. ORMAI (Hungary): From the safety assessments, it would appear that if we wanted to rely on institutional control, it would have to be for as long as 700 years, which is not very realistic.

P. ORMAI (Hungary) [in reply to a question regarding repository expansion in the 1990s, and whether this expansion was accompanied by any change in operating regime]: No, it was not. It consisted simply of the creation of two additional vaults.

MANAGEMENT OF ACCUMULATED HIGH LEVEL WASTE AT THE MAYAK PRODUCTION ASSOCIATION IN THE RUSSIAN FEDERATION

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Abstract

At present, thousands of cubic metres of high level wastes (HLW) are stored at the Mayak Production Association (PA) in Ozersk, the Russian Federation. Despite fulfilling the required specifications, such a method of storage cannot be accepted as totally safe. Therefore, liquid HLW should be incorporated into a strong solid matrix. For this purpose, the HLW vitrification process is now implemented at the Mayak PA to produce phosphate glass blocks. The glass blocks in metallic containers are deposited to a storage facility. However, the accumulated liquid HLW contain large amounts of non-radioactive salts which increase costs at the stage of glass melting as well as in monitored storage of glass blocks. Besides, some HLW macrocomponents exert adverse effect on the process safety and on the resultant glass quality. Hence, it is appropriate to recover radionuclides from HLW bulk into concentrates of small volume for their subsequent solidification and to direct ballast mass to inexpensive near surface storage. For this purpose, at the Mayak PA an industrial facility combining the extraction and precipitation technology has been created. In the first stage, cesium and strontium are separated by chlorinated cobalt dicarbollyde (ChCoDiC). In the second stage, actinides and rare-earth elements (REE) are recovered by oxalate precipitation from raffinate. Towards the end of 2001, about 1200 m^3 of HLW were reprocessed. In parallel with emptying the HLW tanks, the specific activity of glass blocks was doubled. The cost price of the vitrification process was reduced by 60%. Modernization of the technology involves elaboration of the all-extraction flowsheet. To accomplish this, the Radium Institute and the Mayak PA in collaboration with the Idaho National Engineering and Environmental Laboratory (INEEL), in the United States of America, have developed two alternative technologies. The first technology envisages the use of ChCoDiC for recovery of cesium and strontium; actinides, REE and technetium are recovered by iso-amyldialkylphosphine oxide. The second technology (the UNEX process) involves simultaneous recovery of cesium, strontium, actinides and REE from HLW. This extractant is a mixture of ChCoDiC, carbamoylphosphine oxide (CMPO), and polyethylene glycol (PEG) in phenyltirufluoromethylsulfone (FS-13). The novel technologies were put through a series of tests on actual HLW. Both processes afford recovery of long lived radionuclides by more than 99.9%, which enables the transfer of HLW bulk into a category of waste suitable for near surface storage.

1. INTRODUCTION

In the Russian Federation, the concept of the closed nuclear fuel cycle (NFC) involving spent nuclear fuel (SNF) reprocessing is accepted [1]. It is known that one of the advantages of the closed NFC is the possibility for radical resolution of the problem of long term safe management of long lived radionuclides, because the SNF reprocessing allows them to be recovered and handled separately.

An efficient method for the management of long lived radionuclides is transmutation. Another promising way is to create extra strong matrixes being disposed into geological formations. In particular, the technology for production of synthetic materials is now under development in the Russia Federation using a high temperature synthesis of minerals of zircon group, garnet, cubic zirconium oxide, etc. [2]. The principal feature of these minerals consists of including into the mineral matrix an individual element or at least chemical analogs, but not a non-separated mixture of nuclides contained in SNF. Such compositions make these materials very close to natural minerals whose stability has been verified as capable of lasting over millions of years.

Just as in the case of transmutation, in the case of the synthesis of highly strong matrixes for geological disposal there is a need for selective recovery of long lived radionuclides contained in SNF. This may be afforded by the availability of reprocessing plants with special facilities for recovery of long lived radionuclides in the NFC infrastructure.

In the Russian Federation, the production association Mayak exists (in Ozersk) for reprocessing spent fuel, primarily from WWER-440 [3].

Management of long lived radionuclides at the Mayak Production Association (PA) is similar to practices in operation in other reprocessing plants around the world: the non-separated mixture of long lived radionuclides is vitrified and the glass blocks produced are delivered to monitored interim storage in a special facility (Fig. 1). So, the development of efficient separation technologies for the radical management of long lived radionuclides is needed for their use in the future.

However, it should be noted that even the present practice in management of high level wastes requires the recovery of long lived radionuclides. This is owing to the fact that the liquid wastes accumulated from the previous activities of nuclear centres for tens of years are stored in special tanks. In particular, at the Mayak PA, thousands of cubic metres of acidic HLW are stored in this way (Table I). Despite meeting the technical requirements, such storage cannot be accepted as safe. Evidence of this is the accidental HLW discharge from one of the tanks at the Mayak site in 1957, which caused radioactive contamination of the environment.

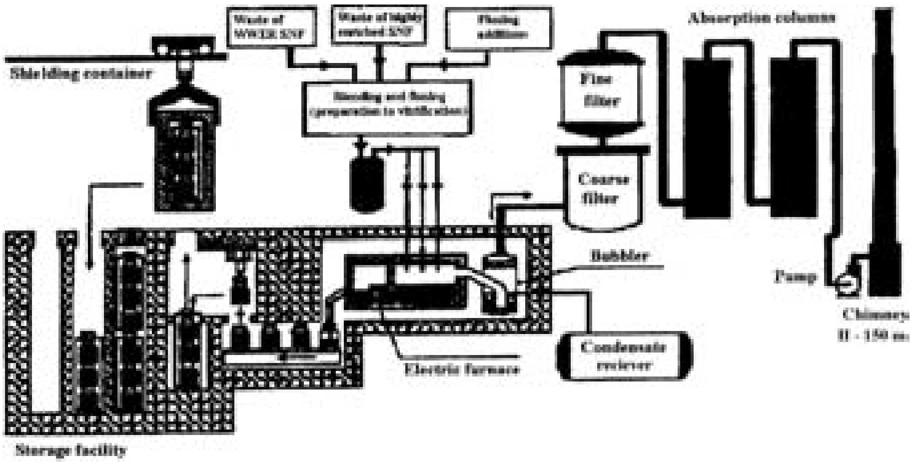

FIG. 1. The radwaste vitrification process in the EP-500 electric furnace.

TABLE I. ACCUMULATED ACIDIC HLW OF THE MAYAK PA AND INEEL

	Mayak PA		INEEL	
Waste	Tank AD-6704 12 units	Tank AD-18001/3	SBW	Calcines after dissolution
Volume (m^3)	3043	1272	5600	1 m^3/100 kg calcine

The key operation of HLW reprocessing technologies is the selective recovery of cesium, strontium, technetium, rare-earth and transplutonium elements, as well as residues of uranium, neptunium and plutonium from HLW remaining after the Purex process. Around the world, the practices of the different processes (such as precipitation, sorption, extraction and chromatography) for the recovery of these components are under development. The object of this presentation is to consider developments in the Russian Federation (first of all, extraction ones) which are now already in service at the Mayak PA, or which approach their introduction.

2. CHLORINATED COBALT DICARBOLLYDE FOR THE RECOVERY OF CESIUM AND STRONTIUM

The most advanced technology for radionuclide recovery from HLW is now the extraction technology with the use of chlorinated cobalt dicarbollyde (ChCoDiC) in polar diluent. The fundamentals of the ChCoDiC extraction process were jointly developed by specialists from the Radium Institute and the Institute of Nuclear Research (Czech Republic) [4]; thereafter, the Radium Institute in collaboration with the Mayak PA brought this development up to commercial use at the radiochemical plant [5].

The extraction of cesium, strontium and other elements into polar solvents by cobalt dicarbollyde (anion with (-1) charge) proceeds as a result of the recovery of the dissociated ion pair Cs^+B^-(B^--ChCoDiC anion) into the organic phase.

The constants of extraction exchange of cesium cation for a proton of organic phase decrease considerably with increasing acidity of the aqueous phase, which provides the possibility for the efficient stripping of cesium.

Strontium is recovered from HNO_3 solutions about three orders worse in comparison with cesium. This is caused by the hydrophilic character of strontium cation. The recovery of strontium by ChCoDiC is attained by the introduction of polyethylene glycol (PEG) into the composition of the extraction mixture, which exerts a synergistic effect and increases the distribution coefficient of strontium by a factor of approximately 1000. This enables strontium to be extracted even from strongly acidic media. Cesium is extracted by ChCoDiC – PEG mixtures nearly to the same degree as in the absence of PEG.

Among the investigated substances suppressing strontium extraction, hydrazine is most efficient for strontium stripping; it is easily washed out at the stage of regeneration from the organic phase.

The results of conducted studies have revealed the feasibility of developing the flowsheet for cesium and strontium recovery by ChCoDiC and PEG (Fig. 2); the advantages of this flowsheet are as follows:

- ChCoDiC (in the presence of PEG) allows the recovery of Cs and Sr directly from acidic HLW solutions; this considerably simplifies the operations of the preliminary preparation of solutions;
- Extraction selectivity is high;
- ChCoDiC losses with aqueous phase are negligible;
- High chemical and radiation stability of ChCoDiC provides prolonged contact of extractant with strongly acidic HLW and process products.

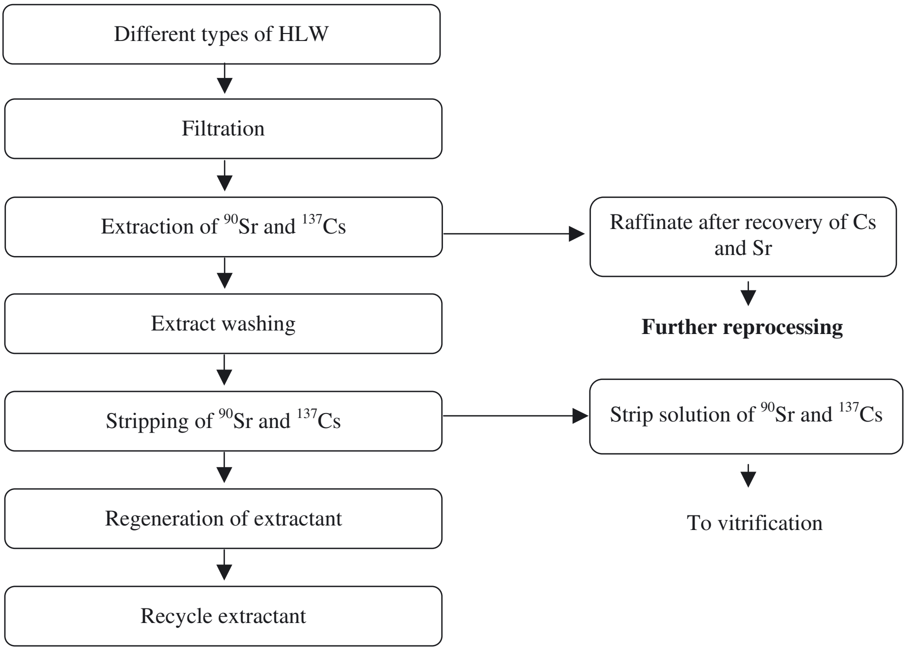

FIG. 2. Key extraction flowsheet for reprocessing HLW with the use of ChCoDiC at the UE-35 industrial facility in the Mayak PA.

The pilot-industrial facility for HLW partitioning (UE-35) by the use of ChCoDiC was established at the Mayak PA in 1995. The extraction section of the facility was the best adapted to the existing and perspective extraction systems. Main units of the facility are four contactors of mixer-settler type with pulse phase mixing. The contactors are arranged from blocks, each of them consisting of two stages in one casing. The total working volume of contactors is 2.88 m^3. The throughput for total streams is around 700 ℓ/g.

The flowsheet involves a unit for filtration of initial HLW and recycle extractant. Furthermore, the UE-35 facility is equipped with a three-stage system of gas cleaning, alarm system and remote system of fire extinguishing, a system for sampling through stationary boxes with samples conveyer, a unit for the preparation and sampling of reagents with temperature and level control instruments and blocking systems.

Along with assembling and preliminary testing between 1992 and 1995, complex scientific research work was carried out. The ChCoDiC-based extraction system was adapted to the combined recovery of Sr and Cs radionuclides from HNO_3 solutions of HLW having a very high salt content.

The operating life of the extraction system was determined in the course of reprocessing the ageing military HLW; it was estimated as high as 1900 full cycles of extractant. To ensure operation safety, the stability of hydrazine nitrate in process products, the character of its decomposition, the distribution of hydrazoic acid between aqueous solutions and the gaseous phase were studied as applied to HLW partitioning conditions.

In August 1996, the world's first pilot-industrial facility for HLW partitioning was put into operation with the use of actual solutions. In the framework of the stated problem on combined recovery of long lived strontium and cesium radionuclides, three contactor units were operating, comprising 8 extraction stages, 2 extract scrubbing stages, 14 stripping stages and 2 recycle extractant washout stages.

At the beginning of the facility operation, the optimal phase flowrates were established, the compositions of extractant and stripping solution were adjusted. When bringing the facility to stable operating conditions, the total flowrates were about 370 ℓ/h, that is, somewhat more than 50% of the highest possible value; the extractant composition was consistent with that determined earlier; 9M HNO_3 solution in the presence of 25 g/ℓ hydrazine nitrate was used as the stripping agent.

The practically unsalted concentrate of ^{90}Sr and ^{137}Cs is added to solutions destined for vitrification. The volume activity of prepared charge was about 32 Ci/ℓ, whereas this value is conventionally equal to 16–20 Ci/ℓ. This made it possible to produce glass with twice the specific activity (up to 550 Ci/kg). As a result, a 5% increase in expenditure on the partitioning facility has led to the reduction of production costs of high level glass by 60%. Results of the UE-35 operation at the close of 2001 are presented in Table II.

Thus, the operating experience of the UE-35 facility enables a conclusion to be drawn that it is possible to dispose of the most hazardous waste with the concurrent emptying of tanks over several years.

Pilot-industrial reprocessing of old salted HLW was recently begun at the partitioning facility, to recover not only ^{137}Cs and ^{90}Sr, but also An and REE into individual fractions, and thus convert aqueous waste solutions in the ILW category.

The whole flowsheet for the reprocessing of accumulated HLW reprocessing includes the following processes:

— Preparation of feed solution by clarification (threefold settling and filtering through a double layer of granular materials) and dilution with condencate up to 250±25 g/ℓ content of total nitrate-ions;

— Extraction recovery of cesium and strontium under the conditions of the combined extraction-stripping operation at the UE-35 facility by using the mixture of ChCoDiC in F-3 diluent (metanitrobenzotrifluoride);
— Destruction of hydrazine nitrate in the combined strip product of cesium and strontium, and delivery of Cs-Sr concentrate to evaporation and vitrification;
— Reprocessing of aqueous waste solutions by the method of oxalate precipitation, to recover α-emitting An and β-active REE;
— Dissolution of actinide and REE oxalates residue in HNO_3 at 90–95°C, to produce their concentrate.

TABLE II. INDUSTRIAL OPERATION RESULTS OF THE UE-35 SEPARATION FACILITY IN THE MAYAK PA

Operation year	Operation duration (months)	Characteristics of reprocessed HLW	
		Volume (m^3)	Total activity (kCi)
1996	3	210	11886
1998	2.5	95	6539
1999	~1	62	1498
2000	~3	254	6156
2001	11	558	23436
Total	20.5	1179	49515

Since 1999, owing to the optimization of HLW reprocessing technology, throughput of the facility has been increased by a factor of 1.5–2 (relative to feed solution), and the concentrating degree of strontium and cesium at stripping stage has been increased by a factor of 1.7–2. The accounted discharges of cesium and strontium with aqueous waste solutions were below 2%. Treatment of aqueous waste solutions by oxalate precipitation makes it possible to remove up to 90–95% of α-emitters and up to 70–80% of REE radionuclides.

Such a combination of extraction and precipitation methods for HLW reprocessing is considered at the Mayak PA as a temporary flowsheet.

The second line of the UE-35 facility at the Mayak PA is aimed at developing a complete extraction technology for recovery of Cs, Sr, An and Tc from HLW. To create such a technology, different processes are now under investigation; two of them are almost ready to introduce:

— The POR process (explained in Section 3) with the use of iso-amyl-dialkylphosphine oxide which provides the recovery of An (U, Np, Pu, TPE[1]), REE and Tc over a rather wide range of acidities [7–10];
— The universal process (UNEX process) intended for the simultaneous recovery of An, REE, Cs and Sr from HLW and enabling the separation of the recoverable radionuclides into different fractions [11–14].

As a result of laboratory studies, the best compositions of extraction systems meeting the requirements imposed on selectivity, chemical and radiation stability and operational safety were established. Based on these data, the process flowsheets were developed and tested at pilot facilities under dynamic conditions with the use of actual and simulated HLW.

3. EXTRACTION OF ACTINIDES, REE AND TECHNETIUM FROM LIQUID ACIDIC HLW BY ISO-AMYLDIALKYLPHOSPHINE OXIDE

Among phosphine oxides, the short-chain phosphine oxides and the phosphine oxides with branched radicals possess rather high solubility in routine diluents; therefore, preference was given to the use of iso-amyl-dialkylphosphine oxide (technical name: phosphine oxide different-radical, POR).

A complex of extraction, physico-chemical and operational properties in different diluents was studied for this experiment. For separate stripping of TPE and REE, it was necessary to use complexones, DTPA in particular. Buffer agents like aminoacetic acid were used to stabilize the separation conditions.

When studying the radiation stability of POR, the extractant samples were irradiated to $2 \cdot 10^6$ Gy. Slight changes of the extraction properties on such exposure were easily eliminated by treatment of the irradiated extractant with sodium carbonate solutions.

As a result of studying the POR properties, some possible variants of its use were revealed, especially for recovery of all actinides and technetium from raffinate generated upon Cs and Sr recovery by ChCoDiC-extractant. The flowsheet is shown in Fig. 3.

This flowsheet as applied to reprocessing of accumulated HLW was checked on the actual waste of the Idaho Center (USA) in the framework of a collaboration between the scientists of the Radium Institute and INEEL. The flowsheet involves the combined extraction of actinides, REE and technetium

[1] TPE refers to transplutonium element.

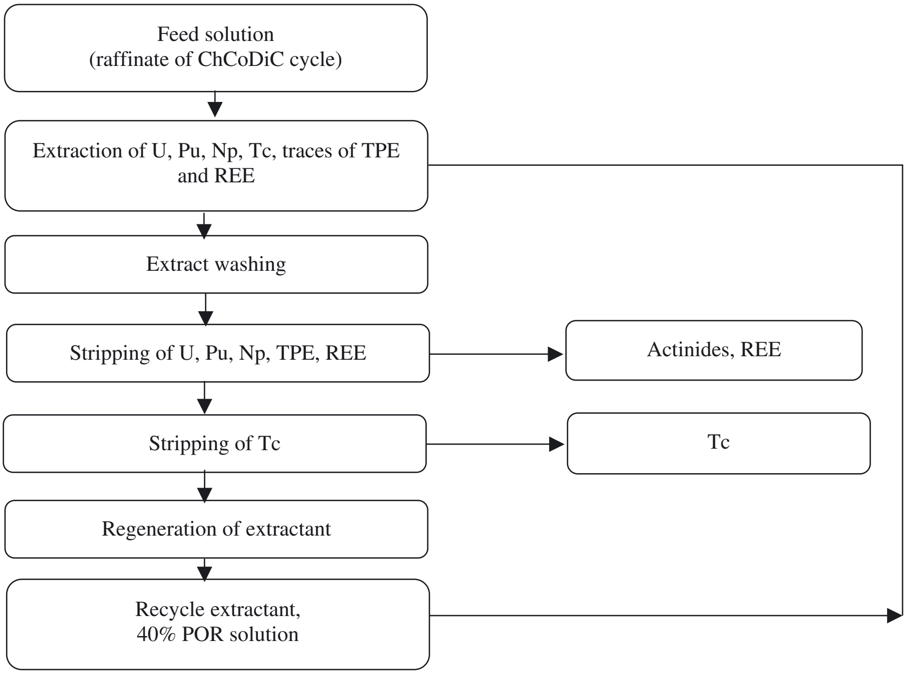

FIG. 3. Key extraction flowsheet for industrial reprocessing of raffinate from ChCoDiC cycle by using the POR-based extraction system.

with their subsequent combined stripping. Recovery yields for An and Tc are shown in Table III.

The data of Table III show that, in combination with the ChCoDiC process for Cs and Sr recovery, the POR process provides separation of the main long lived radionuclides from HLW and transforms the major waste mass into the LLW category.

4. UNIVERSAL EXTRACTION (UNEX) PROCESS FOR THE SIMULTANEOUS RECOVERY OF CESIUM, STRONTIUM, ACTINIDES AND REE FROM LIQUID ACIDIC HLW

The scientists of the Khlopin Radium Institute and INEEL have jointly developed the universal extraction process (UNEX process) which allows the recovery of Cs, Sr, An and REE concurrently from acidic HLW. For this purpose, the mixture of ChCoDiC, PEG and CMPO was chosen; it would be logical to assume that this mixture should extract Cs, Sr, An and REE.

TABLE III. EXTENT OF RECOVERY AND RAFFINATE CONCENTRATION IN COBALT DICARBOLLIDE AND PHOSPHINE OXIDE DYNAMIC TEST

Element	Extent of recovery (%)	Raffinate concentration	Class A
Cs	99.3	0.7 Ci/m^3	1 Ci/m^3
Sr	99.97	0.033 Ci/m^3	0.04 Ci/m^3
Gross alpha (Am, Pu, Np, U)	98.9	5.2 nCi/g	100 nCi/g
Tc	90	0.006 Ci/m^3	0.3 Ci/m^3

However, the mutual effect of each component on radionuclide extraction necessitates searching for optimal components among the selected class of compounds.

In accordance with the conducted studies, preference was given to diphenyl-N,N-dibutylcarbamoylphosphine oxide and non-substituted PEG with short (8-10) oxyethyl chain (PEG-400) which, in combination with ChCoDiC, provide the simultaneous recovery of Cs, Sr, An and REE. Metanitrobenzotrifluoride or phenyltrifluoromethylsulfone (FS-13) can be used as diluents for this mixture. The molar ratio between ChCoDiC, CMPO and PEG is 5:1:1.

For the selected composition of a universal mixture, a series of studies was carried out and its efficiency was confirmed under operating conditions.

The radiation-chemical stability, corrosion resistance and explosion/fire safety were confirmed by special investigations. The extraction system stability was demonstrated in the course of prolonged process tests. Only PEG should be made up at regular intervals because of its higher solubility in the aqueous phase.

For the stripping operation in the UNEX process, different reagents were proposed which enable the concurrent stripping of all the recoverable radionuclides or the production of individual fractions: Cs; Cs+Sr; An+REE. On the basis of these options, the flowsheets were developed and tested under dynamic conditions at a facility of centrifugal contactors with the use of actual and simulated HLW in the Idaho Nuclear Center.

The flowsheet employed combined extraction and the subsequent combined stripping of all the recoverable radionuclides (Fig. 4) was tested on actual INEEL HLW, since this technology is most commonly used for the

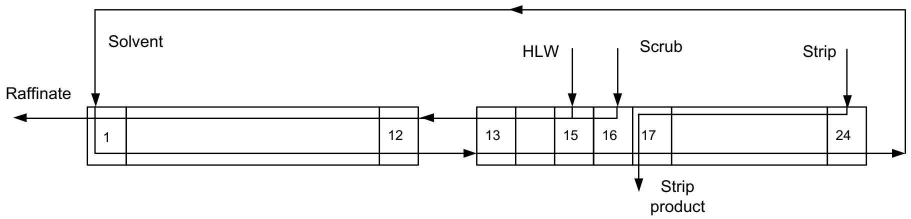

FIG. 4. The UNEX process flowsheet for the simultaneous removal of Cs, Sr, REE and actinides from HLW (numbers refer to centrifugal contactors).

TABLE IV. UNEX TEST RESULTS WITH ACTUAL RADIOACTIVE WASTES

	Removal efficiencies		
	INEEL		Russian
	Tank (%)	Calcine (%)	Tank (%)
α^*	90.96	99.92	99.7
*Cesium-137	99.4	99.99	99.95
Strontium-90	99.995	99.73	99.99

* Includes U, Pu and Am.

practice of accumulated HLW management. The test results of this flowsheet using HLW from the Russian Federation and the USA are given in Table IV.

The obtained data on the recovery of Cs, Sr, An and REE afford the conversion of bulk waste into the LLW category suitable for near surface storage; this fact drastically lowers the cost of the whole HLW management cycle.

5. CONCLUSION

The development of efficient technologies for the recovery of long lived radionuclides from HLW is urgent for the implementation of the promising management methods (transmutation and disposal), as well as for the existing practice of HLW management. Since 1996 at the Mayak radiochemical plant in the Russian Federation, the industrial facility has been in operation which provides the recovery of cesium and strontium from accumulated HLW by

ChCoDiC extraction and the subsequent precipitation of actinides and REE by oxalic acid. The next stage is aimed at the development and implementation of the actinide separation technology of long lived radionuclides from HLW. Over 20.5 months of the facility operation, about 1200 m^3 of liquid HLW were removed from tanks, reprocessed and vitrified. For this purpose, the following two processes are studied and tested: processes based on iso-amyldialkylphosphine oxide (POR process) and the mixture of ChCoDiC, carbamoylphosphine oxide (CMPO) and polyethylene glycol (PEG) (UNEX process). After the comprehensive study of extraction, physico-chemical and operational properties of selected extraction systems, the testing of processes was conducted at test facilities with the use of actual or simulated HLW. Mixer-settlers and centrifugal contactors were used as extraction equipment in these tests. The test results show that the POR process and the modified transuranium extraction process, referred to as the TRUEX process, enable the recovery of uranium, neptunium, plutonium, TPE, REE and technetium from HLW, and allow the possibility of producing individual fractions. The UNEX process permits the simultaneous recovery of actinides, REE, cesium and strontium from HLW. During tests, the potentialities of the UNEX process for obtaining such fractions as cesium, cesium+strontium and actinides+REE at the stripping stage were also demonstrated.

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Discussion following paper by V.N. Romanovsky

P. RISOLUTI (Italy): You mentioned collaboration with Idaho National Laboratory. Does its waste contain aluminium from materials testing reactor (MTR) fuel?

V.N. ROMANOVSKY (Russian Federation): The waste is just the solidified product after the reprocessing of aluminium-containing fuel, so we tested our UNEX process for aluminium-containing and for zirconium-containing calcines. The results were very satisfactory.

P. RISOLUTI (Italy): Why do you not vitrify your liquid high level waste directly, without recovering the caesium and strontium?

V.N. ROMANOVSKY (Russian Federation): As I said in my presentation, the raffinate from the reprocessing of commercial spent fuel goes direct, without pretreatment, to the vitrification facility as it does not contain a high concentration of salts — unlike the raffinate from the reprocessing of high level waste from the defence sector.

REMEDIATION OF THE OLEN SITE

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1. INTRODUCTION

While looking for extractable copper ore, a mining engineer of the Union Minière du Haut Katanga found, on 10 April 1915, important pitchblende deposits in the area of Shinkolobwe in the Katanga district in what was known then as the Belgian Congo. The first very high grade ore (averaging about 50% uranium oxide) arrived in the port of Antwerp, Belgium on 5 December 1921, and production at the Olen facility (in Belgium) began in July 1922. Because of the exceptional uranium content, less than 10 t of ore were needed to produce 1 g of radium. Belgium dominated the world market for radium until the mid-1930s when comparable high grade ore was discovered along the shores of the Great Bear Lake in north-western Canada, and an extraction plant was built at Port Hope, in the Canadian provence of Ontario. Starting in 1952, owing to the development of particle accelerators and nuclear reactors, other radioactive substances could be developed with shorter half-lives, which gradually reduced the use of radium. In Olen, a stock of pure radium remained behind in the 'users packaging'.

The storage of primary materials, by-products and waste products, and the emission of treated wastewater gave rise to a dispersed pollution inside and outside the walls of the plant. In the middle of the 1950s, a central storehouse was built for all final products, intermediate products and wastes. In the 1970s, a start was made on dismantling the production installations, which put an end to this activity. However, the storehouse and the local contamination on the plant grounds and outside the plant remained. Between 1980 and 1982, about 3000 t have even so been disposed of by sea dumping.

Today, the 'Olen radioactivity file' (known as OLERA) consists of three sub-files, as follows (schematically presented in Fig. 1):

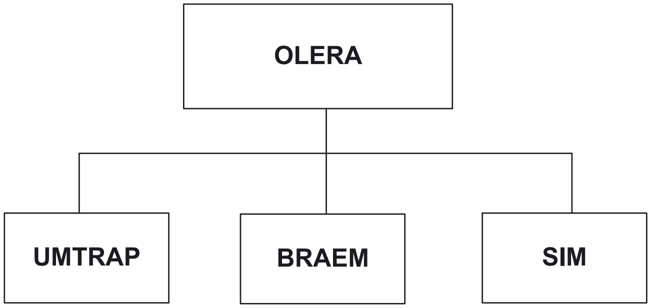

FIG. 1. The sub-files of the Olen radioactivity file (OLERA).

— The UMTRAP file relates to the authorized storehouse built on the plant grounds for radioactive waste from the production activity.
— The BRAEM file relates to the radioactive pollution scattered outside the plant grounds.
— The SIM file deals with the residual pollution within the plant grounds.

1.1. Global view of regulators and implementers

In November 2001, a joint standpoint of the Federal Agency for Nuclear Control (FANC) and the Belgian Agency for Radioactive Waste and Enriched Fissile Material (NIRAS) was issued concerning the radiological aspects[1] of the cleanup of the radioactive contamination of the Olen facility (currently owned by Umicore) and the vicinity. The present paper highlights the general approach for the remediation of the Olen site and presents a strategy for long term management of the resulting radioactive waste, in coherence with other waste categories dealt with by NIRAS.

The general strategy to be followed when considering remediation comprises the following activities:

— Establishing the *inventory* (including radiological and non-radiological, quantities and specific activities);
— Identifying the remediation options, including the technical installations necessary for the remediation, the storage and/or disposal of materials coming from the remediation; a final disposal for non-conditioned materials is not excluded;

[1] In Belgium, the regional authorities are responsible for all non-radiological aspects of waste management.

— Selecting an option, considering the radiological and non-radiological impact, socio-economical aspects, technical feasibility and required legal security;
— Developing and obtaining approval of the remediation project;
— Taking into account authorization aspects;
— Remediation;
— Ensuring surveillance and control.

In this strategy, the principle that any cleanup should be justified from a radioprotection point of view is of prime importance. In the joint standpoint, the principle of looking for a local long term solution for waste resulting from remedial actions has, even so, been accepted. The ‘polluter pays’ principle will also apply on remediation, as it is stated that any transfer of radioactive materials to NIRAS should be accompanied by the necessary financial resources covering the prescribed monitoring and remaining risks (loss of structural stability of the installation). Finally, it has been recommended that an appropriate consultation structure be created to accompany the decontamination projects, in which the local authorities and the local population are involved.

To deal with large volumes of very low level long lived waste resulting from remediation, NIRAS and the FANC introduced a new category of waste, very low level waste, with the aim of constructing a surface disposal facility on the remediation site to receive this waste. By only accepting very low level long lived waste in such a final disposal, and thus placing very strong restrictions on the stored activity (in Bq) and activity concentration (in Bq/g), the long term monitoring and control programme can be kept minimal. Instead, a permanent and passive institutional control, such as restriction on the land use, becomes an additional element of long term safety. The consequence of this viewpoint is that during remediation, measurements will be required with the following twofold purpose:

— Verification of the inventory;
— Removal of hot spots which represent a too high risk for a surface disposal of very low level long lived waste. The indicative limit of 40 Bq/g as proposed in the global view will have to be confirmed by a site specific and design specific safety assessment.

1.2. Situation in October 2002

1.2.1. The UMTRAP file

This storage facility on the plant site includes remnants from the radium production period. It also includes a limited quantity of polluted materials and

FIG. 2. Situation before cleanup (photograph reproduced courtesy of Umicore).

FIG. 3. Building the storage facility — applying the radon cover (photograph reproduced courtesy of Umicore).

FIG. 4. Applying the multi-cover (photograph reproduced courtesy of Umicore).

a large quantity of soil from the cleanup of the old radium factory at the beginning of the 1980s. After that, this depot was transformed into a safe and stable storage place for the stored materials (see Figs 2, 3 and 4).

The principle applied for the covering was generally accepted in the United States of America in the 1980s (uranium milling and tailing remediation action) and was accepted in the 1980s by the involved national ministries as affording better protection for human beings and the environment. The existing permits from the production period were converted by the Government into a permit with special conditions for this storage of radioactive waste. One of these conditions is to perform a long term safety evaluation. This study is currently being worked on, and the final report will be submitted to the permit granting authority, accompanied by the advice of NIRAS. Different scenarios are being considered in this study, including a normal evolution scenario with a constant biosphere and one with a changing biosphere, and altered evolution scenarios treating glaciation and different kinds of human intrusion (including scenarios such as construction, residence, boreholes and waste retrieval). One of the scenarios requested for study is the effect of the removal of radium needles and sources. In the future, it is up to the permit granting authority, the FANC, to decide what the next steps to be taken are in this file, whether or not corrective actions are necessary to ensure the long term protection of humankind and the environment. No formal need or request has been formulated at this time for the transfer of this radioactive waste to the radioactive waste management organization, NIRAS.

The radiological inventory of the storage facility is relatively well known and contains the following components:

— Radium sources and needles: about 200 g ^{226}Ra;
— Uranium mill tailings: total mass of 2000 t containing about 700 g ^{226}Ra with specific activities varying from 9000 to 30 000 Bq/g;
— Other residues: total mass of 14 000 t containing about 110 g ^{226}Ra with specific activities between 200 to 7500 Bq/g;
— Contaminated soil and scrap: total mass of 60 000 t with an average ^{226}Ra concentration of about 20 Bq/g.

The tailings and residues also contain a considerable amount of natural uranium (about 30 t). Figure 5 shows an overview of the location of the different waste streams.

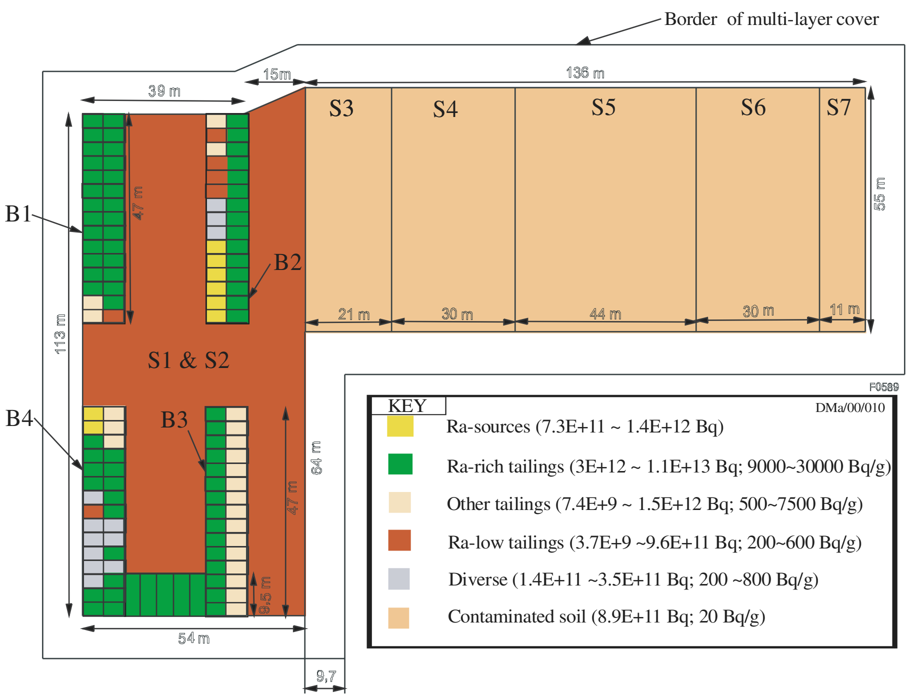

FIG. 5. Distribution of waste types in the storage facility (reproduced courtesy of SCK•CEN).

1.2.2. The BRAEM file

The BRAEM file relates to the radioactive pollution outside the plant grounds. Figure 6 presents an overview of the places with an enhanced radioactivity in the surroundings of Olen.

According to the Kirchmann study [1, 2], radioactive substances are located under the present intermunicipal (IOK) and industrial (UM) disposal site (see Fig. 6). These waste products are now buried under more than 20 m of non-radioactive waste and therefore cannot be detected with a gamma detector [5].

Location D1 in Fig. 6 was formerly a low lying area. Between 1955 and 1960, the difference in level was filled up with residues of cobalt production, the debris of a former building of radium production and a limited amount of radium extraction residues. The thickness of the waste varied between 0 and about 3 m, depending on the original difference in level. The D1 dump, with a

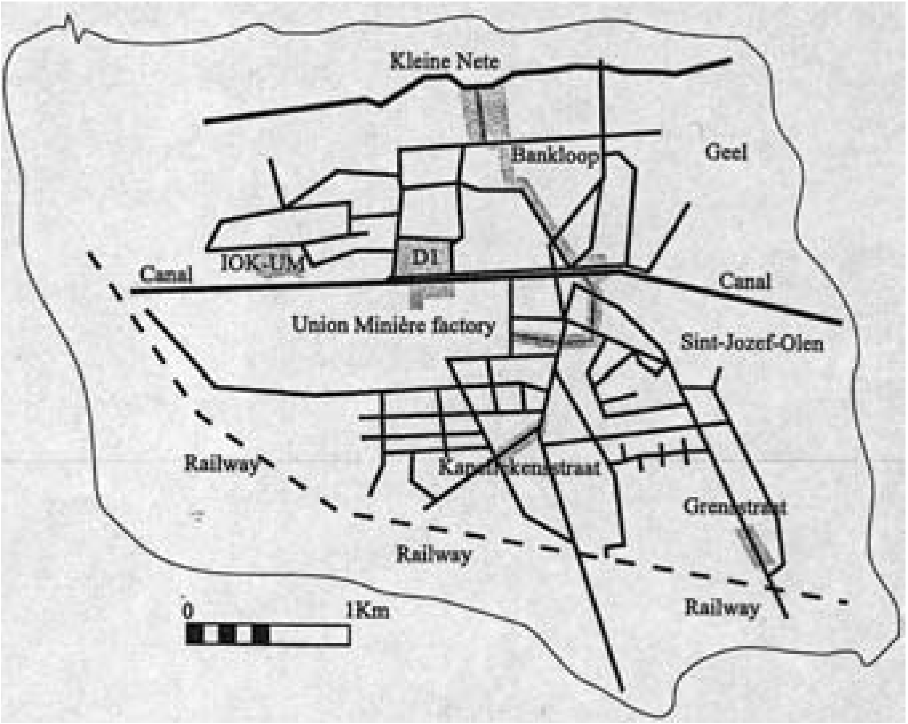

FIG. 6. Presence of radium at Sint-Jozef-Olen. In the shaded areas, substances with enhanced radium concentrations are present. (Figure taken from Vanmarcke and Zeevaert, Ref. [5].)

surface of 10 ha (approximately 0.1 km^2), was accessible to the public until the beginning of the 1990s, when the dump was cordoned off by a fence. Surface gamma measurements performed on a grid with a mesh of 25 m showed the following dose rates: maximum (150 μSv/h), mean (2.8 μSv/h) and median (1 μSv/h). Samples taken at local maxima showed concentrations as high as 34 000 Bq/g. To gain an insight into the distribution of the radium profile, a shell bit was hammered 3 m on a grid of 40 m by 40 m. The boreholes were logged with a NaI detector, as were the cores. Complementary ^{226}Ra concentrations were measured in the core material.

Radium-226 concentrations were obtained varying from 43 Bq/kg up to 930 000 Bq/kg. From this reconnaissance campaign, an average value for the D1 dump of 7 Bq ^{226}Ra/g has been estimated. Figure 7 shows the contours of the D1 dump.

Radium has been, nevertheless, dispersed into the environment. The purified liquid effluents of the radium facility were discharged into the stream called Bankloop. The Bankloop is 1800 m long; it begins at the fence of the Umicore plant and discharges into the Kleine Nete River. The first 600 m of the stream, up to the canal, lies in a residential area. Then the Bankloop flows

FIG. 7. The location of the D1 dump is in the close vicinity of the Umicore plant. The D1 dump is presented as more or less the area within the contours.

through a predominantly agricultural area. The lower reaches were frequently flooded in the winter until the beginning of the 1960s when, as a result of soil reclamation work, the last 420 m of the stream were displaced. The radium contamination of the banks is mostly confined to a narrow strip of 5–10 m wide on one or both sides, caused by the regular dredging of the sediment. In the flooding zone, the contamination extends over an area of several ha [5].

Figure 8 gives an impression of the first 600 m of the Bankloop, a stream that flows through a residential area.

At different places in the village of Sint-Jozef-Olen and in the neighbouring city of Geel, several stretches of road and isolated points were identified during the different gamma surveys. The two most contaminated roads are shown in Fig. 6, namely the Kapellekensstraat and the Grensstraat.

In 1989 and 1990, media coverage of very high contamination in the village of Sint-Jozef-Olen resulted in a detailed radiological characterization of the contaminated areas and an evaluation of their impact on the population exposed [4]. The results of these studies commissioned by the Federal Government and performed in the early 1990s have shown that the present day risks are very limited. However, the authorities asked Umicore to proceed to a

FIG. 8. An impression of the first 600 m of the Bankloop, flowing through a residential area.

cleanup “not because there is any danger at present for public health, but rather in order to substantially improve the isolation of the contaminated materials from the environment, which will allow us to keep the dose impact for the local population very limited in the future as well.” A follow-up committee was established with all the parties concerned, including the cabinet of the competent Minister, the company, the regulatory authorities (FANC), NIRAS, the energy administration, the water policy department of the provincial government of Antwerp, the municipality of Olen, the city of Geel, the shipping department, the Public Waste Management Agency of the Flemish region (OVAM) and the Flemish Land Agency (VLM). The committee requested several additional studies and the results as well as the remedial options were discussed in this committee. Within the committee, there has been a consensus on the remedial option for the remediation of the D1 dump, considered to be a trigger for the cleanup of the contamination outside the plant walls.

Past radiological characterization studies are sufficient to identify remediation options, select an option and develop a remediation project. Continuous measurements during the remediation are, however, required to:

— Verify the inventory for compliance with the concept of very low level long lived waste and compliance with regulations;
— Remove the ‘hot spots’, which represent a too high risk for a surface disposal of very low level long lived waste. The eventual hot spots will be stored on the plant site in a licensed storage disposal for which the company is the licensee. In May 2000, Umicore was entrusted with the concrete mission to proceed with the development of a remediation project. It was asked in November 2001 to elaborate a scenario for the project.

Umicore then developed a project plan for the BRAEM project to clean up the radiological polluted grounds outside of the Umicore plant at Olen, and to build a licensed final disposal for the very low level long lived wastes generated by the cleanup works with the aim of transferring this disposal to NIRAS.[2] For this reason, NIRAS already participated in the project planning phase and will be involved throughout the whole project. Clearly, the role of NIRAS is not the role of the project manager but, being an important stakeholder, NIRAS will actively advise Umicore and will be consulted by Umicore during the different stages of the realization of the disposal facility.

[2] Considered in the BRAEM project are the D1 dump, the contaminated streets, the waste fluxes coming from the remediation of the Bankloop, but limited to the area between the plant and the Roerdompstraat, building materials coming from an old laboratory and some small local contaminations.

Different milestones in different fields were identified within the BRAEM project:

— Part 1 deals with the remedial works itself and with the construction of a disposal site for the waste streams coming from the remediations, with the exception of the storage for possible hot spots. These hot spots will be stored in a licensed storage facility on the Umicore plant.
— Part 2 deals with all kinds of authorization aspects including, in particular, the upfront identification of the applicant for the different authorizations, as well as the permit granting authority. As in Belgium, environmental aspects fall into regional government concerns and radiological protection is a federal matter. Both regulations and legislation must be harmonized.
— Part 3 deals with the general principles for dialogue and communication. In parallel with its programme for the burial of low level waste in nearby communities, NIRAS strives for a broad consensus supporting the long term solution of radioactive waste management and made it a requirement for Umicore to adopt the same approach.
— Part 4 deals with the necessary steps that need to be prepared in order to transfer the disposal site to NIRAS. More details will be specified, in particular, that the disposal site must be licensed; that the concept must fit within the overall management strategy for radioactive waste of NIRAS (including conceptual aspects, waste acceptance criteria, qualification of measurement devices, recording the information and site requirements); that a broad consensus must be established among local stakeholders; and that, finally, the transfer must be accompanied by a financial provision allowing the waste management agency long term monitoring, and covering for all or nearly all future risks.

At present, the project is in the preparatory phase, identifying authorization procedures and stating the requirements of the waste management agency allowing a transfer of the disposal site after closing the project.

A working group representing the different local stakeholders has been founded on the initiative of Umicore. NIRAS is participating in this working group as an observer, to follow the efforts to achieve a broad consensus and to explain the methodology of NIRAS if asked.

From the cabinet of the competent Minister, a task force has been created, with members of the organizations directly involved, such as the regulatory authorities (FANC), NIRAS, the water policy department of the provincial government of Antwerp, the municipality of Olen and the Public Waste Management Agency of the Flemish region (OVAM) and Umicore. This task force is meeting on a regular basis to guarantee a proper follow-up of the BRAEM project and remove any obstacles along the road.

It is expected that the application for the licence will take until the end of 2004, and granting of the license will take until mid-2006. The actual remediation is foreseen for the beginning of 2007, and it is expected that the disposal site will be finalized in 2010.

1.2.3. The SIM file

Due to the many years of activities, there are other contaminated locations present within the plant enclosure, besides the UMTRAP installation. During the decommissioning and cleanup of the old radium factory, not all pollution in the plant grounds could be removed. However, there are no radiation risks for the personnel or the environment.

This file has two major components, namely:

— The old dump site in the north-eastern corner of the plant, with a limited quantity of radioactive material;
— The local contamination of the subsoil.

Umicore is actually in the process of performing the first step of the remediation strategy, that is, performing measurements to establish an inventory.

In the joint standpoint of the FANC and NIRAS, the principle of the two fractions (i.e. a low engineered surface disposal for very low level waste and removal of the hot spots) was also seen as the solution for this SIM file. Naturally, this viewpoint must be confirmed by measurements and safety assessments.

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Discussion following paper by J.-P. Minon and A. Dierckx

A.J. HOOPER (United Kingdom): You referred to restrictions on land use as a form of passive institutional control. Could you be more specific?

J.-P. MINON (Belgium): We are discussing with the local community and the local authorities possibilities like the creation of a permanent wooded area or 'radiation park', with active institutional controls for an initial period of, say, 20 years.

P. METCALF (IAEA): Was the storage facility on the plant site built to standards in keeping with the practice?

J.-P. MINON (Belgium): Yes, it was — at the beginning of the 1980s.

P. METCALF (IAEA): Could you briefly describe the planned surface disposal facility for very low level waste?

J.-P. MINON (Belgium): The facility will be fully engineered but very simple. It will consist of trenches with concrete walls and a capping.

P. METCALF (IAEA): Would that be regarded as a practice that meets normal standards?

J.-P. MINON (Belgium): That is a difficult question which is currently under discussion.

Clearly, removing the waste from the D1 dump and the banks of the Bankloop Stream is an intervention. Putting the waste, which will have to be well characterized and be accepted in accordance with certain criteria, into the facility still to be constructed looks like a practice situation.

F. ZORZOLI (Italy): Could you say something about the possible return of radium needles from countries to which they were sold in the past?

J.-P. MINON (Belgium): I know that Union Minière took back some radium needles, but I believe that it did so voluntarily or on a commercial basis. We have no law in Belgium requiring that the manufacturer of radium needles take them back after use.

STATUS OF THE UNITED STATES DEPARTMENT OF ENERGY'S SITE REMEDIATION PROGRAMME

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Abstract

The present paper provides an overview of the status of the United States Department of Energy (USDOE) site closure activities and a case study on closure of the Rocky Flats Environmental Technology Site (RFETS), concentrating on recent changes in management of the US programme and the resulting lessons learned. Over the past year, the USDOE has been changing fundamentally the way it manages its Environmental Management or cleanup programme. This programme is responsible for the cleanup of 114 sites across the United States of America. About US $6.7 billion each year are spent to manage sites, safeguard nuclear materials, dispose of waste in numerous operating low level waste disposal facilities and to manage a transuranic waste geological repository, remediate extensive surface and groundwater contamination, and deactivate and decommission thousands of excess contaminated facilities. The fundamental change is in focusing efforts on risk reduction and site closure rather than maintaining the status quo, which has lengthy closure schedules and increasing life-cycle cost estimates. The USDOE is taking lessons learned from successful projects, such as the RFETS, and applying those lessons to the entire cleanup programme. At the RFETS, a risk-based management approach is being adopted, which applies effective contracting strategies and an overall sense of urgency to produce performance that serves the interest of the workers, the public and other stakeholders. The goal is to replicate this success at other sites being closed. In February 2002, the USDOE completed a comprehensive review of the Environmental Management programme, entitled the Top-to-Bottom Review. The review found numerous structural and institutional problems and identified specific remedies. The report urged the programme to transform its mission from managing risk to eliminating risk. Some of the problems and recommendations include improving contract strategy and management; moving to an accelerated, risk-based cleanup strategy; aligning internal business processes; and realigning the programme scope to closure. Since completion of the Top-to-Bottom Review, there has been a rapid implementation of changes at the programme level. Implementation at the site level has resulted in a set of performance management plans, which begin to establish accelerated schedules. The plans are developed with the support of regulators, sharing a desire for accelerated cleanup of sites. Cleanup and closure of all sites, previously estimated to take until the year 2070, can be completed decades sooner than previously suggested. The plans are also used to seek a separate funding account for site accelerated cleanup activities. In parallel with the implementation of the plans, a set of projects are being conducted that addresses specific technical or business needs identified in the report on the Top-to-Bottom Review. The focus of the latter part of the present paper shifts from the broader programme level activities and lessons learned to a case study on the RFETS. Highlights include lessons applied to other closure sites, such as an improvement in business practices, the use of an innovative contract approach and the development of performance incentives.

The present opportunity to address this conference and share some recent experiences in the area of site remediation on behalf of the United States Department of Energy (USDOE) is much appreciated. In particular, the focus of the present paper is on site remediation with respect to the efforts of the USDOE invested in risk reduction and accelerated site closure. The present paper provides an overview of the status of the site closure activities, concentrating on recent changes in management of the US programme, followed by a case study on closure of the Rocky Flats Environmental Technology Site (RFETS, also referred to as Rocky Flats), highlighting lessons learned.

The United States of America has a large legacy of radioactive waste resulting from past activities and events which span nearly half a century. There are a total of 114 cleanup sites composed of over two million acres of land used by the Government for nuclear research and development, and nuclear weapons production activities. By and large, most of this land is not contaminated but within the boundaries of such sites are numerous radiological controlled areas with thousands of individual facilities and release sites. Sites are scattered across the nation. Some sites, such as Rocky Flats, are located nearby and adjacent to growing suburban neighbourhoods, while others are secluded and many remain kilometres from any community. The financial liability to clean up the nuclear legacy in the USA is estimated at somewhere between US $220 billion and $300 billion. The US Government, through programmes administered by the USDOE, spends between $6 billion and $7 billion each year to manage sites, safeguard nuclear materials, dispose of waste, remediate extensive surface and groundwater contamination, and deactivate and decommission thousands of excess contaminated facilities. The cleanup programme began in earnest about 12 years ago, and until recently was planned to continue until the year 2070. This represents a legacy for generations to come.

The USA has a relatively mature waste management programme. A system of disposal of low level waste has been in place for up to five decades at some sites. Government and commercial low level waste disposal facilities have been operating at the Hanford Site in Washington State and the Savannah River Site and Barnwell facility in South Carolina. There is a commercial low level waste disposal site in Utah. The USDOE operates low level waste disposal facilities at the Idaho National Engineering and Environmental Laboratory in Idaho, the Nevada Test Site in Nevada, Oak Ridge National Laboratory in Tennessee and a transuranic waste geological repository, the Waste Isolation Pilot Plant near Carlsbad, New Mexico. In addition, the Yucca Mountain site in Nevada won Government approval to begin the licensing phase as the USDOE's first geological repository for high level waste. Other disposal facilities are also planned, under construction or completed, for wastes from cleanup projects at former uranium milling and production facilities, such as the Weldon Spring Site in Missouri, and the Fernald Site in Ohio. As may be expected, the USA has a large cleanup and waste management programme.

Over the past year, the USDOE has changed fundamentally the way it manages its Environmental Management or cleanup programme. First, the programme was looked at very closely. The long schedule and large cost estimate was found to be unacceptable. It was also discovered that only about one out of every three dollars spent was funding actual cleanup and risk reduction activities; the rest was spent on maintenance, fixed costs of keeping sites and facilities open, maintaining safety and security and other support activities. Progress was also looked at, and it was found that between 1998 and 2000, more than 40% of USDOE sites changed their expected closure dates by more than one year, and most changes were in the wrong direction — longer.

It was within this context that the US Secretary of Energy in August 2001 called for a review of the cleanup programme and USDOE management philosophy, with a goal of quickly and markedly improving programme performance. This study, called the Top-to-Bottom Review, was completed in February 2002 and clearly identified a systemic problem with the way the cleanup programme was conducting its activities. The report resulting from the review describes the problem as follows:

- Too much emphasis was on managing risk versus reducing risk to workers, the public and the environment;
- Projects were not managed with a completion mindset or an appropriate sense of urgency;
- Process, rather than cleanup results, formed the basis for performance metrics, contracts, cleanup approaches and agreements with regulators.

The fundamental and significant programme change that is now being implemented focuses on all USDOE cleanup efforts on risk reduction and accelerated site closure, rather than maintaining the status quo, which has lengthy closure schedules and increasing life-cycle cost estimates. To markedly improve programme performance, the USDOE is prepared to eliminate significant health and safety risks as soon as possible and review the remaining risks on a case by case basis. This requires the co-operation of regulators and stakeholders to determine the most appropriate cleanup schedules and approaches. The goal is to work together with the end state in mind, and avoid getting ensnared in the process. In some instances, this strategy requires a commitment to provide additional funding in the near term to implement new and breakthrough approaches. This means the support of the US legislature is needed to fund the programme sufficiently. Ways are being sought to streamline and expedite cleanup of sites and reduce costly surveillance and maintenance activities. In doing this, the safety and security of radioactive waste and nuclear materials that are waiting disposition must continue to be ensured. The bottom line here is that tax dollars are being put to more productive use and it must continue to be ensured that every dollar spent, wherever possible, goes toward effective cleanup activities. In some instances, this has been painful for companies seeking government contracts, because some past activities that do not directly support the cleanup mission have been discontinued and dollars have been redirected to other sites and activities.

At present, the process continues to evolve. New acceleration strategies are described in 18 performance management plans, each covering one or more sites. These plans summarize the current conditions of sites, the end state, the strategies needed to get from the current conditions to an end state, and the management process to support the new approach. The USDOE continues to work closely to develop new agreements with regulators to implement these plans. Changes have taken place, or are in the process of doing so, with respect to agreements, cleanup milestones and regulatory permits at a number of sites. This demonstrates the willingness of regulators to work together on implementing new goals, principles and approaches for accelerated risk reduction and cleanup. Crucial to this process is the request for up to $1.1 billion in additional funding for this fiscal year in a new cleanup reform budget account. At present, US legislators are considering this request as they make funding decisions, which the USDOE is optimistic will be successful.

With respect to the present paper, the request was to describe how the change from managing risk to reducing risk has been achieved, especially in terms of clearance or disposal. This change is still in the early stages of implemention, so it is hoped that specific examples can be given in the future, of issues that need to be overcome, based on this experience. The Rocky Flats cleanup experience provides insight into the type of change expected. At such sites, discussions continue with regulators about new cleanup approaches that are risk based. The resulting changes could have an impact on the amount of waste disposed or residual radioactivity remaining at cleanup sites when work is complete.

In addition to these redirected efforts to accelerate cleanup at USDOE sites, ten special project teams have also been created to implement initiatives coming from the Top-to-Bottom Review across the entire programme. Teams are considering opportunities that range from changing regulatory agreements to expedite cleanup, to looking for breakthrough strategies.

How to make business systems work better is the current focus. A small business strategy is being implemented that promotes competition and new ideas.

Acquisition strategies and contracts are also being aligned to accomplish accelerated cleanup plans. This will demand increased performance from those who desire to bid for and perform cleanup work in the USA. In the USA, private companies are contracted to manage waste and materials, and clean up sites by the USDOE. A Contract Management Review Board has been established and lessons learned from successful projects are being applied, such as the experience of Rocky Flats as new contracts are put in place or old ones are modified.

Another area being looked at is continuing site infrastructure and stewardship costs. As sites are closed, it is recognized that certain administrative functions performed at the site in the past can be consolidated in a business centre. Contracting, human resources, accounting and legal support are among those functions that can be centralized to serve many small site projects, as opposed to continuing to have staff at multiple sites which are closing. A project team is also identifying activities which are supporting other programme missions and are not specific to cleanup. Once identified, these activities can be transferred to other parts of the agency, keeping the mission focused on cleanup and closure of sites.

Sweeping changes are taking place with regard to how human resources are being managed. Some of the strategies being employed are changing management paradigms through reassignment of senior government executives. This brings in new perspectives and challenges executives to use their full leadership potential. Executive mentoring has been instituted and, in some instances, retired executives have been called on to help groom the new cadre of executives. The authorities within the line management between headquarters and field offices are being clearly defined in order to focus accountability on the senior executive in charge of cleanup. Managers are being held accountable through enhanced performance plans that are directly linked to challenging accelerated performance goals. The structure in the headquarters organization has been flattened, eliminating several layers of management. The headquarters support contractor services have been significantly reduced and funding has been rechannelled directly toward cleanup. The same is now being done at field offices. Incentives have been offered to workers considering retirement, while at the same time hiring controls are being implemented to change the skill mix of the workforce in order to meet future challenges.

Full implementation of the vision requires continued progress on many fronts. Site cleanup plans are being updated, which 'tier' from the programme management plans. Continued emphasis is placed on refining contract performance initiatives and aligning contract acquisition strategies. Another major change being implemented is the restructuring of the science and technology programme to directly support the focused cleanup efforts. And finally, ways to restructure business systems continue to be sought, in order to support streamlined programme and project management.

At this point in the discussion, it is useful to focus specifically on the experience at Rocky Flats, since the lessons learned from this single project are driving the changes to the cleanup programme just described. The vision for the Rocky Flats closure project includes the following elements:

— All radioactive waste and nuclear material are removed,
— All buildings are demolished,
— Environmental contamination is cleaned up,
— The land becomes part of a national wildlife refuge.

Completion of this vision is planned for 15 December 2006, at a cost of $6.7 billion. At Rocky Flats, a risk-based management approach is being adopted that applies effective contracting strategies and an overall sense of urgency which serves the interest of the workers, the public and other stakeholders.

The Rocky Flats site is located just outside Denver, Colorado, in a major metropolitan area. The then US Atomic Energy Commission established a production plant there in 1951 to manufacture nuclear weapons components using plutonium, uranium and beryllium metal. The plant site is composed of 384 acres surrounded by 6200 acres of buffer zone. The buffer zone has become one of the last pieces of natural high prairie environment remaining in this area for two reasons: there has been limited access to the site over the past 50 years, and there has been the development of surrounding communities. Over time, the suburban communities have caught up to the site, and today 600 000 people live downstream from surface water running from the site. In 1992, the operations of the plant underwent the transition of becoming an environmental cleanup mission. In 1997, the plant was designated as a pilot site closure project and efforts began to formulate an accelerated closure baseline.

Since 1997, the site closure baseline has evolved. In 1997, the initial estimate for closure was $36 billion and closure was estimated to take 50 years or more. As planners began to adopt more of a closure project paradigm, a baseline was developed in May 1999 to complete work in 2006 at a cost of $8.3 billion. In June 2000, this baseline was revised to reflect the closure contract signed with Kaiser-Hill, L.L.C., for a cost of $6.7 billion.

So what is being done for $6.7 billion? When the project is finished, the following will be achieved:

— Removal of all stored plutonium metals and oxides and highly-enriched uranium and the shipping of this material to locations in the USA for safe storage;
— Disposal of 15 000 cubic m of transuranic waste at the Waste Isolation Pilot Plant geological repository;
— Disposal of 224 000 cubic m of low level and mixed low level waste;
— The cleanup and release of 130 environmental sites;
— The demolition of 325 000 square m of buildings and 800 structures.

As of today, great progress is being made and work remains on schedule for completion in 2006. Operating disposal facilities for low level and transuranic waste are busy taking care of waste generated at Rocky Flats. Approximately one third of the work has been completed. As of September 2002, the following has been achieved:

— The removal of a large fraction of stored plutonium metals and oxides and highly-enriched uranium;
— The disposal of about 5 000 cubic m of transuranic waste;
— The disposal of about 60 000 cubic m of low level and mixed low level waste;
— The cleanup and release of 31 environmental sites;
— The demolition of about 30 000 square m of buildings and about one quarter, or 180, structures;
— The consolidation of all the nuclear materials in one facility in July 2001 to significantly reduce security costs;
— The completion of draining and processing of liquids from the plutonium processing buildings so that the label of ‘most dangerous building in America’ no longer applies.

Many trucks are moving down the roads from Rocky Flats to the disposal facilities in Nevada and New Mexico. To date, over 700 shipments of TRU waste have been made to the Waste Isolation Pilot Plant. In an average 40-hour work week, one truck with radioactive waste leaves the site each hour. This represents a high level of work activity at this site and at the disposal sites to keep the trucks rolling.

Many lessons are being learned from the Rocky Flats project. Such lessons can be seen as the building blocks for future closure projects. First, the mission and scope of any project must be clear and focused on closure. The work becomes a closure project, in the same way as a construction project has a beginning and an end. This means that the culture may need to change from one of continuing to maintain facilities safely to one of closure. Second, there is a need to identify the interfaces and what items the headquarters programmes or other sites must provide. The term for this is government-furnished services and items (GFSI). An example of GFSI would be providing disposal facilities at other sites and shipping services, such as shipping containers provided to Rocky Flats for disposing transuranic waste at the Waste Isolation Pilot Plant. From experience, it was found that work is performed based on an assumption that another organization will provide a service on time. When the service is late or unavailable, costs rise.

A key to success at Rocky Flats is contract structure. The completion of closure — not process or progress — is the key indicator for making a profit or fee. The closure contract at Rocky Flats which the US Government has with Kaiser-Hill, L.L.C., is a cost plus incentive fee (CPIF) closure contract. The contract end is determined by the physical completion of the work scope — not a term of years. The 2006 closure goal is embodied into a target cost, target schedule and target fee or profit. A lot of profit is at stake. In addition, Kaiser-Hill shares in savings and is penalized for cost overruns and delays. There are also potential penalties, for things such as safety and security violations. This provides significant incentive for the contractor to meet established performance targets, because significant profit or fee is at risk.

The following is an outline of how the fee works. The final fee determination is made at project completion. In the cost incentive area, the contract specifies a target fee of $340 million for a target cost between $3.95 billion and $4.16 billion. If the cost of the project finishes below $3.95 billion, the Government will share the savings (70% to the Government and 30% to the contractor) in the form of additional fee to the contractor. The maximum fee can be as high as $460 million. Likewise, if the cost of the project finishes above $4.16 billion, the Government will share the penalty (70% to the Government and 30% to the contractor) in the form of a reduced fee to the contractor. The minimum fee is $150 million. Understandably, there is much incentive in terms of large profits for the contractor to find ways to accelerate work and save money. During the progress of the project, incentive fee payments are made that are conditional and subject to final performance. A significant portion of the fee is withheld as a balloon payment until the project comes to an end. Earned value measurement is used to monitor project process.

The cleanup contract clearly defines the scope of work for the contractor and specifies GFSIs that must be provided by the Government to support closure. These services may take the form of shipments of waste and material to other sites for storage and disposal. In this way, the Government, too, assumes a share of the performance risk, because the contractor can seek equitable adjustments to contract cost and fee if these GFSIs are not provided.

This unique contract holds both the Government and the contractor highly accountable in a unique partnership. The incentives are there, in terms of large profit potential, to achieve accelerated cleanup. To date, the experience has been so good that ways to get similar terms in other contracts at other sites are being sought, as existing ones are renegotiated or replaced.

With incentives to get work done, it is imperative that the contractor and the Government maintain a good relationship with the regulators, which in the case of Rocky Flats is the State of Colorado and the US Environmental Protection Agency. Working closely with regulators is important to the accelerated success of the project. It is important to reach a common understanding on cleanup levels that are protective of workers, the public and the environment, while at the same time achieving a risk-based cleanup of the site. This is not always easy to achieve, however, there are areas within the control of the cleanup contractor that can help accelerate regulatory approvals. Some of these areas include the use of standard operating protocols and sampling plans for all cleanup activities. Use of standard formats which the regulator is familiar with for more than one cleanup area helps approvals to be obtained more quickly.

The USDOE has the following slogan: "We work safely, or not at all". Because of the inherent hazards associated with handling nuclear material and waste, cleanup, and demolition work, safety becomes much more than a mantra. As cleanup work is accelerated, care must be taken to ensure that safety is not sacrificed. At Rocky Flats, experience has shown that construction or occupational risk increases as nuclear risk decreases. A safety programme is required to address this which continually adapts to ensure workers are trained for the risk and hazards involved in the work they are performing that day. As work progresses, communications are important and stand down time occurs to address issues as they arise. It is important that the contractors and the Government have independent safety programmes and that these programmes drive continuous improvement through tools such as safety assessments, real time tracking and trending.

Beyond ensuring the safety of the workers, it is important to understand and motivate a workforce that is working itself out of a job. When cleanup activities began at Rocky Flats, a production mentality existed. With almost 50 years of operating experience, in some cases this meant that multiple generations of family members had worked or were working at the plant. Transforming a workforce from a production plant mission to a cleanup mission was a challenge. Some of the ideas that help to get and keep a motivated workforce are the following:

— Employee wellness programmes to deal with the trauma of change and workforce reduction;
— Incentives and additional retirement benefits, such as health and pensions, to achieve voluntary reductions;
— Transition benefits and assistance for those workers that must be separated;
— Incentives to keep the remaining workers on the job and performing until the cleanup is complete, such as good salaries, bonuses and work schedules that provide four days off every other weekend.

Another important area is openness and public involvement. At Rocky Flats, it is fortunate that the citizens' advisory board and the local public officials work together to achieve cleanup. At Rocky Flats, work continues with the involvement of the public on important issues such as agreeing on the environmental end state, setting cleanup levels and selecting remediation alternatives. A co-operative relationship is important as concerns are discussed over stewardship of the site after cleanup is complete. The site will become a wildlife refuge by law, under the Rocky Flats National Wildlife Refuge Act signed by President Bush in December 2001.

Another important lesson learned is the use of standard demolition contractors to remove non-contaminated buildings. Allowing more companies to bid on work that resembles normal, commercial demolition means cost savings to the Government. It was found that portions of the site work can be done in this manner very effectively and with significant cost savings.

Looking for better and cheaper ways to work by deploying technology has also been a key lesson learned. The amount of transuranic waste being generated has been significantly reduced and more costly disposal thereby avoided using simple chemical decontamination techniques on gloveboxes. Gloveboxes can be decontaminated and disposed as low level waste, with a relatively small transuranic waste product from the cleaning stream. Plasma arc technology is being used successfully to cut large pieces of equipment in order to reduce radiological and industrial hazards posed to workers from mechanical saws and other cutting devices. Finally, inner tent chambers have been used during glovebox size reduction to contain radioactivity and reduce associated cleanup risks.

Time constraints have allowed only a few important lessons learned at Rocky Flats to be described. Participation is welcomed in the annual lessons learned or Technical Information Exchange Workshop, where much more information is available. Last month a very successful 14th workshop took place in Oakland, California. A sincere welcome is extended to participants of this conference to come to the USA and hear more about what is being done at all the closure sites in the next Technical Information Exchange Workshop, which will take place in the autumn.

In conclusion, there is much going on in the USA to refocus efforts on accelerating cleanup and closing sites. There are numerous operating low level waste disposal facilities, a geological repository for transuranic waste, and great strides are being made toward the goal of operating a high level waste repository. Interest is no longer confined to the cleanup process. The new point of focus is the end goal. Site closure projects are managed in the same manner as construction projects. Experience gained from best practices at sites such as Rocky Flats, in areas which include contract reform, streamlined management, improved business practices, motivating workers and finding innovative solutions, is being applied to the entire cleanup programme. The challenge is to look at one's own programmes and see whether they can benefit from the same changes.

Discussion following paper by P.M. Bubar and D. Tonkay

P. METCALF (IAEA): Do any of the special project teams to which you referred deal with disposal?

P.M. BUBAR (United States of America): Yes, the team dealing with everything "other than spent fuel and high level waste". That team is trying to identify better management practices for the characterization, treatment and disposal of low level waste — including low level mixed waste. It is looking at disposal practices, with a view to making maximum use of commercial facilities and of the US Department of Energy's facilities.

The only impediment we have to clearing our sites is the fact that at present no disposal facility in the USA can take radioactive waste that is essentially in the Class C range but also has non-radioactive hazardous constituents. We do have a facility at Richland (Washington State) where that kind of waste can be disposed of, but the regulator has not agreed to our bringing waste from elsewhere to that facility.

P. METCALF (IAEA): Is the disposal of waste in the US Department of Energy's disposal facility in Nevada taking place under regulatory control?

P.M. BUBAR (United States of America): No, the regulators do not regulate that facility — under the Atomic Energy Act, the US Department of Energy is self-regulating as far as its radioactive material is concerned.

However, we give the regulators full access to all information about the material being brought to the facility, so that they can verify that the material contains no non-radioactive hazardous constituents. Also, the regulators are actively involved in closely monitoring the waste characterization and packaging processes at the sites where the waste is generated in order to ensure that no mixed waste is being shipped to the disposal facility.

J. GREEVES (United States of America): How are the cleanup standards set?

P.M. BUBAR (United States of America): They are based on the agreed future land use. In the case of Rocky Flats, for example, it has been agreed that an area of 100 acres in the middle of the site where most of the nuclear weapons production took place may be used for industrial purposes and that the surrounding 6200-acre buffer zone will become a wildlife refuge. We and the regulators are now consulting with a view to setting cleanup standards for the industrial-use area that will limit the additional annual cancer risk to between 10^{-4} and 10^{-6}.

A. WALLO (United States of America): I would add that there is an exercise currently under way in Colorado where the stakeholders have successfully pushed for an initial cleanup standard of 25 mrem plus ALARA. We are now calculating whether that fits the risk range as well as the dose limits.

P.M. BUBAR (United States of America): There is no national policy requiring site cleanup to a certain risk or dose range. We are using 25 mrem at Rocky Flats and try to use it at other sites. However, the stakeholders and the regulators sometimes push for 15 mrem or even lower, and for 10^{-6} instead of 10^{-4}. Then we have to spend a lot of time and energy on reaching agreement.

PANEL

WHAT LESSONS HAVE BEEN LEARNED FROM PAST EXPERIENCES? HOW SHOULD WE MANAGE WASTE IN FACILITIES BUILT TO PREVIOUS SAFETY STANDARDS?

Chairperson: **T. Norendal** (Norway)

Members: **P. Ormai** (Hungary)
V.N. Romanovsky (Russian Federation)
J.-P. Minon (Belgium)
P.M. Bubar (United States of America)

Panel Discussion

J. HULKA (Czech Republic): In ICRP 82, the ICRP recommended 10 mSv as the annual dose below which intervention is probably not justifiable and 100 mSv as the annual dose above which intervention is justifiable in all cases. I would be interested in hearing opinions about whether that recommendation is likely to change anything in individual countries.

A. WALLO (USA): I do not think it will change what we are doing in the United States of America. In our cleanup programmes, we have been trying to merge the 'risk range' approach and the 'dose constraint plus ALARA' approach, and I think we shall continue to do that.

However, the ICRP recommendation may be useful in our planning for emergency response to accidents and terrorist threats, where I think we shall be using the optimization approach rather than dose limits.

J. GREEVES (USA): The USA, which can afford to clean up Rocky Flats to 300 μSv/a, should have no problem with that ICRP recommendation, but other countries may well have problems with it; they may fall into a trap if they base themselves on what is happening in the USA.

I think this is an issue which the IAEA should keep a close eye on.

J.-P. MINON (Belgium): The waste which we have at the Olen site in Belgium is mixed waste: chemical waste mixed with radium milling waste, uranium contaminated soils and so on.

In moving such waste from one place to another, it is important to ensure that it will be chemically and radiologically harmless for a long period of time; that is the basis of the decision regarding the D1 dump at the Olen site.

Our calculations indicated that nothing needed to be done on radiological grounds, but the authorities requested Umicore (the former Union Minière) to clean up the Olen site "not because there is any danger at present for public health, but rather in order to substantially improve the isolation of the contaminated materials from the environment, which will allow us to keep the dose impact for the local population very limited in the future as well."

P. METCALF (IAEA): The ICRP 82 recommendation provides a reference point for deciding whether to intervene in an exposure situation — for example, after an accident — in order to reduce the exposure.

Many of the situations we are considering nowadays, however, are situations where people are not at present being exposed but where human intrusion in the future could cause exposure.

In his presentation, P. Ormai talked about the removal of sources from a near surface repository because of concern about the possibility of intrusion. That raises the question of what is to be done with those sources — will they end up constituting a still greater risk?

The point of reference provided by the ICRP recommendation may be helpful for a country where a practice existed many years previously and which cannot afford to carry out a cleanup, since it may indicate that things are not too bad and nothing has to be done. An affluent country will probably do something, especially if there is a lot of public pressure.

So, I think the ICRP recommendation may be useful in a difficult situation. However, where you have a controlled situation and are thinking of removing the controls from the site in question, you may decide that the likelihood of intrusion is sufficiently low for the risk to be acceptable.

A. WALLO (USA): I think the point P. Ormai made is about real doses versus hypothetical doses. That's one of the reasons why I asked the question about improved intruder barriers.

In the USA, there is the expectation that institutional controls will work, so we are not going to decontaminate every site down to 300 μSv on the assumption that the site will be taken over by a resident farmer. There will be an assumption of land use control, so you are not going to assume that in every case a site is free for every use.

P.M. BUBAR (USA): In the USA, the Federal Government will have to maintain a presence, even at small sites. For example, at Rocky Flats, the wildlife refuge will be maintained by the Fish and Wildlife Service, and the Hanford site will be owned by the Federal Government in perpetuity.

People are more ready to accept institutional controls if they know that the Federal Government is going to be responsible for maintaining them.

P. METCALF (IAEA): Can even the Federal Government of the USA legislate for perpetuity?

J. GREEVES (USA): It already has legislated for perpetuity, in the case of mill tailings.

I think the challenge (and the IAEA faces this) is to come up with a graded approach, for example, in the requirements that we are working on in the IAEA's Waste Safety Standards Committee (WASSC). For interventions, there need to be standards and accountability; for practices, there need to be standards at a different grade. I think the job for the IAEA is to get that done. Unfortunately, we are not there yet, and it is going to be difficult to write the reports required by the Joint Convention.

A. WALLO (USA): Institutional controls may fail, but it is quite possible that catastrophic events will not occur in the event of a failure. Societies tend to act responsibly even without governmental guidance.

Consequently, I think that our role in this generation is to ensure that future generations know what we did, why we did it and what we expected of them, so that they can do what is necessary regardless of what kind of government they have.

P.M. BUBAR (USA): I do not think that we should work on the assumption that future governments will be more stupid than we are. Perhaps we can, on the contrary, work on the assumption that future governments will be less stupid than we are, having learned from our experience and the experience of our successors.

Further to what A. Wallo just said about our role in this generation being to ensure that future generations know what we did and so on, I would say that, if the builders of the nuclear weapons production facilities which we are now cleaning up had left adequate records, we would have far fewer problems now. We must leave adequate records for future generations.

T. NORENDAL (Norway): In my view, secrecy of the kind that surrounded the construction and operation of those nuclear weapons production facilities will not be tolerated by future generations, which will demand more information about and stricter controls on the activities of governments in the nuclear field.

J.-P. MINON (Belgium): The builders of those nuclear weapons production facilities and the builders of the Olen facility did not think of the fact that they were creating radioactive waste management problems for future generations — problems due in part to fundamental changes in the values of society. What was acceptable as a safety level some decades ago is not acceptable now, because risk perceptions have changed. Perhaps the most problematic aspect of radioactive waste management is possible discontinuities in the way people think.

T. NORENDAL (Norway): Perhaps we could now have a discussion on the lessons which we have learned and the recommendations which we might make to our governments.

It seems to me that governments did a lot of things in the past which would not be permitted today, that many past practices would not be accepted today, that many of the things done in the past are causing problems today and that those problems can be overcome — but at great cost and not without a lot of effort.

So, what can we learn from past practices and how should we go about introducing new practices?

V.N. ROMANOVSKY (Russian Federation): We have learned from the past. For example, following the 1957 accident at the Mayak site, where a tank containing liquid high level waste exploded and there was a huge discharge of radioactivity into the environment, we now attach great importance to the incorporation of liquid high level waste into stable solid matrixes.

P. ORMAI (Hungary): It seems to me that people have been learning from the past in several countries besides Hungary and that reassessing the safety of near surface repositories is no longer a side issue in those countries, some of which have embarked on the systematic modernization of their near surface repositories.

Another lesson learned seems to be that extreme conservatism in safety assessments can lead to unreasonable decisions — that there needs to be an appropriate balance between the level of conservatism and the rigour of analysis.

In my view, it is important that intervention decisions be robust in the face of uncertainties, since interventions are expensive and time consuming. That is why, in the case of our Püspökszilágy disposal facility, we have decided that further monitoring is necessary.

When there is an acute problem, for example, you have spent fuel in a near surface repository, an additional iteration of the safety assessment is not very helpful. If you know the repository inventory and have the necessary resources, you should act in a timely manner.

Countries which decide to modernize their near surface repositories need optimization techniques of some kind. This is a problem, as the risks associated with such repositories are not imminent and, as stated in ICRP 76, the optimization of protection against potential exposures is still a largely unresolved issue.

J. GREEVES (USA): The presentations made in this session covered issues ranging from the management of radioactive waste from nuclear-powered submarines in the Russian Federation, to cleaning up, to very low levels in the USA. In my view, with the methodology described in ICRP 82, it is possible to tackle all those issues.

T. NORENDAL (Norway): An important question which arises when one tackles such issues is that of the standards to be applied. If you apply high standards, you may be able to dismantle only one submarine; if you apply lower standards you may be able to dismantle two. As J. Greeves indicated earlier, the USA can afford cleanup levels that many other countries cannot afford. We in Norway take affordability into account when helping other countries to deal with radioactive waste management problems.

A.J. HOOPER (United Kingdom): The technology, the skills and the experience necessary for managing radioactive waste from past activities and events undoubtedly exist and, in my view, we should not be afraid of committing resources to the management of such waste. We should bear in mind, however, that the cost can be prohibitive.

While I have the floor, I should like to say that, in my opinion, regulatory authorities should give more thought to how institutional control fits into the overall licensing of a waste management activity, particularly at the end of remediation or the closure of a near surface repository.

J.-P. MINON (Belgium): Further to what I said about changing risk perceptions, I refer to my presentation where I said that some 3000 t of radium-bearing material from the Olen site was dumped in the sea at the beginning of the 1980s. No objections were raised to the sea dumping of that material. Then came a fundamental change in people's thinking and the sea dumping of such material stopped. Much of the material at the Olen site now is there because of that fundamental change. Whether it is better that the material in question be at the Olen site rather than at the bottom of the sea is a moot point.

A. WALLO (USA): Fundamental changes in people's thinking occur from time to time, but society deals responsibly with the consequences. For example, you are now dealing with the material still at the Olen site.

J.-P. MINON (Belgium): There are always several solutions to a given problem. Society chooses the solution which it considers to be appropriate at the time when it makes its choice.

A. WALLO (USA): At a certain point in time, the radioactive waste management community decided that isolation — not dilution — was the solution. If someone had decided 50 years earlier that all radioactive waste should be diluted down to near background levels, there would be no need for isolation now. However, that would not have meant that dilution was the best solution.

J.-P. MINON (Belgium): You may be right in what you say. However, a geologist would say that with time everything becomes diluted, even that which is isolated.

P. METCALF (IAEA): In this session, concern was expressed about preserving information for future generations. In Session 4, however, G. McCarthy, an archivist, showed us that there are now some very reliable ways of preserving information. In my view, therefore, when talking about institutional controls for long periods, we should perhaps focus less on whether they are feasible and more on how to ensure that they are put in place.

Also in this session, reference was made to the conservatism of the assumptions underlying safety assessments. I think there is a need for international harmonization with regard to safety assessment methodologies. For its part, the IAEA is encouraging efforts to achieve such international harmonization.

P.M. BUBAR (USA): We are trying to complete cleanups and thereby work ourselves out of business. However, we are finding that regulators and community representatives are often unwilling to state that a cleanup has been completed, because they do not know what will follow in terms of institutional controls.

P. ORMAI (Hungary): At the Cordoba Conference, it was widely felt that institutional controls were unlikely to remain effective for more than about 150 years.

H. HULKA (Czech Republic): In my view, a great deal of remediation work is unnecessary on radiological grounds; it is carried out for political, aesthetic or other reasons. For example, I do not think it was necessary, on radiological grounds, to spend over 10 million euros on the remediation of uranium tailings at Wismuth, in Germany.

If there is so much concern about ionizing radiation, why is so little done about radon? In the Czech Republic, for example, there are over 20 000 people living in buildings with radon concentrations higher than 400 Bq/m^3, which means annual doses of about 10 mSv, but this situation is hardly discussed.

While I have the floor, I would mention another situation in the Czech Republic — one regarding which a decision has yet to be taken. We have a river that is contaminated from uranium mining; the radium concentrations along its banks are about 2000 Bq/kg. However, nobody lives on its banks, and the river flows through an area of great scenic beauty. The only reason for remediation, at considerable expense, would be to protect a few anglers who go to fish in the river. It might be better to declare the area to be a national park — with enhanced radioactivity.

A.L. RODNA (Romania): When we talk about potential severe nuclear accidents, we are told to bear in mind that, although the effects would be catastrophic, the probability of such an accident occurring is very low. I find this perfectly understandable. What I do not understand, however, is that, when we talk about 10 mSv as a limit for intervention at a long lived, low level waste repository in the case of an intrusion scenario, we do not take into account the probability of the intrusion. Why do we not think in terms of the collective dose that would result from the intrusion? Why do we not take the risk to be the product of the dose multiplied by the probability?

If we do not trust a society to protect the planet from long lived, low level waste for 300 years, we presumably expect that society to change in some disastrous manner. In that case, why should we care about a dose of 10 mSv?

T. NORENDAL (Norway): That is a sensitive point on which politicians, on one hand, and radiation protection specialists, on the other, are unlikely to agree. Much depends on the public's perception of risk, and that changes. I believe that in western Europe, for example, the public's perception of risk was affected by the Chernobyl accident and, more recently, by revelations about military activities that the public was previously not aware of.

In my view, honest communication with the public is very important for obtaining the public's approval of intervention levels and of standards.

P.M. BUBAR (USA): The US Environmental Protection Agency's programme for educating the public about radon in the home was not very successful. Representatives would visit people who had built their homes near, say, a uranium mining site, measure the radon levels in those homes and explain the risks, comparing them with the risks associated with activities like smoking. However, they came up against the problem of risks incurred voluntarily versus risks incurred involuntarily. The people had chosen to build their homes in an area which they knew to be near a uranium mining site, in the same way that they chose to smoke, and they simply did not care.

A.J. HOOPER (United Kingdom): As a result of surveys, it is known where the radon hot spots in the United Kingdom are. Radon detectors have been offered to the people living at such hot spots, but the offer has not been accepted very often. In addition, a grant is available for the installation of under-floor ventilation in homes where the radon dose level is 10 mSv/a or more.

PUBLIC ATTITUDES TO RADIOACTIVE WASTE

(Session 8)

Chairperson

J. BARCELÓ VERNET
Spain

PUBLIC OPINION SURVEY ON RADIOACTIVE WASTE IN THE EUROPEAN UNION

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Abstract

The paper presents the results of public opinion surveys conducted in European Union countries on the subject of radioactive waste. It provides a snapshot of attitudes to radioactive waste, the knowledge that people have about it, the confidence they have in the different bodies associated with the management of radioactive waste and about media reporting on the subject. It provides insights on public perceptions of nuclear energy in relation to other energy sources. Finally, attention is drawn to the need for countries to understand the views of their own public as an important input to finding solutions to the radioactive waste problem.

1. BACKGROUND

In 1998, the European Commission conducted a public opinion survey on the subject of radioactive waste. Over 16 000 people across the European Union were interviewed on the subject. A new survey was undertaken in October and November 2001. A comparison of the results of the two surveys (on public opinion in the European Union on radioactive waste generally) shows that in the intervening period, there had been very few significant changes. The events of 11 September 2001, in particular, appear to have had no measurable impact on people's views.

The information is supplemented by data from a more recent Eurobarometer survey (European spring 2002) covering all energy sources which included a number of questions about nuclear energy and its wastes. For each survey, close to 1000 people were selected at random and interviewed in 12 Member States. In addition, 2000 people were interviewed in Germany; 1300

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* The views expressed in the present paper are those of the author and may not necessarily reflect those of the European Commission.

in the United Kingdom, and around 600 in Luxembourg. The total sample was, therefore, close to 16 000 in each case.

In the case of several of the questions, there was a significant number of answers indicating the ‘don’t know’ option. This gives rise to the dilemma of how to present the data. In some instances, it is useful to normalize the data by removing the ‘don’t knows’ and recalculating the views of those expressing a definite opinion to 100%. When this has been done, the paper refers to the views of respondents and treats them separately from the ‘don’t knows’.

More detailed results of the survey are available on the European Commission’s web site.

2. PEOPLE ARE WORRIED ABOUT RADIOACTIVE WASTE

From both surveys, it is clear that the average European is worried about radioactive waste. He or she is also very poorly informed about the topic. In 1998, three quarters of the population were worried about radioactive waste. There was considerable regional variation in the replies. Those in the south of the European Union were most worried (up to 98% in Greece) while those in the north-east had the least concern (down to 41% in Sweden).

This regional variation also occurred in the 2001 survey, though the percentage of ‘worried’ people in the European Union had actually fallen below 70%. In fact, in the following five Member States, more people said they were not worried than said they were: Denmark, Finland, Luxembourg, the Netherlands and Sweden. Greece still had the most people worried by radioactive waste. Rather surprisingly, among the ‘worried’ States, France scored very highly with nearly 75% being worried about waste.

People appear to be more concerned about how radioactive waste is managed in other countries than in their own. Over 75% of the respondents were worried about how such waste is managed in other Member States and over 80% were worried about how it is managed in the candidate countries.

3. PEOPLE ARE NOT WELL INFORMED ABOUT RADIOACTIVE WASTE

Three quarters of the people questioned thought they were not well informed on the subject in both surveys. Only between 2% and 3% of the public thought they were very well informed. From the questions included to test the knowledge of the individuals, they were generally accurate in their assessment of their low level of knowledge.

For example, in the 1998 survey each person was asked which Member State in his or her opinion produced the most radioactive waste. France was the first choice — but only by 24% of the people; Germany came second with over 20% (in fact, Germany was the first choice in the following five Member States: Denmark, Greece, Portugal, Spain and Sweden), equal first with France in Finland and only slightly behind France in the opinion of the French. The UK was first choice in the UK — and also in Ireland. However, over 40% of those interviewed replied 'don't know' to this question.

A further survey question asked how much radioactive waste was produced in the European Union each year per person. Four options were given: less than 1 litre; between 1 and 10 litres; between 10 and 100 litres; and over 100 litres. It should not have been a surprise that over 60% did not know. The first choice was between 1 and 10 litres and the second between 10 and 100 litres. The actual answer is somewhat less than 200 millilitres per year (even those responsible for the survey had to work this out using data from situation reports). Furthermore, the trend is decreasing and is now probably down to an average of 100 millilitres per year per person.

The large majority of people (75%) realize that there are several types of radioactive waste. However, an even greater majority (over 79%) believe that all radioactive waste is very dangerous.

4. WHAT IS DONE WITH LOW LEVEL RADIOACTIVE WASTE?

When asked what was done with low level radioactive waste, very few people — one person in eight — realized that the large majority of waste is disposed of by shallow burial. Even in countries such as France and the UK, where sites have been in operation for many years, less than one person in five identified this as a technique for disposal. An alarmingly high percentage believed that it is dumped at sea or exported to other countries. The latter beliefs probably result from the high publicity given to discharges from reprocessing plants and to some international movements of spent fuel for reprocessing in these plants. In the UK, for example, only one person in nine (11%) knew, or guessed, that it is disposed of in shallow or near surface facilities. Close to 30% think it is disposed of in deep facilities and 17% opted for it being disposed of at sea. Even in France, only 16% identified at or near surface burial as the technique used for disposal of such wastes, with nearly twice as many opting for deep disposal.

There was a significant 'don't know' response to this question (average 26%). While this might have been anticipated in States where the quantities of such waste are relatively small, such as those States without nuclear power prog-rammes, the fact that well over 40% of the people in Spain gave this reply was rather surprising, given the operation at El Cabril: 20% thought such waste was buried deep underground and only slightly fewer indicated it was dumped at sea.

Clearly, there is confusion in some States between what happened to the different waste types in the distant past, what is happening now and what is planned for the future. However, the question raised by this issue is this: should it really be a cause of concern? How many people know, for example, what happens to any form of non-radioactive hazardous waste in their country? On the other hand, how many industries face public acceptance problems because of the management of such waste?

5. TRUSTED SOURCES OF INFORMATION

Asked who they would turn to for further information or trust concerning how radioactive waste is managed in their own country, average Europeans were divided among independent scientists (32%), non-governmental organizations (31%), government bodies (29%), waste agencies (27%), with the media (23%) and international organizations (22%) also playing a role. Relatively few people appeared to trust the European Union (although they were not asked to define who they thought represented the European Union on this issue). The nuclear industry was the least trusted source of all with only 10%. Multiple answers were possible so the percentages add up to more that 100 in some cases and well below 100 in others. There was considerable variation, with Swedes trusting most sources and Italians trusting hardly anybody!

Respondents from Sweden, for example, had a high level of trust in their national waste management agency (60%) and over 36% trust the nuclear industry in general. The large majority also trust non-governmental organizations (70%), the media (55%) and government (52%). Over 40% of the respondents from Germany trusted their waste agency, though only 10% trusted the nuclear industry. Possibly the most difficult numbers to explain came from Denmark, where 45% trusted their waste agency while only 25% trusted non-governmental organizations. It also came as a surprise that there is more trust in the nuclear industry in Ireland (14%) than in France (11%). Spain had the lowest level of trust in its waste management agency (14%). Portugal had the lowest level of trust in non-governmental organizations (19%). Italy had little belief in its media on such issues (17%) and even less in independent scientists (16%)!

It is interesting to note that nearly 10% of the population spontaneously said they did not trust anybody to give them information about radioactive waste and an additional 10% said they did not know who to trust.

The picture changes quite significantly when asked who can be trusted for information about how waste is managed in other States within the European Union, though independent scientists (27%) are still the most popular source followed closely by non-governmental organizations (26%). However, while close to 30% would trust national governments for information on waste in their own country, only 10% would rely on them for information about waste in other Member States. There was also less reliance on information given by the media (down to 17%) and waste agencies (14%). On the other hand, it was pleasing to note that the trust in the European Union was greater — increasing to over 20%. Still very few people trusted the nuclear industry (8%). Again, 10% trusted nobody and the 'don't knows' increased to 20%.

Regional variations followed a similar trend to those in the previous question. However, rather surprisingly, the Irish had a higher level of trust in the information from the nuclear industry than the British, alhough the difference was admittedly very small (10% in Ireland compared with just below 9% in the UK).

The international organizations working on peaceful uses of nuclear technology were trusted by a little over 20% of the population for information on waste management both inside their country and in other States.

6. ACCURATE REPORTING

When respondents were asked if they thought the media was fair in its reporting of nuclear issues, there was a fifty-fifty split. The Irish had the greatest faith in their media, with 80% thinking the reporting was fair. The Danes were also ready to believe the media (66%), with the UK not that far behind (63%). The Italians had the lowest opinion of the accuracy of the media with only one person in three thinking it reports fairly.

Less than 20% thought that the nuclear industry was open in its reporting, while almost 70% said it was not. This is a very worrying statistic. Among the public, there is a low level of belief in what the nuclear industry says. In spite of the industry's efforts in recent years, the public's impression is still one of secrecy and cover-ups in most States. However, once again there is significant regional variation. While only 12% of Italians thought that the nuclear industry was open in providing information, over 46% of the people in Sweden agreed that the industry in their country was. It might not be unreasonable to assume that this is because Sweden is probably the Member State with the strongest industry/public interaction in the nuclear sector, and a leader in public involvement in the various consultation processes. Of the other States, industry is viewed as open by more than 30% of the population only in Finland and the Netherlands.

7. SOME INTERESTING PERCEPTIONS ABOUT NUCLEAR ENERGY IN RELATION TO OTHER SOURCES OF ENERGY

Before moving on to look at what people think should be done with nuclear waste, it is interesting to see the issue in the context of the public's current perception of present and future energy supply and the role of nuclear energy in that. The following results are taken from an even more recent Eurobarometer regarding European opinions on energy in general. This survey was conducted mainly in March 2002.

— Asking people how much of the electricity in their State was produced by nuclear energy gave some rather surprising results. Nearly one Austrian in five believes that 'nuclear' produces a significant amount of electricity in the country. The percentage is even higher in Luxembourg (36%), though the close proximity of a number of nuclear plants may explain this misconception. However, this is not likely to be the case in Italy where the majority of respondents thought 'nuclear' produced at least a 'medium' amount of their electricity. There was a surprisingly high percentage of 'don't knows', with 34% in Portugal and 30% in Greece. There were marginally more 'don't knows' in the UK (23%) than in Ireland (22%).
— Asked if it was true that over one quarter of the electricity generated in the European Union was from nuclear power, the majority agreed in all Member States. However, in several countries, especially those without nuclear plants, over 40% did not know. This was notably the case in Spain (43%) and in Greece (over 50%).
— Around 90% of those interviewed thought global warming and climate change were serious issues that needed immediate action. However, nearly half the people interviewed thought nuclear power made a significant contribution to climate change. Excluding the 'don't knows', this percentage rose to 63%. In fact, the majority of respondents gave this answer in most Member States (over 90% in Greece, close to 90% in Spain and over 85% in Portugal). This view was held by the minority in only four Member States: Sweden (23%), Denmark (30%), Finland (34%) and the Netherlands (43%).
— More people wanted additional information about nuclear power and radioactive waste (36%) than wanted more information about new energy options (27%) and how to save energy at work (13%). This supports the results of our 1998 survey on radioactive waste when over 80% of respondents expressed an interest in knowing about how radioactive waste is managed.

- The main source of information about energy was television (40%), followed by newspapers (23%) and radio (13%). All other sources, including the Internet, accounted for 5% or less of information.
- Over 30% indicated that new forms of energy and 'renewables' (including hydro) will provide most of the energy required in 50 years' time. Fusion (16%) was the second choice, followed by gas (14%), nuclear (12%) and oil (10%). Solid fuels came last with 3%. In every Member State, except Austria, fusion was identified as likely to produce more of the required energy than fission.
- It is interesting to note that the majority of people also thought that new and 'renewables' would be the least expensive form of energy by that time. Asked if they would be willing to pay more for such energy, the resounding answer was 'no'!
- Given a list of eight possible priority topics for government action, the majority of people identified food safety (52%), but this was quite closely followed by nuclear safety (50%) and then by management and disposal of waste (47%). A maximum of three answers was possible. Rather surprisingly was that road accidents (which result in thousands of deaths across the European Union each year) was only identified as a priority by 19%. Safety of oil and gas transport was identified as a priority by 16%.

There is a lot of other interesting information in this survey, but the above endorses the view that the public needs — and wants — more information about nuclear energy and its waste, and wants governments to give those issues a higher priority.

8. THE GREENHOUSE EFFECT — AND THE ROLE OF 'NUCLEAR'

In the energy survey, a lot of people thought 'nuclear' made a significant contribution to climate change. However, in the 2001 radioactive waste survey, a related question was also asked, but in the form of a statement which said "nuclear power produces less greenhouse gas emissions than other energy sources". In response to this statement, just over 40% agreed, slightly over 20% disagreed, but nearly 40% did not know! The latter percentage seems to be very high considering that the absence of emissions is one of the major benefits of nuclear energy.

At first glance, these results might seem to be in conflict, however, it is not too difficult to find an explanation in the different wording of the question. It appears that 'nuclear' is seen by the majority as making a significant contribution to climate change, but that it contributes less to the greenhouse effect than, for example, fossil fuels. Given the concern with which the public regards climate change, the benefits from the use of 'nuclear' might need to be better explained in future.

9. HOW CLOSE WOULD YOU LIVE TO A REPOSITORY?

In 1998, people were asked what the minimum distance was that they would like to have between their home and a place where there was radioactive waste. The results produced no major surprises. Fewer than 1% would live within 1 kilometre of radioactive waste, less than 4% within 10 kilometres and less than 20% within 200 kilometres. Close to half wanted a minimum distance of 1000 kilometres. However, even for this question there were significant regional variations. For example, around 40% of respondents from the Netherlands were ready to live within 100 kilometres of the waste, while fewer than 3% of respondents from Greece were.

10. NATIONAL OR REGIONAL REPOSITORIES?

In both surveys, respondents were asked if they thought each State should have its own repository or if there should be regional (i.e. shared) repositories. In 1998, 75% opted for national disposal while 12% chose regional repositories and 13% did not know. These numbers had changed by 2001 to 63% and 18%, with a higher percentage (19%) of 'don't knows'. It is not clear why this change has occurred, as the questions were very similar. Denmark and the Netherlands were the States most favouring regional repositories (with over 40% of those expressing a view in favour). In Greece, Italy, Portugal and Spain over 80% of the respondents were in favour of each Member State disposing of its own high level waste.

It is interesting to look at the actual numbers here. Of 1000 people interviewed in Greece, 728 thought that each State should dispose of its own high level waste. In Sweden, the number was almost exactly the same (722). In France, the number was slightly less (687). It might have been expected that Finland, in many ways the Member State most advanced in its planning for a disposal site, would have been close to Sweden and France, but there the number was down to 603. This was very similar to Austria with 609. The Member States where the fewest people favoured national disposal sites were Denmark (528), Ireland (521) and the Netherlands (481). This may be because the two non-nuclear States and the States with the smallest nuclear programme in the European Union did not want to have the major cost of constructing a repository for their small or very small quantities of waste. However, in this case, why the big difference with Greece? Why is Austria so similar to Finland? There are more complex factors at play here that might be explored.

11. WHY HAS HIGH LEVEL WASTE NOT BEEN DISPOSED OF?

When respondents were asked why they thought high level waste had not yet been disposed of, nearly half of them (46%) said because there was no safe way to do it. Not surprisingly, it is in the more anti-nuclear of the States (such as Austria and Ireland) that this percentage tends to be highest. However, rather surprisingly, it is a view held by close to 50% of respondents from Sweden and over 50% of respondents from France. On the other hand, only around 20% believe that the delay was caused by the authorities carefully assessing all the risks before taking a decision, and a similar percentage believe that a decision might be politically unpopular.

As many as 90% of respondents thought that the lack of a decision on how to dispose of the high level waste had a negative impact on the image of nuclear energy.

12. DO YOU AGREE THAT …?

In the 2001 survey, a number of statements were made and respondents were asked if they agreed or disagreed with those statements.

The following statement concerned keeping the nuclear option open: "If all the waste is safely managed, nuclear power should remain an option for electricity production in the European Union." Just over 50% agreed with this statement, while only 25% disagreed and the same percentage did not know. So, of those expressing a view, two out of three were ready to keep the nuclear option open. This 2:1 ratio holds for many Member States and rises to over 3:1 in Belgium, Italy and Sweden. In fact, in only one Member State (Austria) was there a majority against keeping the option open. In some States, the 'don't knows' formed a significant percentage of the response. This was particularly the case in Portugal and Spain (over 40%), as well as Ireland (37%). On the other hand, in Denmark, Finland and Sweden, the 'don't knows' dropped to around 10%.

To another statement, "the generation using nuclear power should be responsible for dealing with its waste", it may come as no surprise to know that

80% agreed with this while only 7% disagreed. There was a 13% ‘don’t know’, with again the Iberian Peninsula accounting for many of these while the Scandinavian Member States had by far the smallest number. If such a response comes as no surprise, it would be interesting to try and explain why so few States are not really doing anything about taking decisions on the long term management of their waste.

Finally, in 1998, respondents were asked if they would feel reassured if the European Union was to set the rules for the processing and safety of radioactive waste: 68% of those interviewed (76% of respondents) replied positively as opposed to 22% (24% of respondents) who replied negatively. In fact, in all Member States there was a majority of respondents in favour of the European Union setting the rules. There were significant variations ranging from a very small majority in Denmark (50.2% compared with 49.8%), a small majority in Germany and Austria (57% compared with 43%), to a very large majority in Italy (94% compared with 6%) and Spain (92% compared with 8%). For this reason, strong public support for the new nuclear package is clearly expected.

13. THE KEY MESSAGES

The present summary of three Eurobarometer surveys does little more than present a snapshot of the opinion of the public on nuclear waste, in particular radioactive waste, in the European Union. There is an enormous quantity of information that could still be analysed in more detail. It is recommended that individual Member States examine their own data to better understand the views of their own public.

However, even at this relatively superficial level, some conclusions can be drawn:

- The average European is worried about radioactive waste.
- The average European knows very little about radioactive waste and how it is managed.
- The average European wants to know more about radioactive waste.

There are some strong regional variations, with the north-eastern region of the European Union being the least worried and the best informed. Southern Member States are often more worried and less well informed.

This is not to say that simply informing people will reduce their worries or change their views. What is particularly important is the quality of the information and the way it is made available. In Finland and Sweden, the public have been extensively involved in debate and discussions about radioactive waste over a long period. Many have also played a role in the decision making process.

Two observations can be made:

— Waste management agencies are trusted sources of information in some countries, but not in all.
— The nuclear industry is trusted by very few people.

There is some indication that waste management agencies appear to be most trusted in those Member States where they have spent time in contact with the public. They are clearly regarded as separate from the nuclear industry as such. Some agencies might make more effort to be involved in the nuclear debate with the public.

The industry, unfortunately, still seems to be linked in the public's mind to a culture of secrecy and cover-ups. Openness and transparency are the keywords here, although gaining trust will still take many blemish free years.

A further observation to be made is the following:

— A solution to the waste issue is a vital step in public perception.

The European Commission believes that finding a solution to the waste issue, in particular, high level and long lived waste, is vital. This is equally true regardless of whether the nuclear option is to be closed or to remain open.

While the technology exists for safe disposal of such waste, it is a very common belief in the European Union that no solution has been found. Only a minority of the public realize that the main problem is more a question of making difficult policy decisions. The public would like to see progress made in this area. Continuing failure to make significant progress endorses the public's present view and has a major influence on the overall perception of nuclear energy.

MEDIA PERSPECTIVES ON THE RADIOACTIVE WASTE ISSUE

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I'd like to thank the organizers of this conference for inviting me to speak to you today. At least, I think I'd like to thank them—because looking around, and looking at the programme, I see I am the only journalist up here on the platform. At first I thought I must be terribly important but then I realized that my role here is more like the coconut in the coconut shy at the funfair. It is impossible for proceedings to continue without me, but I should be prepared to take a few knocks along the way.

I know that many of you follow the precept of the radical African American leader Malcolm X. He said: "If you are not part of the solution, you are part of the problem." And for many here, the media is a very large part of the problem. It is almost axiomatic that the development of technical solutions to the problem of the long term disposal of radioactive waste has been blocked in many countries by public opposition. And many people in what might be loosely called the nuclear community blame people like me for stirring up, even creating, an irrational opposition to safe and adequate proposals for handling waste.

I'm not here to defend the media, or even my particular part of the media, that is, television news. I have my own criticisms of the reporting of risk issues in general, and the issue of radioactive waste in particular. More of that later. But I do not believe the media has created or sustained opposition to the disposal of radioactive waste. There are, I contend, other well founded reasons for this opposition.

But before I try to elucidate those reasons, let me add to what you have just heard about the state of public opinion. I would like to draw your attention to the results of a very recent sounding of opinion in the United Kingdom. They come from a survey carried out with focus groups — the kind of groups politicians use to test their policies. The survey was carried out for the UK Government's Department for Environment, Food and Rural Affairs, as part of a public consultation on how the disposal of waste should be governed.

Researchers with eight different focus groups in different cities in the UK guided their discussions and noted attitudes to the issue. Their report said that radioactivity in general was poorly understood, that awareness of radioactive waste was low, and that understanding was slight and often inaccurate. People's fears centred on the possible effects of leakages and explosions including, after 11 September 2001, those caused by terrorist acts. People thought that the reprocessing industry should be abandoned immediately and nuclear power generation stopped as soon as alternatives came to fruition. Waste should be stored securely but retrievably on-site to avoid risks involved in transporting it.

Whatever you may think of this as a strategy, I would like to draw your attention to the general ignorance that the survey revealed. Because that presents me with one of the constraints which rules my life. In two ways. First, in writing any report on these matters, I have to explain words and concepts that have become second nature to most of you. But secondly, and more importantly, this ignorance is reflected among the people who decide what goes into a television news bulletin or into a newspaper. Few of those people have any technical or scientific background. That affects the kind of stories they want to see in their publications. I have forgotten the number of times I have had to convince a senior editor that a planned routine discharge of radioactive waste from Sellafield does not mean that the world as we know it is coming to an end.

It also influences how editors decide how a story should be covered. Whether, for example, it should be covered by a specialist reporter like me who has a slight knowledge of the subject matter, or by a general reporter who might have no knowledge at all. Or how much needs to be explained to the viewer or reader and in what depth.

But there is a further, and increasingly more important, constraint and that is time. This determines how journalists operate in two ways. At the beginning of the process it determines how much research can be done before the story is written. Increasingly, journalists have less and less time for this kind of preparation.

Let me give you one example. Some weeks after the attack of 11 September 2001, a plane crashed leaving New York. The immediate thought in the minds of journalists was that this could be another terrorist attack. The television network that I work for, with the largest audience in the UK, decided to abandon its usual programmes and switch immediately to open-ended coverage of these events. Within ten minutes of the crash in the United States of America, we were on air broadcasting pictures of the wreckage from our US affiliates. Within 15 minutes, I was in a studio broadcasting live, trying to identify why the plane had crashed. It was impossible to do anything more than speculate. At the time, the wreckage suggested to me, after covering many previous plane crashes, that there had not been an explosion and that the crash was probably not a terrorist act but an ordinary plane crash. Events later proved this to be correct.

But the point I am making is not to blow my own trumpet, but that I had practically zero time to research and prepare what I was saying. In these circumstances, we have to recognize, and tell the viewers or readers, that we are basing what we say on guesswork — educated guesswork derived from what we can see with our own eyes with the help of experience.

We also have to recognize that mistakes are inevitable. Indeed, at one point, I told viewers that the wreckage did not have the typical pattern of metal that had suffered an explosion — of being bent outwards around the fringes of a hole. This is known as petiolation, because it looks rather like a flower. Unfortunately, I told viewers it was called exfoliation — which has nothing to do with flowers or metal but is a beauty treatment for the skin.

This kind of instant journalism is becoming more and more typical. It's made possible by the massive expansion of satellite networks which makes it possible to bring pictures into a television studio from almost anywhere in the world in a matter of minutes and to transmit them to viewers around the world almost instantly.

There are, for instance, five continuous 24 hour news services available in English to viewers in Europe: Euronews, CNN, BBC, Sky and ITN. The competition to be first on air with a story, especially with pictures, is immense. Much as I would like to take half an hour to carry out some research before appearing on air, that is not an option available to me. In the event of a major nuclear event on the scale of Chernobyl, for example, I would be on air within five minutes.

Indeed, as an aside, here in Vienna while preparing for this conference, I have been on air twice on our 24 hour channel, talking about the scientific background to the dossier that was delivered here to the IAEA from Iraq and about the background to the inspections taking place now in that country. I had only a few minutes to prepare those contributions over the mobile phone to my studio in London.

But there is an up side to these developments in broadcasting news: 24 hour news channels by definition have a lot of air time to fill. Yesterday, if any of you watched CNN, you would probably have seen a story about an English nobleman advertising in the newspapers for a wife. It's what we call a filler. And these fillers provide an opportunity.

A few weeks ago, for example, the 24 hour channel I work for broadcast a report I did on the decommissioning of the prototype Advanced Gas Cooled reactor at Windscale. I spent a day at the plant, being briefed by staff involved in decommissioning, and filming various parts of the process. At the end of that process, intermediate level waste ends up in special concrete boxes. I was able to demonstrate the safety of these boxes in the report by standing next to them with a dosemeter showing a zero level of dose being received.

This kind of reporting provides an opportunity to tackle the lack of knowledge among the general public about radioactive waste and how it is handled away from the hothouse pressures of an immediate incident or event.

Time is also a constraint on journalists in another way. Our reports are inevitably short. The average report I do is probably just under two minutes long. That's about 300 words. You have already listened to four times as many words during this talk. At first sight, it might be attractive simply to make news programmes longer. But there seems to be a more or less direct relationship between length and the number of viewers. Hour long news programmes in the UK attract at best about 5% of viewers. Half-hour bulletins get audiences of about 30%.

Indeed, most people in most countries now derive most of their knowledge of news events from television news. The figures vary from survey to survey, but fairly consistently show that about 70% of people see television news as their main source of news. Newspapers, especially the more serious newspapers, can devote much more space to their coverage. They could, for example, print the whole of this talk on their features pages. But their audience figures again are small: about 5% and not every reader will read a particular article.

So I would argue that if the public's lack of knowledge is to be tackled, there must be at least some input into that process through the popular media on which many of them rely.

That makes it all the more important to understand how stories are selected for the popular media — how do editors pick items to appear in news programmes? The first factor is that there should be an event — a plane crash, a demonstration, a battle, a terrorist attack, a parliamentary debate, a scientific publication in a journal or whatever.

Secondly, the event should have particular characteristics. It should be unexpected. It should pass the 'what' test. Many of the most memorable news stories are memorable precisely because of their unexpectedness, for example, the attack on 11 September 2001 or the assassination of John F. Kennedy. They should also be amazing — they should pass the 'wow' test. The landing of a man on the moon was hardly unexpected but it was amazing and that's why it was headline news.

Thirdly, they could be a close relative of amazing — and that is quirky or funny. The English lord advertising for a wife, for example. The paradigm of this kind of story in England is the skateboarding budgie: a story about a budgie that could skateboard. I work for the network that broadcast this story and another about a dog that could drive a car (well at least steer a car), and let me tell you these stories are often the ones that viewers remember long after they have forgotten more important reports.

And lastly, stories should affect as many people as possible. It has become almost a golden rule of television news that stories should have a human face — should, whenever possible, be seen through the eyes of the people they affect. So nowadays almost every health story has an interview with a patient who has taken the treatment which is the subject of the report, to explain how it works for them.

Putting all these factors together might make what we imagine to be the best possible story in the field of radioactive waste. How about "Thousands ill after eating black pudding contaminated by Sellafield leak"? Or "Sellafield cats glow in the dark"?

Or "Thousands to develop cancer after nuclear explosion". Well, that one actually did happen. It was called Chernobyl. And I raise that not only because Chernobyl was an important event in itself but because it is also what I call a 'conditioning event'. That is, it shaped or conditioned public opinion for many years to come. You can tell that simply because almost everyone remembers the name and will bring it up sooner or later in any discussion of radiation risks.

But why was it so important? I think it's because it summed up many people's fears about the nuclear industry. Not only because of the potential for large scale damage (that's true of other industries as well) but also for two other reasons. Firstly, it typified the secretiveness of the industry. The disaster was revealed not by the Russians but by monitoring at a Swedish nuclear station. It was extremely difficult to find out what had happened and what the consequences might be.

Secondly, it demonstrated the laxness of regulation and the lack of accountability of the industry. Of course, the then Soviet nuclear industry was far from typical of the nuclear community worldwide, but these elements of secretiveness and lack of accountability reinforced the image of the industry in other countries where civil nuclear power had its origins in the secret world of nuclear weapons. The lesson that many people learnt from Chernobyl was that you can't trust the nuclear technocrats.

Let me quote here. This is from Professor Brian Wynne of Lancaster University, who has followed the debate on radioactive waste since the planning inquiry into the building of the thermal oxide reprocessing plant at Sellafield in 1977. He is also a member of the prestigious Royal Society's Committee on Science in Society. He says: "The widespread public mistrust of scientific inputs to policy decision-making on issues involving risks has been long acknowledged as perhaps THE defining issue for resolving the paralysis which besets long-term radioactive waste policy" and goes on to say that this mistrust is "a public response to a history of failed institutional performance and not to misperceived risks".

In other words, public mistrust is based not on what people read in the newspapers or watch on television — however mistaken that may be — but on their distrust of the controlling bodies in nuclear matters which they see as secretive, unaccountable and lacking strict regulation. I don't go all the way with Brian on this. I think, for example, the abysmal lack of basic knowledge does lead to misperceived risks and that this does have some influence on public opinion.

But whatever you or I may be able to do to diminish that ignorance will be of no avail unless bodies, national and international, become more open, more accountable and more openly regulated — and unless they take seriously the debate on stakeholders and how they can be genuinely involved in decision making. The honesty of that involvement is best judged by the openness of the bodies concerned in the final decision. What that means is that you may not like the decisions reached but agree to abide by them even if you think they are wrong. Of course, the same responsibility devolves on the stakeholders too.

In this context, I'd like to conclude by drawing your attention to an excellent example of that process in action. And that is the example of Nirex Limited in the UK, which manages plans for the long term disposal of radioactive waste. But to understand this example fully, a little history is needed.

Back in the 1980s, Nirex, then as now a body controlled at board level by waste producers, proposed I think it was six sites as repositories for low level waste. There had been little open public consideration. People living near the sites objected vociferously. Technical objections were raised. Non-governmental organizations campaigned long and hard against the proposals. Eventually they were shelved. Then there were proposals for deep rock disposal for more active wastes, eventually focused on the Sellafield site. Much the same happened. Again the plans were shelved.

The current position in the UK is that there are 10 000 t of solid long term waste in storage awaiting a decision on its long term future. In the next century, as nuclear reactors are decommissioned, the amount of waste will rise to 500 000 t. The Government is currently in the process of setting up an independent body to advise on a process of public debate involving stakeholders backed up by research. The Government will make a decision in 2006 which will begin to be implemented after another round of public consultation, in 2007. It is widely expected that Nirex, perhaps reconstituted in some way, will be at the heart of this process.

But Nirex has already started along this road. If you look at its web site on the Internet, you will find, for example, a policy statement on transparency which starts by saying that Nirex strives to be transparent and accountable in all its activities. Its Board, it says, is committed to a policy of openness.

Of course, if you are a journalist, you regard such fine words with an element of necessary scepticism. How open is ‘open’? Well, Nirex goes on to say, it provides access to most of its documents except when they cannot for legal or commercial reasons. But, asks the journalist, how do we know you are not keeping documents secret for the wrong reason? Well, Nirex tells us, you can appeal to a review panel. Aha, says the journalist, and how independent is that? Well, it publishes an independent annual report into appeals it has examined and into the working of the transparency policy. And it has an independent Chairperson who has an impressive track record in government and independent organizations which are active in human rights and consumer issues.

In other words, at every step, the policy on transparency is itself accountable and open. Nirex seems to have genuinely taken on board the need for openness, not as a virtue to be lauded but as necessary to developing a process that will in the end lead to decisions about radioactive waste that are acceptable to the public. *Not* because some technocrat says they’re acceptable, but because the public has been intimately involved along the way. Nirex had learned the lessons of history.

But how does all this affect the media? I think it will have a profound effect. First of all, because media coverage in the past, which many people in the industry saw as negative, was fed and sustained by the secrecy of the industry. Nothing attracts a journalist’s attention as much as a secret. Some years ago now, I was told by workers at Sellafield of an incident involving, they alleged, the spillage of radioactive material in a particular building there. Nothing was published about this incident and because of the track record of secrecy of British Nuclear Fuels plc (BNFL), I was perfectly willing to accept, at least as a working hypothesis, that it had been covered up. They also told me of irregularities in the wearing of film badges, which meant that workers were cheating and falsifying their records to stay in more profitable jobs involving further exposures.

We broadcast a report listing these allegations. They were investigated, the first not substantiated, the second upheld. More bad publicity for Sellafield.

The point I am making here is that it was my judgement about the secrecy at Sellafield which encouraged us to report the allegations. If the same spirit of openness that I’ve described at Nirex now had existed at Sellafield then, I don’t think those reports would have been broadcast. Not only because I would have trusted the BNFL more, but also because, one hopes, reports of these incidents would be available from the company for me to check.

Secret organizations get bad press. Organizations that do not actively dispel secrecy in areas of public concern get worse press.

But I also think there's another reason why the example of Nirex will affect what I do. And that is simply that they are using the greatest technological advance of the past two decades — the Internet — to great advantage. In this context, the Internet is a vehicle for making public information that would otherwise be extremely difficult, even financially impossible, to release. If only the Iraqis had put their declaration on the Internet, we wouldn't have the spectacle of some poor soul in the United Nations trying to photocopy 12 000 pages of documents.

In the process of making information available, bodies like Nirex are doing two things. They are establishing a direct contact with non-governmental organizations, local objectors, indeed with the public, without having to pass through the refracting prism of the media. They are talking direct to many with whom previously they could not talk.

And they are undercutting any suspicion that journalists may have about their openness, as well as providing a research tool to journalists who really want to back up their stories.

An industry that is striving for openness and transparency, and can convince journalists that its attempts are genuine, is an industry that will, at best, avoid negative coverage and at worst, establish the foundations of trust that are needed to counter-attack negative reports effectively. There's an old saying in the UK: 'familiarity breeds contempt'. In this case, I think that's entirely wrong. Here I think 'familiarity breeds contentment'. Satisfy reporters that you have nothing to hide and eventually they'll go away in search of some other scandal — whether it's royal butlers or the Prime Minister's wife buying a flat in Bristol.

PANEL

WHAT DETERMINES PUBLIC ATTITUDES? WHAT SHOULD BE DONE?

Chairperson: **J. Barceló Vernet** (Spain)

Members:
E. Atherton (United Kingdom)
D.M. Taylor (European Commission)
L. McGinty (United Kingdom)
B.-M. Drottz-Sjöberg (Norway)
B. Robinson (Environmentalists For Nuclear Energy)
Y.A. Sokolov (Russian Federation)

Panel Discussion

Y.A. SOKOLOV (Russian Federation): What determines public attitudes? They are determined by various factors, for each of which corresponding actions can be identified. Public attitudes towards nuclear power can be influenced by assurances of sustainable energy supplies, by demonstrations of the reliability and safety of the technology and by the attractiveness of its economic and ecological benefits.

There are no doubts about the potential of nuclear power as regards future sustainable energy supplies. The credibility of nuclear power management depends on the existence of a clear strategy, efforts focused on a limited number of options, and international co-operation. Optimization of the technology extending from the front-end to the back-end of the nuclear fuel cycle is essential. International co-operation is very important for achieving full development of advanced nuclear technologies within the constraints of available funding and is vital for creating positive public attitudes towards nuclear power.

Once there is agreement on the potential of nuclear power, a basis for a radioactive waste management strategy can be formulated as an integral part of the nuclear fuel cycle. The credibility of radioactive waste management policies suffers from the limited reliability of long term forecasts. Also, ‘keeping the radiological impact as low as reasonably achievable’ is a rather general objective. For public acceptance, it is better to be more specific. Comparing the toxicity of radioactive waste at the point of ultimate disposal with the ‘natural’ toxicity of the uranium that has been removed and used for power production can lead to qualitative requirements as regards the amount and composition of radioactive waste at the point of ultimate disposal (convergence in accordance with a ‘similar in nature’ principle). The local impact of radioactive waste disposal systems would probably be accepted by the public if they were based on a ‘similar in nature’ principle. For that principle to be satisified, the proper partitioning of radioactive waste and mobilization within matrixes exhibiting natural equilibrium properties and thus a stable status in geological formations are required when one is considering the ultimate disposal of radioactive waste.

E. ATHERTON (United Kingdom): At Nirex, we have considered the question: “What determines public attitudes?” and have concluded that public attitudes towards radioactive waste management are affected by, inter alia, the perceived legitimacy of the organizations involved in the debate, the way in which decision making processes are conducted (how transparent and inclusive they are) and the behaviour of those involved in the decision making processes (how respectful they are of others, how well they listen to the concerns of others and how they take those concerns into account).

Regarding the question "What should be done?", we have concluded that those responsible for radioactive waste management should, bearing those factors in mind, consult with stakeholders proactively, provide justifications for their own decisions and show how the stakeholders' concerns have been taken into account.

B.-M. DROTTZ-SJÖBERG (Norway): I shall focus on public expectations, as I think that they are among the key factors influencing attitudes and what happens in the public participation process.

I am pleased that the presentations of D.M. Taylor and L. McGinty gave a framework, because this framework, which E. Atherton also talked about, is important for understanding how the public perceives matters.

For many years, we discussed the concept of 'risk'. We have since taken a step forward; we are currently discussing the concept of 'stakeholder'. There seem to be at least two different views of what it means. A broader definition embraces almost everybody. However, 'the general public' is never a stakeholder. A narrower definition of 'stakeholder' is 'someone who has a clearly specified interest', and it is the definition which I like to use.

It is of great importance how you define 'stakeholders' and their roles and whether you are inviting stakeholders to participate in a decision making process or merely to contribute to it. If you are not very specific as regards what you are inviting them to do (their roles, what they are expected to represent and what their contributions are expected to achieve), there will be a lot of confusion in the following discussion. Implicit assumptions that are not fulfilled (for example, a belief that 'participation' means real influence and not just contributing to a discussion) could lead to a much more confrontational discussion than if you have made it clear that it means the provision of good input materials for subsequent decisions.

In line with this, I think that 'citizen' would be a better concept than 'stakeholder' if one is referring to participation by 'the public'. To a certain extent, it would clarify the roles that invited parties might be expected to play in a particular process. Also, it would point to the existence of a system of representation within a society that could help to guide the discussion. One should bear in mind that groups of scientists and other experts are not really in a position to invite people to participate in political decision making processes. They are sometimes seen as stakeholders themselves, and who is 'in charge' is an interesting discussion in itself.

Organizations inviting stakeholders in the broad sense of the concept should be prepared for a discussion different from the one planned; for example, they should be prepared for a discussion on questions such as what is to be on the agenda and who is representing what. Before issuing invitations, one should therefore consider how to prepare organizationally to meet the different expectations of the different actors in public participation processes.

So, before public participation or a ‘stakeholder’ discussion, it is important to clarify what the roles of those involved are to be — what those persons are expected to do.

A very good way of gaining an overview of the validity of participation processes is to look at the existing democratic representation system and to consider how it could be better used for participation discussions. In the past few days, we have heard that politicians should be more involved in ‘stakeholder’ discussions, and I agree with that.

B. ROBINSON (Environmentalists For Nuclear Energy) I should like to start by saying a few words about how the association of Environmentalists For Nuclear Energy (EFN), of which I am a member, tries to influence public attitudes.

The purpose of the EFN is to provide complete and straightforward information about the environment. Although barely five years old, the EFN already has almost 6000 supporters and members in over 40 countries.

Its principal vehicle is a book entitled Environmentalists FOR Nuclear Energy written (in French) six years ago. There have been many editions, including a pocket edition, of the book in French, and an English version (with an introduction by Professor James Lovelock, one of the founders of the modern environmentalist movement) appeared in 2001. Romanian and Japanese versions (the latter with an introduction by Y. Akimoto, a Hiroshima survivor) appeared earlier this year. Chinese, German, Italian, Korean, Russian, Slovak and Slovene versions are being prepared.

The EFN has a web site, www.ecolo.org, with pages in 14 languages. Also, it has a Communications Group of volunteer lecturers and writers. In addition, it produces an e-mail newsletter (in English and French).

In the EFN’s view, public attitudes are determined largely by the media, which ‘buy’ the sensational wares — biased, if not mendacious, statements — of anti-nuclear organizations which I regard as ‘merchants of fear’. After a while, such statements come to represent what is ‘politically correct’, and the media become afraid to say anything that is ‘politically incorrect’.

People working in radioactive waste management programmes tell the media that research is under way, and this suggests that a solution to the radioactive waste problem is still being sought. In fact, we know what the solution is, permanent disposal in geological repositories, and the purpose of the research is to refine the approaches to that solution. Here is a misconception which the media could, if they were willing, help to clear up.

D. BONSER (United Kingdom): Regarding the questions put to the Panel (“What determines public attitudes? What should be done?”), I think that we in the nuclear industry tend to talk in technical language about facts, whereas the people outside the industry who put questions to us, seeking assurance, tend to talk about feelings and ethical values. So there is, in effect, a language gap. What are the views of the Panel members in this connection?

E. ATHERTON (United Kingdom): In the past, most technical people believed that by writing an honest report they were making their information accessible. What we are realizing now is that the information in technical reports is not accessible to most people — that things like well illustrated leaflets written in plain, non-technical language are necessary.

When ordinary people from outside the nuclear industry engage in a debate about radioactive waste management, they draw on their everyday experiences in trying to make sense of something about which they know very little. In that situation, we need to discover the questions which they are really asking — as opposed to the questions which we initially think they are asking. So we need to listen carefully, trying to understand their feelings and ethical values, and then to answer their real questions — and to do so in the manner in which they want them answered.

That takes a lot of time.

L. McGINTY (United Kingdom): Further to what E. Atherton just said, I would like to give an example of how specialists can be wrong about what people want to know.

In the United Kingdom, the first substantial BBC and ITN reports on the Chernobyl accident were, first, reports by Moscow correspondents on what they had learned about the accident, then reports by science correspondents about what they thought had caused the accident.

As part of a research project, a friend of mine played the reports by the Moscow correspondents to about 80 school pupils aged 16 to 18 years and then asked them what they would like to know next about the accident. Almost unanimously, they said that they would like to know about the accident’s consequences; they were not very interested in what had caused the accident.

The science correspondents — the specialists in this case — were probably wrong in 1986 in their assumptions about what the general public wanted to know most about the Chernobyl accident.

C. THEGERSTRÖM (Sweden): The language gap referred to by D. Bonser is clearly an important issue, but ‘actions speak louder than words’ — a saying that we at SKB have found to be very true.

When we started the siting process, at the beginning of the 1990s, we stated that it would be based on the voluntary participation of municipalities. Initially we were not believed; there was a widespread feeling that, once a municipality started participating in the process, it would not be allowed to withdraw.

When local referenda in the municipalities of Storuman and Malå went against us, however, we withdrew within a few weeks. People then realized that we had been serious about the voluntary nature of municipalities' participation, which did a great deal for our credibility.

E. ATHERTON (United Kingdom): C. Thegerström just gave a good example of the fact that you must do more than simply say to people that you are listening to them — you must act on what they say. You must either take it into account or, if you do not take it into account, explain why you have not.

People do not want to take the decisions — that, they would rather leave to those in authority. However, they like to see that they have had some influence on the decisions.

B.-M. DROTTZ-SJÖBERG (Norway): I think that an important factor is how much trust the population of a country has in that country's social system generally, which may correlate with the extent to which the population participates in elections.

B.E. HEDBERG (Sweden): It is said that people get the politicians they deserve. I believe that they also get the journalists they deserve, and I was wondering how one might initiate a dialogue between us and the media.

L. McGINTY (United Kingdom): One of the problems is that scientific and technical organizations tend to talk only with journalists who are themselves specialists in the organizations' scientific or technical fields. They 'preach to the converted', arranging briefings and field trips for them. They need also to talk with people like general news editors, who decide what items will be included in newspapers and television and radio news programmes. That is not easy, as such people are very busy and tend to distrust scientific and technical experts.

Y. Le BARS (France): I believe that the public has greater difficulty in understanding radioactive waste management issues if closing of the nuclear fuel cycle is being contemplated. That was our experience, for example, at a seminar which we held near our underground research laboratory. I should like to hear the views of Panel members.

Y.A. SOKOLOV (Russian Federation): In my view, in the area of public understanding, much depends on need; when there is a real need, people learn faster. For example, Armenia's nuclear power reactor was closed after an earthquake although it had not sustained any damage. However, it was then reopened following electricity shortages during a severe winter; and the possibility of building a second reactor is now being considered. Or a further example, despite the Chernobyl accident, many regional and local governments are in favour of the construction of new nuclear power plants — again because of need.

As regards closing of the nuclear fuel cycle, I would say that the public is divided. For example, there seems to be little public opposition to the reprocessing of spent fuel from the Russian Federation's own reactors, but considerable public opposition to the reprocessing of spent fuel from reactors in other countries, which is now a possibility under recently passed legislation. In that connection, I would mention that the municipal authorities of Krasnoyarsk have agreed to plans for the enlargement of a spent fuel storage facility located near the city, but only on condition that the spent fuel will ultimately be reprocessed within the region, which they do not want to be simply a 'cemetery' for spent fuel.

J. BARCELÓ VERNET (Spain): In my view, before we really start talking about closing the nuclear fuel cycle, there must be public acceptance of deep geological disposal — the ultimate solution regardless of whether the nuclear fuel cycle is closed or not.

D.P. HODGKINSON (United Kingdom): The second of the two questions put to the Panel is "What should be done?"

In the radioactive waste management field there are a lot of intelligent scientists and engineers who are doing an excellent job but lack the skills necessary for communicating effectively with stakeholders. Perhaps one of the things which should be done is the provision for training in communication skills for such scientists and engineers.

E. ATHERTON (United Kingdom): Most organizations operating in the field of radioactive waste management have recognized that training in communication skills is important, and several of them, for example, SKB and Nirex, arrange for such training to be provided. However, still more such training needs to be provided and, in the long run, science education needs to change further, so that young scientists learn how to communicate regarding their special fields with non-scientists and understand the social and ethical issues associated with those special fields.

R. NOCILLA (USA): Before we decide what should be done, we need to know what determines public attitudes.

As regards Nevada, where I have lived for the past 40 years, my impression is that only people who have been intimately involved in activities relating to the nuclear weapons testing that has gone on there develop a real understanding of radioactive waste management issues. The vast majority of the public — employed mainly in service industries in Las Vegas — are concerned above all about when they will receive their next pay cheque. They read very little, and obtain information about things like ionizing radiation largely from hyperbolic sound bites and newspaper headlines referring to accidents. They are mentally lazy and do not wish to be involved in the taking of what they think could be wrong decisions, and when they learn about protesting activists they say: “Those people are protesting very energetically — they must be right.”

B.-M. DROTTZ-SJÖBERG (Norway): This raises the question of how minorities influence majorities. Research has shown how they do it. Persistence is extremely important, especially in the case of very small minority groups, some of which have been quite successful.

This raises the further question of who represents whom and that of the rules of the game in a stakeholder dialogue. Unless those questions are resolved, the dialogue is unlikely to lead to a conclusion.

So you must think not only about what you communicate but also about with whom you communicate.

D.M. TAYLOR (European Commission): I think we should distinguish between trying to influence the general public’s attitudes towards radioactive waste management and trying to gain local acceptance of proposals relating to a specific site. It may be possible to influence the general public’s attitudes through the media, but at the local level it is necessary for the radioactive waste management experts to engage in a detailed dialogue with the people living in the potential host community. Those people will have gone beyond relying entirely on the media for their information; for example, they will have been receiving input from non-governmental organizations skilled in communicating. So the radioactive waste management expert will need training in communication skills.

A. SIMCOCK (OSPAR Commission): I think the nuclear industry could learn a lot from the success of some major oil companies, for example, Shell, BP and Amoco, in changing the tone of the debate with stakeholders, especially since the *Brent Spar* incident.

The discussion here has tended to focus on solid waste. Clearly, some liquid waste can be converted into solid waste, but there will continue to be a liquid waste issue, with more numerous and more diverse stakeholders than in the case of the solid waste issue. I think the nuclear industry should look at what various other industries, including some of the major oil companies, have done about their liquid waste problems.

D.M. TAYLOR (European Commission): I agree entirely that liquid waste should not be ignored. Our surveys of public opinion in European Union countries suggested that the idea of radioactive effluent entering the sea was conditioning the views of many people, who thought of the effluent entering the sea without any control or limitation being applied.

R. HEARD (South Africa): There is currently, in South Africa, a public inquiry under way regarding radioactive waste management and also one regarding the pebble-bed nuclear reactor being developed in my country. Although the subjects are very different, newspapers write about disposal of the reactor pebbles in boreholes. Similarly, when a South African team went to Morocco in order to condition spent radiation sources from hospitals, we had newspaper headlines like “Chernobyl in the hospital”. How do the minds of newspaper subeditors work?

L. McGINTY (United Kingdom): Whatever industry involving risks you take (the nuclear industry, the chemical industry, the offshore oil industry), the scientists and engineers working in it complain of misrepresentation in the media.

The problem is that scientists and engineers — certainly those in the United Kingdom — do not have effective media lobbies, unlike many other professional groups.

Talking to the media is something which has to be learned, through training. I recently helped to conduct a media training course for government scientific advisers who were deceived by the simplest media trick, that of leaving the microphone on after what they thought to be the end of the simulated interview; they said to the interviewer things which they would never have said if they had thought that the microphone was still on. A politician would never have been deceived by that trick.

There are several companies which organize media training.

C. THEGERSTRÖM (Sweden): In my experience, the public at the local level likes to talk with the scientists and engineers responsible for projects rather than with professional communicators sent out to explain about the projects — but the scientists and engineers need to be trained in communication skills.

However, it is possible at the local level to get one’s message across through ‘allies’ other than professional communicators, for example, general medical practitioners and district nurses. If one gains their confidence, for example, during visits to one’s facilities, they will spread the word. However, one should remember that gaining public confidence takes a lot of time, whereas one can lose it in a few seconds.

A.A. ERASTOV (Russian Federation): It has been said that the history of nuclear power has been a succession of unpleasant events. However, one could say the same thing about the history of humankind generally. It would seem that particularly rigorous safety demands are made of the nuclear industry. For example, calls are constantly being made for an end to be put to the shipping of spent fuel and reprocessing waste between Japan and Europe, whereas there are no calls for an end to be put to the transport of petroleum by sea when an oil tanker breaks up off the coast of Spain and causes massive pollution. Although no accidents have occurred during the shipping of spent fuel and reprocessing waste between Japan and Europe, there will no doubt be opposition to the transport of spent fuel by sea to the Russian Federation for reprocessing.

K. SULLIVAN (Educators for Social Responsibility): I think the nuclear industry needs to appreciate the difference between public acceptance and public participation in decision making. It needs to make up its mind whether, on one hand, it simply wants to persuade the public to accept what it is doing or, on the other, it wants the public to participate in the taking of decisions aimed at solving the problems of radioactive waste management.

Times have changed, and people now want to participate in decision making processes rather than merely accepting what is offered to them.

D.M. TAYLOR (European Commission): I do not think that such a clear distinction can be made between public acceptance and public participation.

When the nuclear industry in a country is looking for a site for a radioactive waste repository, what it wants is public acceptance, which may be achieved through public participation in a dialogue. The nuclear industry is not going to initiate a dialogue for its own sake.

We must be honest and admit that, for the nuclear industry, public participation is hopefully a step towards public acceptance.

B.-M. DROTTZ-SJÖBERG (Norway): I would add that one aim of involving the public in the decision making process should be to arrive at a better decision.

L. McGINTY (United Kingdom): In a dialogue or a decision making process regarding a site for a radioactive waste repository, the participants will include — at the very least — local stakeholders, environmentalists and the nuclear industry. The local stakeholders will have their own preconceptions and objectives, while the environmentalists may well want to prevent an expansion of the nuclear industry, which must not, however, enter into the dialogue or decision making process saying: “Of course, there is no question of the decision going against geological disposal.” If it does that, the other participants will probably just walk away.

Y. Le BARS (France): In dialogues or decision making processes regarding radioactive waste management, one talks about the risks associated with low radiation doses. I have found it very difficult to discuss those risks with the public — far more difficult than discussing, for example, the risk of flooding in a given region.

On France’s Cotentin Peninsula, where the La Hague reprocessing facility is located, we have tried to make people more aware of what radioactivity is, how one measures it, what its effects can be and so on, but much more educational work of that kind needs to be done.

B.-M. DROTTZ-SJÖBERG (Norway): I should like to see the scientific community doing something at the international level to make risks more comprehensible.

M.V. FEDERLINE (USA): In the United States of America, the US Nuclear Regulatory Commission is a stakeholder separate from the US Department of Energy, but it is difficult to get that across to other stakeholders, who tend to lump the two agencies together and not to know what to expect from the consultation processes in which they are invited to participate. It is very important to establish and maintain clarity regarding the roles of the different stakeholders in such processes.

J. BARCELÓ VERNET (Spain): It is sometimes very difficult to talk with stakeholders as they are very badly informed — like the 20% of Austrians who, according to D.M. Taylor, believe that nuclear power is produced in Austria.

A. ZURKINDEN (Switzerland): In my view, a problem of dealing with the media is that media people seem to prefer reporting bad news to reporting good news.

L. McGINTY (United Kingdom): Media people do prefer reporting bad news to reporting good news, largely because the public prefers reading or watching bad news. Some time ago, a television programme series based on good news was transmitted in the UK, but almost no one watched.

In order to get one's message across at the local level, it may be better — as suggested by C. Thegerström — to talk with people like general medical practitioners and district nurses than with journalists, who are less likely to be believed.

B.-M. DROTTZ-SJÖBERG (Norway): I think that in this context we should bear in mind an important difference between, on one h`and, opinions and, on the other, beliefs. People's opinions — easily influenced by the media — may well be negative, but they are usually short lived. People's beliefs are rooted in value systems which can be influenced only by prolonged dialogue, and if they do change in due course, that may well not be immediately reflected in opinion surveys.

T. FLÜELER (Switzerland): The European Commission is preparing a directive which will require member states of the European Union to have radioactive waste repositories in place by 2018. In my view, this requirement will not be met — with a consequent loss of credibility.

D.M. TAYLOR (European Commission): The Commission realizes that the envisaged 2018 deadline will be controversial, but the draft directive will have to be agreed upon with member states, which may change that deadline.

Some objectors to the envisaged 2018 deadline are saying that Finland took almost 20 years to reach the point where it is now, but the directive will require other member states to have selected a site by 2008 and to have authorized repository construction by 2018. The Commission's response is to point out that some of the objectors have been producing radioactive waste for about 50 years — plenty of time in which to find a disposal solution.

The Commission hopes to convey, through the directive, a very strong message: “You are already late.” Proposing a deadline later than about 2018 would enable politicians to think: “That’s four to five parliaments away. There’s no need to worry yet.”

T. FLÜELER (Switzerland): When I talked about loss of credibility if the 2018 deadline is not met, I meant a loss of credibility for the nuclear industry, which needs time for a dialogue.

D.M. TAYLOR (European Commission): In the European Commission’s view, there will be meaningful dialogue only after a particular site, locality or region has been focused on, which will happen only if a fairly tight deadline has been set.

B.E. HEDBERG (Sweden): For a dialogue to be successful, the participants must not only listen to one another but also allow themselves to be influenced by one another’s arguments — perhaps to the point of changing their positions.

E. ATHERTON (United Kingdom): I agree.

C. THEGERSTRÖM (Sweden): It is difficult to conduct a dialogue and try to build confidence when a deadline has been set. For example, feasibility studies — accompanied by dialogue and confidence-building — which we had expected to take one and a half years finally took eight years, at the end of which imminent elections meant that we might soon have to be dealing with new municipal councils. We had to push very hard in order to meet the deadline.

J. BARCELÓ VERNET (Spain): But in Sweden the siting process has started. In a lot of countries it has not.

G. COLLARD (Belgium): Regarding the 2018 deadline, around that time there will probably be a need for new nuclear power reactors in order to meet the demand for electricity. Recalling what Y.A. Sokolov just said about need, I can imagine that the reactors will be built and put into service even if the radioactive waste management problem has not been solved and that the nuclear industry will say that it has 50 years in which to solve it. I hope that by 2018, at least one repository will have been built, so that nuclear power generation can be regarded as a challenge rather than as an adventure.

B.-M. DROTTZ-SJÖBERG (Norway): If there is going to be a need for new nuclear power reactors around 2018, I think it will be important not to spring that need on people suddenly, but to keep them informed so that they can draw their own conclusions about the need.

INVOLVING STAKEHOLDERS IN DECISIONS ON THE SITING OF RADIOACTIVE WASTE FACILITIES

(Session 9)

Chairperson

M.V. FEDERLINE
United States of America

NATIONAL EXPERIENCES IN SITING WASTE MANAGEMENT FACILITIES IN SWEDEN

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1. INTRODUCTION

It is now more than 25 years since a co-ordinated nuclear waste management programme was set up in Sweden. Deep geological disposal of spent nuclear fuel in crystalline bedrock is the preferred option and an extensive R&D programme has been performed. A stepwise approach is being applied to development, technical demonstration and implementation of the disposal system. Siting related experiences within the Swedish programme encompass the following:

— Deep drilling programme at 11 study sites (1977–1985);
— Siting of the intermediate storage facility for spent fuel, CLAB (1976–1979);
— Siting of the final repository for low and medium level waste, SFR (1980–1983);
— Siting of the Äspö Hard Rock Laboratory, HRL (1986–1990);
— Feasibility studies to site a deep repository for spent fuel on a voluntary basis in eight municipalities (1993–2001).

Site specific investigations for the deep repository in two of these municipalities were started early this year (2002) following a clear majority vote within the concerned municipality councils in favour of further participation in the siting process.

The past record of siting related activities in Sweden includes a wide variety of experiences. There are failures as well as successes, shortcomings as well as accomplishments. A general trend is that siting activities have gradually become more and more demanding. CLAB and SFR, 15 to 20 years ago, could be quite easily sited in a process of a few years, involving mainly the Swedish Nuclear Fuel and Waste Management Company (SKB), safety authorities and the directly concerned municipality. The siting of the deep repository has already been going on for some 10 years and it involves, on a much broader scale, many sectors of society and the interested public.

A clear division of responsibilities between the stakeholders, with the responsibility of the producers as a key component, has been of fundamental importance for the stability and transparency of the system for R&D, critical review, licensing and decision making regarding nuclear waste issues. Within this system there is a noticeable shift over the last five years towards a more explicit and comprehensive involvement and influence of the municipalities in the siting regions. That has in turn resulted in local demands for a more visible support for the siting programme on the national political level.

From the perspective of implementers of the SKB, a successful siting of the Swedish deep repository has to continue to build upon the following main pillars:

— Continued good performance of already existing operating facilities and of R&D work to guarantee high quality in technical systems. This is also a prerequisite for keeping and increasing broad social trust in the nuclear waste management programme.
— A transparent siting process based on voluntary participation by municipalities fulfilling the geoscientific, technical and social criteria that are set up for each phase. An active dialogue between the SKB and all parties concerned must continue, with focus on the development of a comprehensive environmental impact assessment as a basis for decision making.

2. BACKGROUND

2.1. Nuclear power in Sweden

Sweden has been producing electricity by means of nuclear power for about 30 years. Originally, the Swedish nuclear power programme consisted of 12 reactors (taken into commercial operation between 1972 and 1985). However, in 1997, the Swedish Parliament decided to shut down a reactor at Barsebäck and on 1 November 1999, one of the two reactors at the Barsebäck plant was closed.

The total installed capacity in the 11 operating units is today about 9400 MWe. This corresponds to about 45–50% of the electricity demand in Sweden. There is a decision in principle to phase out nuclear power but no firm timetable has been set. It is, therefore, most likely that nuclear power will continue to be a major source for electricity generation for at least another 20 years. Recent opinion polls show that a clear majority, i.e. 75%, of the Swedish public accepts continued use of existing power plants.

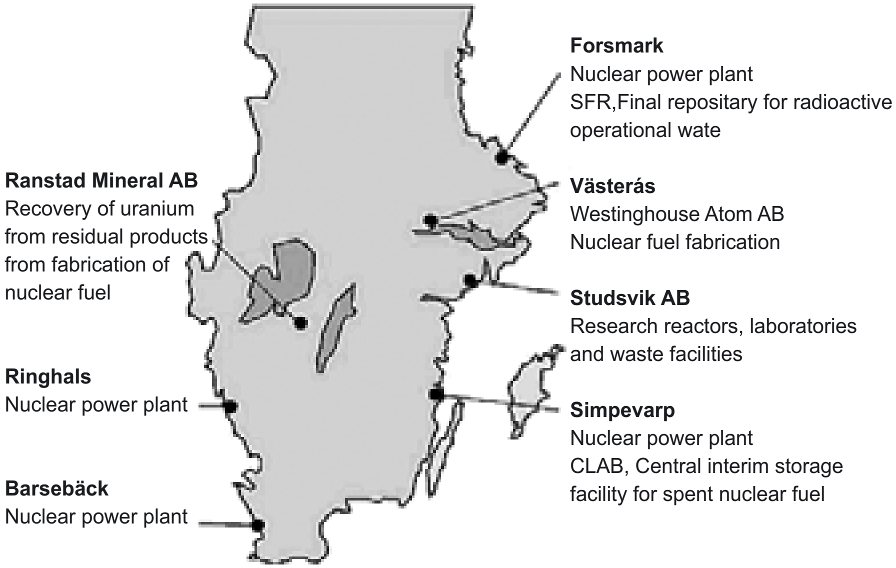

FIG. 1. Nuclear facilities in Sweden.

2.2. Nuclear waste management programme

The responsibility for the management of spent nuclear fuel, as well as for other radioactive residues from nuclear power production, lies with the operators of the nuclear power plants, i.e. the four nuclear companies (see Fig. 1). The companies have jointly formed the SKB to safely manage the spent fuel and radioactive waste from the reactors to final disposal. The task of the SKB is thus to plan, construct, own and operate the systems and facilities necessary for transportation, interim storage and final disposal.

The SKB has developed a system that ensures the safe handling of all kinds of radioactive waste from the Swedish nuclear power plants over a long time period. The keystones of this system are the following:

— A transport system with the ship *M/S Sigyn* which has been in operation since 1983;
— A central interim storage facility for spent nuclear fuel, CLAB, in operation since 1985;
— A final repository for short lived, low and intermediate level waste, SFR, in operation since 1988.

In CLAB, the fuel assemblies and core components are stored in water pools in a storage cavern. The Government gave permission for the expansion of CLAB in August 1998. Construction of a second storage cavern has started and the work will be finished in 2004.

Fundamental guidelines concerning final disposal and the division of roles within the Swedish nuclear fuel management system were laid down by the Parliament and the Government some 20 years ago, and they have served as a stable basis for the development of the programme.

It is the responsibility of SKB to take charge of waste management and find a method and site for final disposal. The Swedish Nuclear Power Inspectorate (SKI) and the Swedish Radiation Protection Authority (SSI) review SKB proposals to make sure they meet the requirements on safety and radiation protection.

Since the middle of the 1980s, the SKB has submitted its R&D programme every three years for government approval. Before the Government makes a decision, the programme is circulated and scrutinized in a broad review, which involves government authorities, research institutions and environmental organizations. The Government also issues permits and licences for siting, construction and operation. The municipalities in which new facilities are to be built must approve the siting.

Financing for all waste management activities is set aside in a special reserve fund via a charge that is based on the electricity production from the nuclear power plants.

The planning for final disposal of spent nuclear fuel is to encapsulate it in durable copper canisters to be placed in a deep repository. The SKB is presently in an advanced stage of planning and of testing methods for the encapsulation of spent nuclear fuel. The testing of sealing methods for the canister is taking place in the Canister Laboratory, located in the central harbour area of Oskarshamn. The future encapsulation of spent fuel is planned to take place in a new plant to be built adjacent to CLAB. The remaining components of the system that is now being planned (see Fig. 2) are the following:

— A factory for canister production;
— An encapsulation facility for spent nuclear fuel;
— A deep disposal facility for encapsulated spent fuel and other long lived radioactive wastes.

The SKB has been working for some years on gathering the supporting documentation that is needed to apply for a siting permit for an encapsulation plant and the initial stage of a deep repository. In its R&D programmes, the SKB has presented a step by step programme for implementing deep geolog-

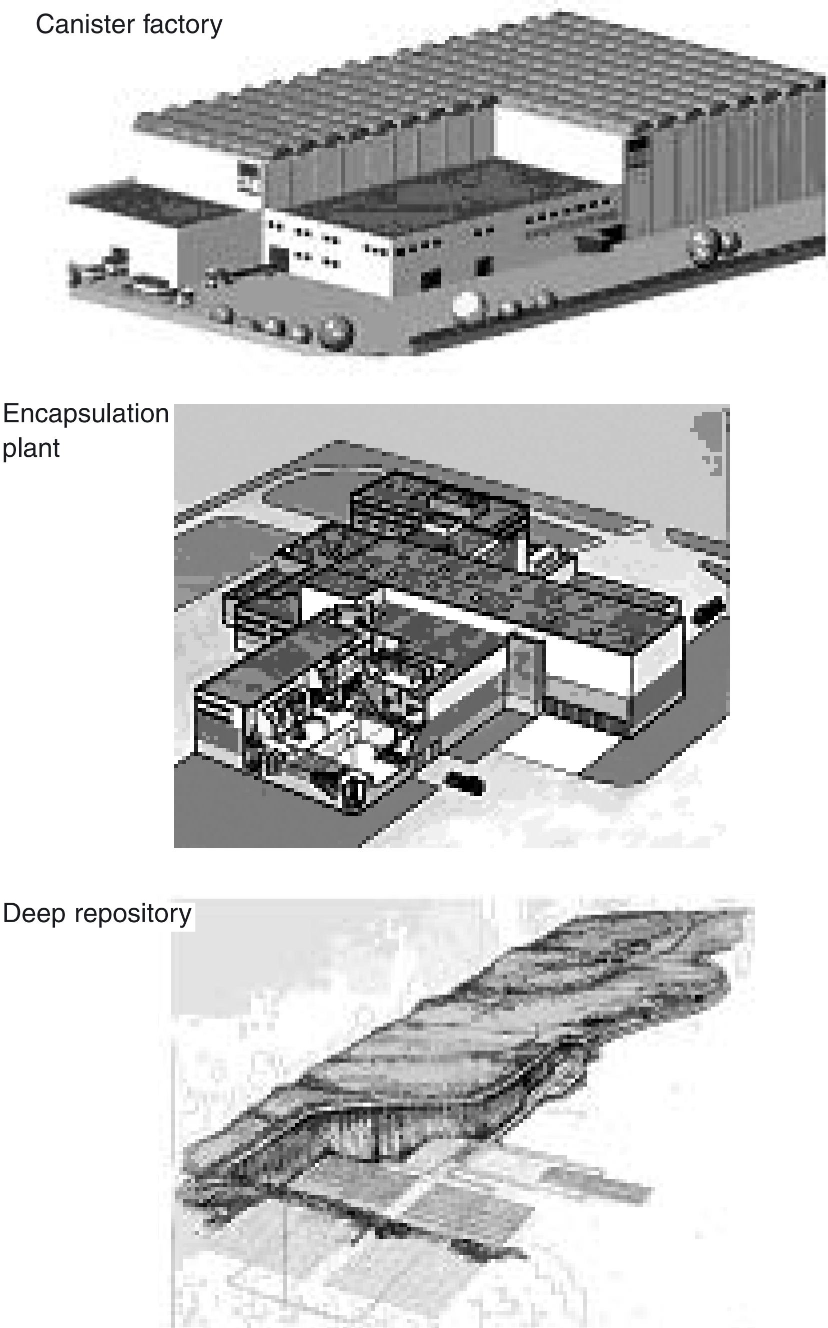

FIG. 2. Remaining facilities for the management and disposal of spent nuclear fuel.

ical disposal of encapsulated spent nuclear fuel. It also includes an active programme for R&D around central issues relating to technology and safety for the deep disposal method and for alternative methods.

It will take at least 40 to 50 years to carry out all measures needed to dispose of all long lived and high level nuclear waste in a safe manner. It is, therefore, appropriate to proceed in steps and keep the door open for technological development, changes and possibilities for retrieving already deposited waste. This will ensure freedom of choice for the future, while at the same time demonstrating the deep disposal method on a full scale and under actual conditions. Decisions regarding siting, construction and operation of an encapsulation plant and a deep repository will also be taken in steps and based on progressively more detailed information.

According to present plans, a licence application for an encapsulation plant at the CLAB site should be prepared by 2005, and the site for the deep repository should be selected and applied for by 2007.

3. SITING OF THE DEEP REPOSITORY

3.1. General

Siting of the deep repository is perhaps the most difficult and sensitive issue within the whole programme. The repository will be sited at a suitable location in Sweden where both rigorous safety requirements can be fulfilled, and necessary activities can be carried out with the consent of the concerned municipality and the local population. Thus, the siting process is based upon voluntary participation by communities interested in the deep repository project.

In 1992, the SKB presented a new strategy for siting a repository for deep geological disposal of spent nuclear fuel.

The SKB considered it possible to start by approaching municipalities that, on a voluntary basis, accepted to participate in the siting process. The SKB also presented the technical and other requirements that should serve as a basis for the siting, as well as the factors that must be taken into account during the course of the work. Clear definitions were developed of the concept's general siting studies, feasibility studies and site investigations.

At the end of 2000, the SKB had completed feasibility studies of eight municipalities. The feasibility studies were undertaken with the objective of making a detailed assessment of the prospect of establishing a deep repository in the municipality (see Fig. 3). The studies included geological conditions, review of available infrastructure, land use and environmental aspects, as well as societal and economic impacts on the community of a potential repository.

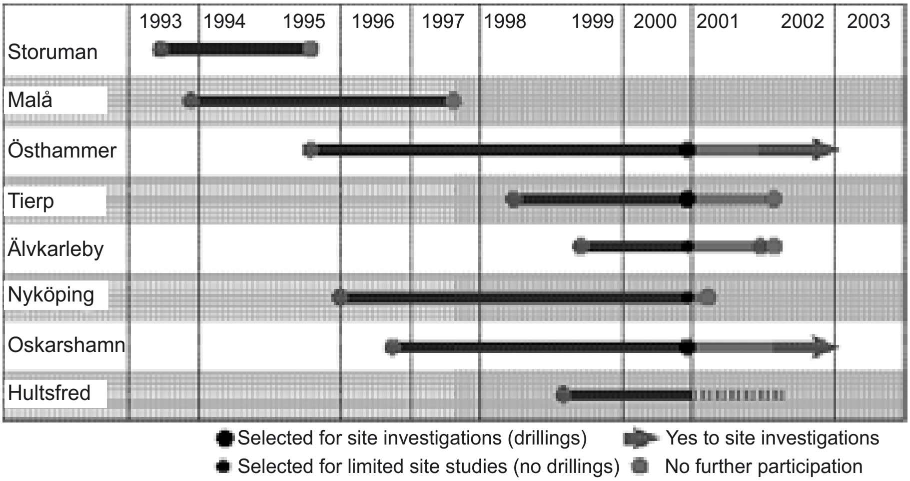

FIG. 3. Feasibility studies in eight municipalities over time.

The selected municipalities were generally found to have good geological prospects and were not opposed to such studies.

In December 2000, the SKB presented an integrated account of the method to use for final disposal of spent nuclear fuel, the selection of sites and programme for the site investigation phase. The proposal was to proceed with site investigations in three of these communities where feasibility studies had been made. After review by the regulatory agencies, the Swedish Government in November 2001 endorsed the SKB proposal to begin site investigations at the three proposed sites. In December 2001, the municipality of Östhammar, and in March 2002 the municipality of Oskarshamn, approved SKB plans to proceed with site investigations. The municipality of Tierp turned down further participation in the siting process. Älvkarleby was also asked about participation in the site investigations, since it was envisioned that encapsulated nuclear fuel could be transported to the harbour in Skutskär and from there by rail to a deep repository in Tierp. In March 2002, the municipal council in Älvkarleby agreed to continued participation. Since, however, the municipal council in Tierp voted against site investigations: by a slim majority, the alternative was eliminated.

3.2. Experiences of stakeholder participation

The feasibility studies contained technical study work. In addition, they set consultation processes in motion for the municipalities and their inhabitants, the affected county administrative boards, neighbouring municipalities and the safety authorities.

This also means that a lot of important and interesting questions have been raised and addressed at a very early stage in the Swedish siting process. The organization set up by the municipalities to follow the SKB work during the feasibility studies has varied in complexity and strength. In Oskarshamn, the whole community council acted as a reference group for the work. This meant that most of the politicians became very knowledgeable about the nuclear waste issues in general, and the work in the feasibility studies in particular. Special working groups acted towards specific questions and towards different target groups (including neighbouring municipalities). A key part of the organization was the group known as the EIA-forum, set up for consultation between the SKB, the Oskarshamn municipality, safety authorities and the Kalmar County Board (chairing the EIA-forum group)

All principal questions in the SKB siting programme have been discussed in the Kalmar EIA-forum group, as well as many site specific ones relating to the Oskarshamn municipality. Notes from these meetings are available for any interested stakeholder (and are also on the Internet).

In both Östhammar and Älvkarleby/Tierp, the municipalities formed special project groups to follow the SKB work, including local politicians as well as representatives for different interest groups. In Tierp, a rather forceful opposition group was formed which also had members belonging to political parties represented in the community council. Both Östhammar and Älvkarleby/Tierp belong to the Uppsala County, which also formed an EIA-forum in the same way as in the Kalmar County. The meetings in the Uppsala EIA-forum can be described as information meetings where all actors exchanged information and views on the current situation.

There were many ways and opportunities available for stakeholders to be involved and influence the programme, in particular, the following:

- At direct meetings and hearings set up by the main actors (the municipality in question, the authorities and also the SKB);
- In discussions at the SKB information offices in the municipalities with feasibility studies;
- Through their representatives in the municipality and the EIA-forum groups;
- Through the debate in mass media.

Table I shows an overview of the main stakeholder groups and their roles in the present programme.

TABLE I. AN OVERVIEW OF MAIN STAKEHOLDER GROUPS AND THEIR ROLES

Stakeholder	Comments
SKB	Implementer, fully responsible for all activities needed to manage the nuclear waste programme, i. e. R&D, siting studies, communication, consultation process and environmental impact assessments
Municipality	Local land management, municipality council equals elected representatives of population, veto power over siting
SKI	Nuclear Power Inspectorate: main safety authority; supervises all nuclear activities in Sweden; reviews the research programme for the final disposal of spent nuclear fuel and finances research into nuclear issues. It also informs the public and media about the safety related work that is conducted; co-operates with the Swedish Radiation Protection Authority
SSI	Swedish Radiation Protection Authority: a governmental authority with the task of protecting people and the environment from the harmful effects of radiation; provides information, education, advice and carries out research
County administrations	The county administrations function as representatives of the State in their respective counties, and as links between the inhabitants, the municipal authorities, the Central Government, the Swedish Parliament and the Central State authorities
Organizations for the preservation of nature and the environment	The deep repository is a matter of great concern to nationwide non-governmental organizations. Large national environmental protection and nature conservancy organizations will be invited to a consultation meeting dealing primarily with general questions, such as alternative methods and sites, or long term safety and environmental protection. Consultation with local organizations is held at least once during both the initial and complete site investigations
Those particularly process affected (närboende)	Special attention is given by the SKB in the consultation to those living close to a potential site. Good co-operation is needed concerning investigation activities and access to private land
The public	Members of the general public are invited to consultations

3.3. Lessons learned from the siting procedure

Some experiences from the feasibility study period regarding the early EIA-forum process are the following:

- — The process must be well known and clear to get acceptance. The actors and/or stakeholders must also see the possibilities for how or in what way the process can be affected or changed and what is already decided upon;
- — Openness and clarity in statements from all actors is absolutely essential;
- — All actors in the process must be prepared to answer questions;
- — All actors must be prepared to listen to (and learn by) the arguments brought up during the process;
- — Discussion in small groups and with the potentially highly affected people in the most valuable parts of the process to build trust and to learn about key questions;
- — There will never be consensus regarding all questions. The fact that there is a consultation process in place does not mean that consensus will have been or has to be reached;
- — The attitudes among those working in the process must reflect their belief that dialogue and discussion of these questions will create a better repository — both technically and socially. There must be respect for all stakeholders and their arguments, and a willingness to listen and learn.

3.4. Selection and decision on sites

In December 2000, the SKB reported to the authorities that the preferred selection of municipalities for further site investigations was Östhammar, Oskarshamn and Älvkarleby/Tierp. In a report, the SKB gave the background for the selection of the three candidates' sites. It also presented the programme for geological surveys of the candidate sites, as well as the background for the choice of the method for final disposal of spent nuclear fuel and HLW.

At the end of 2001, the Swedish Government endorsed the plan for the site selection phase and stated that the KBS-3 design of the repository will be used as the planning basis for the work. Permission from the three municipalities where the candidate sites were located was also required. The municipality of Östhammar decided in December 2001 to accept a site investigation in its municipality. The corresponding positive decision was taken in Oskarshamn in February 2002. In Tierp, the community council voted against further investigations in April 2002, although the municipal council in Älvkarleby agreed to continued participation.

Since the wishes of the municipalities are fully respected by the SKB, there are now, consequently, two site investigations performed: one in Östhammar and one in Oskarshamn. The first boreholes in Östhammar and Oskarshamn were performed in the autumn of 2002.

3.5. The early and the extended consultation process

According to the Swedish Environmental Code, the implementer (SKB) is required to set what is termed an 'early consultation' followed by 'extended consultation'. The early consultation process must involve the county administration and those living close to the site (particularly affected). The extended consultation concerns a much wider circle of the public than the early consultation. Particularly affected individuals will have invitations sent to their homes asking them to attend consultation meetings, and they will receive background material for the meeting and minutes. For this group, it is natural to continue the discussion initiated at the early stages of consultation of what concrete impact the project might have on the immediate vicinity.

Other members of the public will be invited to the consultation via notices in the local press. These notices will indicate where background material for the meeting can be obtained. Minutes from the meetings will be available on the SKB web site, at SKB Head Office in Stockholm, and at SKB site offices. Those interested can contact one of these locations to obtain a copy of the minutes of the consultation.

The consultation meetings deal with subjects such as:

- The current situation with respect to site investigations and results obtained thus far;
- The status of the design and planning work for infrastructure build-up;
- Some topical subjects, for example:
  - The encapsulation plant's impact on the near environment;
  - The deep repository with associated infrastructure — adaptation to existing development and to protected and valuable areas;
  - Handling of rock spoils;
  - Community development;
  - Alternative methods and sites.

Naturally, the subjects presented and discussed at the consultation meetings will change over the years during which the extended consultation is held.

The proposed scope and boundaries of the EIA-forum, as well as work forms, will be dealt with at the first meeting within the framework of the extended consultation. The SKB plans to hold at least one consultation meeting about the deep repository with the public at each site during the initial site investigations. The need for consultations during the complete site investigations should be determined before they begin. The consultation about the encapsulation plant will be co-ordinated in a suitable manner with the consultation for the deep repository.

3.6. Non-governmental organizations

According to the Environmental Code, those organizations likely to be affected will be invited to the consultations on the project. According to the legislative history of the Environmental Code, this refers above all to environmental protection and nature conservation organizations active in the locality where the activity is planned. The SKB, therefore, intends to hold consultation meetings with the local environmental and nature conservation organizations at the concerned sites. These consultations give the SKB an opportunity to obtain information on local contributions to the design and location of the deep repository in such a way that the impact on humans, the environment and landscape can be limited. Extended consultation with local organizations is held at least once during both the initial and completed site investigations.

The deep repository is a matter of great concern to nationwide non-governmental organizations. Large national environmental protection and nature conservation organizations will be invited to a consultation meeting dealing primarily with general questions, such as alternative methods and sites, or long term safety and environmental protection.

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Discussion following paper by C. Thegerström

A. NIES (Germany): Have the municipalities participating in the siting process in Sweden been receiving financial support for their participation and, if so, have accusations been made of trying to 'buy' the municipalities?

C. THEGERSTRÖM (Sweden): In the early days of the siting process, the municipality of Storuman billed SKB for its participation costs (for example, the costs of attending meetings and conducting its own studies) and SKB reimbursed the municipality. This procedure worked quite well, but questions were raised. Consequently, the Government decided after a few years that the participating municipalities should each receive an annual grant of two million Swedish crowns. The grant, which is not channelled through SKB, is regarded by the public as a right of the participating municipalities, and the question of their being 'bought' has been laid to rest.

A. NIES (Germany): What would happen if the municipalities still participating in the siting process ultimately said 'no'?

C. THEGERSTRÖM (Sweden): We should be back at square one, since a 'no' from a municipality would never be overridden.

I imagine we would start again, once more opening up the process — perhaps modified in some way — to the entire country, and there would be some further years of interim storage.

A. ZURKINDEN (Switzerland): What has been the role of the regulatory authorities in the siting process?

C. THEGERSTRÖM (Sweden): Their role has gradually increased. Initially, they were reluctant to send representatives to the municipalities of

Storuman and Malå, as they wished to be seen as being neutral and felt that not becoming involved was the best way of doing that.

However, the municipalities were unhappy about the non-involvement of the regulatory authorities. In fact, the Oskarshamn municipality said: "The regulatory authorities are our experts; we could never build up the expertise in things like safety assessment which the regulatory authorities possess." So, representatives of the safety authorities came to attend SKB's meetings with municipality representatives more frequently, making statements about, for example, whether the SKB was, in their view, proceeding in the right way.

THE LESSONS LEARNED FROM THE UK RADIOACTIVE WASTE MANAGEMENT PROGRAMME

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Abstract

The present paper reviews the history leading up to the rejection of the proposal to build a Rock Characterization Facility (RCF) in 1997 and discuss the lessons learned by its promoter, United Kingdom Nirex, from analysis of past approaches. The lessons are considered under the following headings: process (policy development and implementation), structure (an independent organization responsible for long term radioactive waste management), and behaviour (the need for openness, transparency and accountability in future processes). On the basis of these lessons, the paper points the way forward for resolving the problem of radioactive waste management in the UK.

1. INTRODUCTION

The United Kingdom and other countries have, for over 50 years, been grappling with the issue of radioactive waste. During that time, there have been advances in scientific understanding and changes in both policy and public opinion.

The present paper reviews what has happened in the UK in the last 30 years leading up to the Rock Characterization Facility (RCF) planning inquiry in 1997. The paper then outlines the lessons Nirex Limited has learned from its review of the events leading up to the RCF planning inquiry.

Radioactive waste exists. Nirex believes that dealing with this is an ethical issue that society as a whole must address. Responsibility rests with this generation, now, to take the steps necessary for creating the framework in which a publicly acceptable way forward is found.

2. HISTORY

In 1976, the sixth report of the Royal Commission on Environmental Pollution was produced [1]. The report recommended a number of institutional changes to allow a strategy on long term radioactive waste management to be drawn up and then implemented.

The Nuclear Industry Radioactive Waste Management Executive (Nirex) was set up in 1982 to research, develop and operate radioactive waste disposal facilities on behalf of the nuclear power industry. Nirex also had responsibility for sea dumping. In 1985, Nirex became a limited company — United Kingdom Nirex Limited — known as Nirex.

In the early 1980s, Nirex searched for shallow disposal sites for intermediate level waste (ILW) and some low level waste (LLW). However, there was strong public opposition. In 1987, the Government decided that both ILW and the LLW that could not to go Drigg should be disposed of in a deep facility.

This switch in policy prompted a new search for a site for a deep geological repository to take all ILW and some LLW. Around one third of the UK land mass was considered to have potentially suitable geology. By 1989, Nirex had compiled a shortlist of ten land-based potential sites plus two generic offshore options. From these, Dounreay and Sellafield were selected for detailed study. Sellafield was then chosen as the preferred site for continued investigation in 1991.

An extensive programme of geological investigations was focused on the Sellafield site. Twenty-nine deep boreholes were drilled to investigate the properties of the geology around the site, and considerable modelling work carried out to assess the suitability of the site for repository. In 1992, a need was identified for a Rock Characterization Facility (RCF), an underground laboratory to investigate further the detailed properties of the potential host rock. Nirex applied for planning permission to build the RCF in June 1994 and the application was rejected by Cumbria County Council in December 1994. Nirex appealed against the decision and this resulted in a public inquiry that took place between October 1995 and February 1996.

The result of the public inquiry was that the rejection of planning permission for the RCF was upheld. The UK Secretary of State for the Environment announced on 17 March 1997 that he supported the decision not to allow the construction of the RCF and, consequently, Nirex terminated its work at Sellafield.

Since 1997, Nirex has been reviewing the processes and actions that led up to the RCF decision to try to learn what contributed to the failure and how things might be done differently in the future. Key parts of this review are examples provided by other countries' experience and recent academic research.

The following sections outline the findings of the review and some of the initiatives Nirex has undertaken to respond to them.

3. LESSONS LEARNED

Nirex believes that the central lesson to learn from the past and from international experience is that progress towards a legitimate policy depends on transparency. Everybody needs to be able to see how the policy has been, is being, and will be developed and implemented. The institutional framework needs to allow for society to be able to understand and influence all aspects of this endeavour.

With transparency as a prerequisite, lessons learned can be analysed into three themes:

— *Process:* The way policy is developed and implemented;
— *Structure:* The organizational arrangements;
— *Behaviour:* How the different organizations involved interact with each other and stakeholders.

Under these themes, the very complex sets of relationships between national and local interests, science and society, and the culture of the different groups of people involved can be brought into focus.

The following sections outline the key lessons learned under each of the themes.

4. PROCESS

The first major theme identified by Nirex in its lessons learned from the past is that of process. These lessons suggest that the way in which policy is developed and implemented must change. Experience both in the UK and internationally points towards certain key features being present if a policy is to be seen as legitimate by society as a whole. These include:

— Setting up appropriate organizations at the beginning of the programme to undertake the work;
— A clear programme, developed through consultation, that addresses:
- What work needs to be undertaken;
- Who will undertake the work;
- How people can become involved;
- What outcomes are required;
- How and when decisions will be made;

— Stakeholder involvement throughout the programme;
— Active seeking of stakeholders' views by the organizations involved in waste management;
— Justification of all decisions showing how stakeholders' views and the outcomes of consultation have been taken into account;
— Providing feedback to all those who participate.

Nirex believes that checks and balances need to be built into the system. Research needs to be independently reviewed and scrutinized. Nirex also believes there should be early regulatory involvement in reviewing waste management concepts.

Another aspect of process is the nature of the relationship between the nation as a whole and any host community. Nirex views this relationship as a contract, either explicit or implicit. A lesson learned from the past and international experience is that this contract is only seen as legitimate when visible and explicit.

The nature of the contract could involve several components, including compensation, planning gain, regional development, direct employment, allowance for volunteer communities and a veto on the project for a local community.

Nirex believes that these issues need to be discussed openly and transparently as early in the policy development process as possible. The ethical basis for such arrangements will need to be part of this discussion. Any outcomes or preferred approach need to be integrated into the national planning regime.

A key step in developing a long term solution to radioactive waste will be the site selection process. Nirex believes the site selection programme (the roles of the stakeholders, the decision makers, the steps to be undertaken), the site evaluation criteria and who is to undertake each step should be developed through consultation with all stakeholders. The whole process must be open and transparent, the names of all potential sites should be published and there should be ongoing consultation.

5. STRUCTURE

The second major theme identified by Nirex in its analysis of lessons learned from the past is that of structure. The structure of an industry affects:

— Policy development and decision making;
— Public confidence;

— Visibility of issues;
— Drivers and incentives;
— Ability to regulate effectively.

Radioactive waste management involves short term decisions that may have very long term impacts. It is essential that these short and long term issues are visible both to the regulators and to others who have to make decisions. The time-scales involved in radioactive waste management span hundreds of thousands of years. To achieve the visibility of issues, Nirex believes there needs to be a separate organization focusing on the long term issues. The organization should have public interest at its heart. It will require a mixture of skills including scientific, technical and social expertise. Nirex believes the organization needs to be separate from the nuclear industry.

An independent stakeholder review carried out for Nirex [2] showed that people wanted the organization responsible for long term waste management to be:

— Independent of pressure from the waste producers;
— Not owned by the nuclear industry;
— Technically competent;
— Politically impartial;
— Protective of future generations.

They did not want those responsible for long term waste management to be compromised by the short term interest of those directly involved in the industry.

6. BEHAVIOUR

The third major theme identified by Nirex in its lessons learned from the past is that of behaviour. How Nirex behaved in the past was a key factor in how it was received by the general public and other stakeholders such as the academic community.

Nirex was criticized for not involving stakeholders and for having a process whose pace was driven by predetermined deadlines and not the needs of stakeholders. Research and experience [3, 4, 5] show that the behaviour of those involved in long term waste management must be:

— *Open:* Debate must take place in the public domain and there should be free access to all relevant information. Those involved should be open to influence from people with different opinions and perspectives.

— *Transparent:* The reasoning behind actions, deliberations and decisions should be made available. It must be clear from the outset how stakeholders and the wider public can be involved and how their opinions will be taken into account and used.

— *Accountable:* Those responsible for the process should be accountable for their actions to all parties. This includes publicizing the reasoning behind decisions and giving people feedback on how their views have been taken into account.

In response to these findings, in 1998 Nirex initiated a transparency policy which states that Nirex is committed to achieving transparency through:

— Fostering openness as a core value;
— Listening as well as talking to people who have an interest;
— Making information readily available under the Nirex Publications Policy and responding to requests for information under the Nirex Code of Practice on Access to Information;
— Making key decisions in a way that allows them to be traced so that people can see and understand how they were arrived at;
— Enabling people to have access to and influence on the future programme.

The work on waste management needs to be reviewed and stakeholders should have access to, and influence on, the work being undertaken. This can be achieved by allowing stakeholders to 'preview' specifications for work and make inputs.

Just providing information to stakeholders does not involve them in the work. There needs to be ongoing dialogue and respect for people's views and knowledge. In the lead-up to 1997, Nirex relied on government policy and was criticized for insufficient scrutiny of alternative options. Environmental Impact Assessment [6, 7] directives mean those involved in long term waste management will have to justify their decisions and investigate alternatives.

An example of where listening to people's issues and concerns and integrating social research has affected the technical research undertaken is the work associated with changing the deep geological repository concept to include monitoring and retrievability. After previously resisting the introduction of monitoring and retrievability, Nirex began to look at the issue following the RCF decision in 1997. Many members of the public, especially in Cumbria, had emphasized retrievability as an issue of great importance, and this view has also emerged strongly in the international context. The House of Lords Select Committee on Radioactive Waste Management [8] requested further information on the feasibility of monitoring and retrievability and the UK Centre for Economic and Environmental Development (UK CEED) consensus conference on radioactive waste management [9] also highlighted monitoring and retrievability as important issues. Subsequently, Nirex held two workshops [10, 11] to obtain the views of stakeholders, including the public, to influence the development of a strategy for progressing work on monitoring and retrievability.

Nirex used the information obtained from the workshops to develop its work programme and provided feedback [12] to those who had been involved. A further workshop was held in February 2002 [13] to provide feedback to people about how the work has progressed and to obtain further inputs from them on its future direction.

Figure 1 shows the Nirex phased disposal concept, which includes a period of monitoring with the ability to retrieve the waste before the vaults are backfilled.

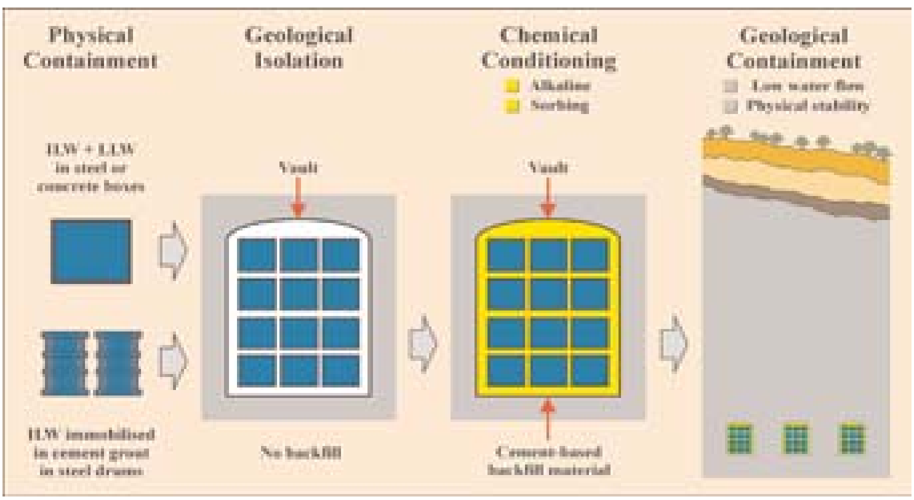

FIG. 1. The phased disposal concept.

7. CONCLUSION

Nirex believes radioactive waste management is an ethical issue and that the search for a long term solution should be driven by society's values. The waste already exists and Nirex believes there are credible options to allow this generation to deal with it. Nirex believes the waste should be dealt with on behalf of the public.

The whole process for developing a solution must be open, transparent and inclusive. Those in positions of authority should be accountable for their actions to all stakeholders.

Nirex's experience and the lessons it has learned show that the decision making process, the behaviour of those involved and the structure of the industry need to be addressed to enable progress to be made.

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Discussion following paper by C. Murray

M. AEBERSOLD (Switzerland): I would be interested to know how important the question of the concept was for the step back to zero. In going forward now, will you first decide on a concept, or will you do this in the same process as involving the stakeholders.?

C. MURRAY (United Kingdom): At point zero, all the concepts (about 12 of them) will be reviewed over the next two to three years. We will continue to develop the phased geological approach over that time, but it will be inside the overall scheme.

M. AEBERSOLD (Switzerland): In Switzerland, we have had a lot of discussion about the independence of NAGRA from the nuclear industry. What do you understand by 'independence' when you talk about Nirex?

C. MURRAY (United Kingdom): By 'independence' we understand independence of thought and action and being seen to be objective.

It will be important that the separation between Nirex and the nuclear industry be as complete as possible. At the moment, we are thinking of continuing to adhere to the 'polluter pays' principle, so that the nuclear industry would continue to provide the financial resources — but through a levy rather than on the basis of a contract, with the financial resources channelled through, perhaps, the Department of the Environment.

Concern has been expressed about the possibility of loss of control over our costs if Nirex became completely independent. However, in the United Kingdom there are regulatory bodies like OFGEM and OFWAT, and we have been suggesting that one of them could ensure that Nirex's costs are kept under control.

STATUS REPORT ON THE OECD/NEA FORUM ON STAKEHOLDER CONFIDENCE

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1. WHY THE FORUM ON STAKEHOLDER CONFIDENCE?

Lessons learned from past difficulties in making progress in national radioactive waste disposal programmes indicate that waste management is both a societal and a technical issue, therefore any significant decisions regarding the long term management of radioactive waste should be accompanied by a comprehensive public review with the involvement of a diverse range of stakeholders. These stakeholders include all interested or concerned parties with a technical or non-technical focus such as local communities, elected officials, non-governmental organizations and the general public.

The Forum on Stakeholder Confidence (FSC) was created under a mandate from the Radioactive Waste Management Committee (RWMC) of the OECD Nuclear Energy Agency (OECD/NEA) to improve the understanding of stakeholders' interaction, to explore means of ensuring an effective dialogue with the public and to consider ways to strengthen confidence in decision making processes.

The FSC was launched in August 2000, in Paris, with an international workshop. Affiliations included universities, national academies, technical oversight bodies, safety authorities, implementing agencies and advisory bodies to government.

2. WORKING METHODS, PROGRAMME AND OUTPUTS

The FSC convenes a series of alternating regular meetings and workshops.

Three annual meetings have been held so far. They include topical sessions on specific issues of interest and are used to elaborate on the lessons learned. A recent topical session focused on the Environmental Impact Assessment as a tool for stakeholder involvement. Case studies are also discussed, for example, the organization and evolution of the public debate in the United Kingdom, or the working group on selection procedures for final disposal of radioactive waste involving the German group known as AkEnd (Arbeitskreis Auswahlverfahren Endlagerstandorte).

The workshop focus on stakeholder involvement in waste management issues in a host country. After a site visit, a wide spectrum of country stakeholders at the national, regional and local levels are invited to express their views on the nature of their involvement and the process by which they are involved. A highly interactive format allows FSC delegates and country stakeholders to compare experience and deepen the discussion. Thematic rapporteurs, invited by the OECD/NEA Secretariat, give feedback to the workshop participants from their own disciplinary perspective. Two workshops have been held to date, in Finland and in Canada.

Besides the workshop proceedings, three further FSC documents will be published in 2003:

— A compilation of outreach activities performed in OECD/NEA member countries in the past few years (survey document);
— An analysis of the lessons learned by the regulators;
— A theoretical and practical review of stepwise decision making.

The latter document in particular will provide opportunities for dialogue with researchers from various disciplines and practitioners in fields outside radioactive waste management (RWM).

The strategic document of the FSC, adopted at the 2001 Annual Meeting, outlines priorities and expectations for this initiative, as well as modus operandi. It is reviewed and updated periodically.

The upcoming programme is developed in twice-yearly meetings of the FSC Core Group. This group, assisted by the OECD/NEA Secretariat, comprises representatives of the FSC institutional ‘constituencies’, that is, implementers, regulators, policy makers and scientists in research and development. Among the events planned at this time are a topical session on stakeholder involvement tools, as well as a national site visit and workshop in Belgium on the practice of local partnerships for developing a low level radioactive waste (LLW) site in that country.

Additionally, a document outlining the overall lessons learned through FSC activities is being augmented and reviewed iteratively. It will be published at the end of the current mandate, in 2004.

3. MAIN LESSONS LEARNED TO DATE

As in any international endeavour, the question has been posed in the FSC of how universal the lessons learned are. To what extent is experience tightly bound to national culture? To what extent may experience be transferred to other contexts? The following are a few of the lessons learned from the workshops held so far, focusing on stepwise decision making, factors required for gaining stakeholder confidence, as well as open questions that require further discussion.

3.1. The workshops in France, Finland and Canada

The Paris workshop provided an opportunity to take stock of the worldwide experience in the field of stakeholder confidence and radioactive waste disposal. It addressed a variety of topics ranging from evolving participatory democracy, stakeholder identity and trust in the institutional framework, to the role of open dialogue in all aspects of radioactive waste management. This experience is documented in both the workshop proceedings and in the survey document begun at that time and which is to be published by the FSC shortly.

One important observation made at the workshop was that mission, organizational and behavioural changes are being implemented worldwide within waste management organizations. In particular, the regulator's role is the one that has been restyled the most in recent years. The Paris workshop also allowed an in-depth view of the Swedish programme.

The first FSC workshop held in a country context was organized in Finland, in November 2001. Representatives from all stakeholder groups — from the local level to the national level — reviewed the sequence of decisions which ultimately led to the Parliament's approval, in May 2001, of siting a spent fuel repository in Eurajoki, Finland. The workshop was preceded by an encounter with the Eurajoki municipality. Feedback was provided to the workshop by experts in public management, strategic decision, community development and social psychology.

Workshop participants found that two structural aspects of the process in Finland were key factors of success. These were:

- The parliamentary Decision in Principle as part of a transparent, stepwise procedure;
- The Environmental Impact Assessment as a framework and guide for public involvement and participation.

The role of the regulatory body, namely, the Radiation and Nuclear Safety Authority of Finland (known as STUK), in building confidence by responding to stakeholder health concerns also stood out. For the local municipality, the right of veto was a significant confidence factor.

The workshop in Finland provided further positive evidence of the cross-cultural applicability of criteria that had been identified, mainly by social scientists, in analysing the successful siting of hazardous and radioactive waste facilities in different countries. Since then, the issue of stepwise decision making has been taken up further by the FSC and it will be presented briefly later in the present paper.

The second national site visit and workshop was held in Canada, in October 2002. The preceding two years were a defining period for radioactive waste management in Canada. In March 2001, an agreement was reached between the Government and three communities in southern Ontario to clean up and locally manage radioactive waste from past uranium refining and conversion activities. In June 2002, the Nuclear Fuel Waste Act became law, enabling Canada to move effectively towards a solution for the long term management of 'spent fuel waste'. At the FSC workshop, three key areas of inquiry were examined:

(1) What the social concerns at play in radioactive waste management are.
(2) How these concerns can be addressed.
(3) Development opportunities for local communities.

Experts in radiation protection, community governance, ethics and stakeholder deliberation provided feedback. The discussions brought insight into the situation in Canada and should assist Canada in undertaking the next steps.

The workshop in Canada confirmed:

— The very important role that local communities and municipalities will play and which needs to be encouraged.
— The nuclear municipalities have a special interest in seeing solutions brought forward. They are especially receptive to dialogue and are already active in that area.
— The importance of having a government body that is active in continuing the process of dialogue and decision making.

3.2. Stepwise decision making

A forthcoming FSC publication identifies three overarching principles from the experience in both social research and practical radioactive waste management, which are independent of the RWM context, and which would seem to represent a consensus as the essential elements of any decision making that claims broad societal support:

— Decision making processes should be facilitated by promoting the constructive and high quality involvement of individuals with different areas of knowledge, beliefs, interests, values and world views, with a technical and non-technical focus;
— Social learning and public education are essential for the development of policy in new topics such as the one in question; this should be facilitated by promoting interactions between various stakeholders and experts;
— Decision making should be performed through iterative processes, providing the flexibility to adapt to contextual changes, likely to occur in long lasting processes (that is, lasting a few decades).

An important corollary is that the implementation of these principles is largely facilitated by a stepwise approach (or adaptive staging) which:

— Ensures sufficient time for developing a competent and fair discourse;
— Allows investigations on alternatives.
— An independent assessment is required.

Radwaste legal frameworks could be analysed as applications of these principles in the long term management of radioactive waste, for example, the legal frameworks existing in the following countries: the United States of America (the 1982 Act), France (1991), Japan (2000) and Canada (2002).

When designing a stepwise process, trade offs between social sustainability of the process and efficiency should be considered: an increase in the number of steps or intervals between them may indicate an increase in the costs and duration of the process. Steps must be understood as relevant by stakeholders and not be seen as an 'alibi'.

Experience has shown that regardless of institutional intentions to limit debate to a specific issue, stakeholders have enlarged the debate to surrounding issues without reference to the manner in which institutions have tried to define the issue at hand.

When translating the principles outlined in a RWM context, a set of specific goals could be stated. The action goals propound a debate and a shared understanding with respect to:

— The system of national energy production, which is responsible for overall decisions on the use of nuclear power. Waste management must be fulfilled, whatever the future of nuclear energy, but solutions for safe waste management are understood as a key factor allowing future decisions for new nuclear power plants: the issue must not be limited to the system of waste management.

- The system of nuclear waste management, which is responsible for defining the directions to be followed, priorities, programmes to be implemented, and methods to be applied for the management of various types of waste. For consideration are priorities for LLW versus high level radioactive waste (HLW), concepts (such as storage, repository and reversibility) and safety principles.
- The system of waste management facility siting, which is responsible for identifying a site, as well as compensation/incentive packages and oversight schemes for host communities.
- The system of waste management facility implementation, which is responsible for decisions on facility construction, operation, monitoring and potential closure.

Articulating RWM decisions at the four levels of systems (discussed in the FSC stepwise decision making paper) provides the possibility of matching tasks with stakeholder capabilities and integrating higher order and lower order constraints and results, as well as integrating expectations at the national and local levels.

3.3. Factors required to engender stakeholder confidence and dialogue

The FSC emphasizes that, when implementing a stepwise process for definition and implementation policy, two other factors contribute significantly to stakeholders' confidence:

- Clear, known and recognized roles and responsibilities for different actors (that is, the actors of the waste management facility implementation system presented above). Consistency is required among those of waste generators, operators and regulators. The FSC emphasizes some specific aspects. In some countries, regulators are involved in the early phases of the process and on contemplated sites. The role of local authorities could be important (in terms of organizing local debate, formal or informal veto power, for example).
- The behaviour of main actors needs to reflect values such as openness, consistency, desire for dialogue, as well as demonstrating technical competence. Respecting the role of each actor, including national and local authorities and politicians is a key commitment, as maintaining rigour in research approach and assessment.

These required factors form the framework for stakeholder dialogue and discussion. Some major requirements for dialogue include the following:

— Sufficient time and resources must be devoted to outreach, consultation and deliberation;
— A range of tools is needed for involving different publics — not all points of view will be expressed in a written format;
— Stakeholders should be allowed to participate from the very early stages of a siting process;
— Public interest in participation can be maintained only if stakeholders believe that they can have an influence on key decisions. Ideally, formulated requests are integrated into work programmes; for example, in order to take into account the demand for alternatives, specific technical or environmental concerns, or new concepts (such as reversibility, a demand which has arisen in some countries);
— Information on management options and alternatives is needed to create a balanced deliberation.

The above factors and requirements have been explored in the FSC topical sessions, case studies and workshops. The findings are extensively documented in the publications in progress.

3.4. Open questions

Alongside the lessons learned, a number of open questions have been identified, including the following:

— How to ensure the fairness of the decision making process for siting a facility? Which guarantees (safety guarantee, development opportunities) need to be obtained from local communities?
— What financial arrangements must be made for stakeholder participation? What type of legitimate contribution can be provided to local communities hosting a national facility (taking into account the specific structure of each national and local tax system)?
— What organizational changes would be helpful in an organization which would enable it to take active and constructive part in deliberative decision processes?

More attention needs to be paid to one particular aspect. Despite an emerging new dynamic of dialogue, there are divergent diagnoses on the status of RWM from the technical specialists, the environmentalists and the general public. The environmental diagnosis shows that RWM has, in non-accidental situations, a very low impact. It is at present less than one in one hundred of other impacts associated with the nuclear industry (for example, mining and operating nuclear power plants). The long term target of HLW repository impact is less than one in ten of the natural radioactivity impact.

But opinion is rather different, as shown by Eurobarometer (2001). In France, for example, 60% think current management is unreliable (2000), and 76% believe that it is an unresolved problem (1999). Radioactive waste is perceived as more dangerous than nuclear power plants (1992–1995, 2001). Such a different diagnosis must be overcome, in particular with the following question:

— How to bring about a shared understanding of the phenomena underlying the risk in RWM, that is, what is radioactivity, how do radionuclides migrate in the environment, and in what way could they cause harm to human beings and the environment?

The FSC will continue to ask and reflect on the hard questions, as it is by their identification and discussion that confidence is also built. The upcoming programme will allow us to address many of them.

4. CONCLUSION

Exchanges between institutions involved with nuclear energy and civil society are no longer confined to rigid mechanisms. A more complex interaction is now taking place among players at national, regional and especially at local levels. In addition, a broader, more realistic view of decision making, in steps, encompassing a range of actors in civil society, is emerging.

At their 35th meeting, the Radioactive Waste Management Committee of the OECD/NEA acknowledged the positive outputs of the FSC. Alongside the goal of distilling in concise, published form the lessons learned about stakeholder involvement, the expectation was to provide a forum for direct exchange in an atmosphere of mutual respect and learning. These expectations are being met. The FSC is one of the rare forums where technicians, civil servants and social scientists can interact; it provides opportunities to analyse field experience in close co-operation with the local and national stakeholders. The FSC is proving to be an effective tool to stimulate a new approach to RWM and decision making. It is helping to promote a cultural change in participating organizations, through the active involvement of their members.

The OECD/NEA web site provides a list of activities and free publications of the FSC (http://www.nea.fr/html/rwm/fsc.html).

PANEL

INVOLVING STAKEHOLDERS IN THE PROCESS OF DECISION MAKING: WHEN AND HOW?

Chairperson: **M.V. Federline** (United States of America)

Members: **T. Flüeler** (Switzerland)
P.A. Brown (Canada)
C. Thegerström (Sweden)
C. Murray (United Kingdom)
Y. Le Bars (France)
R. Nocilla (United States of America)

Panel Discussion

P.A. BROWN (Canada): We are asked to respond to the question of when and how one should involve stakeholders in the decision making process. In my view, the answer is 'early and often', and I should like to give two examples from Canada's experience, of what happens if one does not involve the stakeholders early and often.

The first example relates to a nuclear fuel waste management programme initiated in 1978, on which we spent some $700 million. Instead of embarking on a siting process on the lines of what has been done in Sweden, we opted for the development of a disposal concept. In 1988, we initiated a ten year environmental assessment and review process, with comments invited from the public — including the aboriginal peoples. As a result of this process, it was concluded that the disposal concept, although technically sound, had not gained the acceptance of the public.

The programme came to an abrupt halt, and the Federal Government decided that a fresh start should be made, with a stronger focus on public involvement.

We developed what ultimately became the Nuclear Fuel Waste Act, which came into force on 15 November 2002 and requires the owners of used nuclear fuel to set up an independent organization for managing it. The nuclear fuel waste management organization has, within three years, to submit proposals to the Federal Government covering three options: deep geological disposal; long term or short term storage at reactor sites; and long term or short term storage at a central above ground or below ground facility. The Federal Government will then take a decision.

The proposals have to take into account not only technical issues but also societal and ethical ones, providing for consultations with the public. If the responsible governmental minister is not happy with the consultation programme established by the nuclear fuel waste management organization, he or she may initiate a different consultation process.

The nuclear fuel waste management organization must set up an independent advisory council with members representing a wide range of scientific and technical disciplines, members possessing expertise in public affairs and social sciences, and also members possessing expertise in the field of traditional aboriginal knowledge.

We hope that, with involvement of the public from the very outset, it will be possible to progress well beyond the point which had been reached when the old nuclear fuel waste management programme came to a halt.

The second example relates to the cleanup of the town of Port Hope, which had become radioactively contaminated during the 1930s, when radium was being processed in a factory there.

When the problem was discovered in the 1970s, the regulator took immediate action and removed all radioactive waste material that was in licensable quantities, so that all the hot spots were eliminated. The Federal Government established a low level radioactive waste management office with the task of continuing to look for contaminated sites and, when it found any, cleaning them up and storing the radioactive material.

However, the search for a disposal or long term storage site created a great deal of unrest. The adopted approach was essentially a 'decide, announce, defend' one, and ultimately the three communities where the Port Hope radioactive waste was in storage rebelled and said: "We don't want the waste here. Take it away!"

In due course, the responsible governmental minister decided that a different process was necessary and set up a task force to develop one. The result — after about a year — was a siting process whereby some 850 communities were invited to volunteer to take the Port Hope radioactive waste.

Fewer than 20 communities expressed an interest in discussing the matter, and after a few more years there was only one community with which discussions were still taking place: a 'nuclear community' already aware of the implications of hosting a radioactive waste disposal or storage facility. An understanding was reached with that community, but the Federal Government could not agree with it on the details of a formal agreement, so that the understanding started to fall apart.

As it was falling apart, the communities where the Port Hope waste was still in storage wrote to the responsible governmental minister and expressed an interest in exploring local solutions.

The solution finally chosen was one proposed by those three communities. All the Federal Government did was to provide them with money for such things as paying for the services of consultants. The formal agreement arrived at has now been in place for two years, and its implementation is proceeding well.

These two examples, which highlight the importance of involving stakeholders early and often, were very different, highlighting also the fact that there is no single correct way of involving stakeholders. Each consultation exercise must be tailored to the specific situation.

T. FLÜELER (Switzerland): Listening is difficult, but the nuclear community needs to listen to stakeholders and involve them in radioactive waste management decision making.

When should stakeholders become involved? I would say, as early as possible. What form should their involvement take? In my view, that depends on the respective roles of the different stakeholders. Who should be regarded as stakeholders? In line with the OECD/NEA approach, I would say that the general public should not be regarded as stakeholders but all interested persons and groups should. Why should the nuclear community involve stakeholders? I would say, in order to improve radioactive waste management programmes and to gain public tolerance — public tolerance being something rather more grudging than public acceptance.

It has been said that ‘good’ decisions are good only in relation to the goals for which one is striving, so one needs to know the goals of the different stakeholders. Also, one needs to understand the goals of the radioactive waste management programme (for example, why final disposal or long term storage with monitoring and retrievability is the preferred option), which can take quite a long time. That is why, as I indicated in Session 8, I have misgivings about the fact that the European Commission is preparing a directive which will require member states of the European Union to have radioactive waste repositories in place by 2018.

As to the decision making process itself, I would say that it must be transparent, stepwise and iterative (with interim decision points), accountable and traceable, and that centralized decision making increases opposition.

As to the roles of various ‘interested persons and groups’, I would say that decisions will be taken by directly concerned population groups and by politicians and political authorities; information will be provided by experts (including social scientists and ethicists); non-governmental organizations will raise issues and identify problems, and they may be in favour of a phase out of nuclear power generation; international organizations will provide a platform for consultations; and independent advisory bodies will carry out reviews.

The experts, the safety authorities and the implementers will not be the decision makers, nor will the IAEA; the days of ‘decide, announce, defend’ are past.

As to future generations, potential risk bearers, who should represent them? Non-governmental organizations? Regulators? That has not yet been decided.

P.J. HALLINGTON (United Kingdom): BNFL embarked on a process of stakeholder dialogue in 1998, after the old ‘decide, announce and defend’ approach had proved to be unsuccessful, and I should like to share with you some of the things that we have learned from it.

We have learned that really communicating with stakeholders is not easy, but when one starts to get it right, the rewards can be significant. We are now working towards an approach based on defining, gaining agreement — or at least acceptance — and then implementing, because we recognize that the issues are not just technical but also ethical and social.

We are not reaching out to the general public but to organizations, agencies and individuals with a more immediate interest in the decisions that have to be taken, for example, our shareholders, our regulators, governmental agencies, non-governmental organizations, local people, the workforce, the relevant trade unions and plant management.

Working groups have been set up to consider issues such as spent fuel management options (including reprocessing), plutonium management and radioactive waste (including radioactive discharges).

The stakeholder dialogue process is being independently facilitated by the Environment Council, and I recommend that you visit the Environment Council's web site (www.the-environment-council.org.uk).

All participants in the stakeholder dialogue process seem to have developed an understanding of and a respect for alternative points of view, and we now have a sharper awareness of the potential impact of environmental and social factors on BNFL's business. Also, there now seems to be a common view regarding the validity of certain key sets of data, so that these are no longer being argued about.

We have learned the importance of patience and of trusting people to make proper use of the information we provide, and so far our trust has been justified.

Our experience could be summarized by the sentence: 'It's good to talk.'

R. NOCILLA (USA): I should like to acquaint you with a stakeholder and public participant process relating to the Nevada test site, which covers an area larger than Luxembourg. The test site is surrounded by land controlled by the US Department of Defense, which restricts access to it. Sixty-five miles to the south-east is Las Vegas, and 25 miles south-east of Las Vegas is the Hoover Dam. More than 900 atmospheric and underground tests were conducted at the site.

In 1989, the US Department of Energy's Environmental Management Office was created to deal with contaminated waste from 16 sites. The creation of the Environmental Management Office was accompanied by the adoption of regulations governing restoration and management of the sites through the National Environmental Protection Act, which required all federal agencies to consider the impact of their activities on the public and the environment. A Public Participation Plan resulted in the formation of 11 site specific advisory boards and made public participation and government outreach mandatory.

Each site specific advisory board has its own by-laws and structure and its own major environmental issues. The members are a cross-section of the public: professionals and non-professionals, some of them activists, who respond to advertised solicitations for members.

As far as the Nevada test site is concerned, the focus is on waste management, the underground test area, transport issues and stewardship.

The way in which the stakeholder and public participant process works may be illustrated by an example from 1995, when the US Department of Energy issued a draft waste management environmental impact statement covering low level waste, mixed low level waste, transuranic waste, high level waste and hazardous waste. Four options were considered: (i) no action; (ii) decentralization, with the waste stored at the generation sites; (iii) regionalized disposal, with the waste shipped to a dozen districts for disposal; and (iv) centralized disposal at two sites (Hanford and the Nevada test site). A 90-day comment period was later extended by 60 days. During the initial period, notices inviting comments were published in newspapers and more than 1100 invitations to comment were mailed to community, state and national leaders, activist groups and tribal leaders — in addition to the invitations mailed to all persons who had registered at site specific advisory board meetings.

That effort, which brought in more than 1200 responses from the public, resulted in the rerouting of low level waste shipments to avoid the densely populated area of Las Vegas, the road over the Hoover Dam and places sacred to native Americans — involving a 265 mile increase in the distance to be covered, which increased the accident risk, especially as transport of the waste now takes place entirely over secondary (two-lane) roads. The change was made, at great cost to taxpayers, despite risk analyses which show that the traditional route involves the lowest risk. It demonstrates the Government's willingness to respond to public concerns where feasible. The appendix to the final waste management environmental impact statement contains each comment submitted by the public with the US Department of Energy's response; it shows that the Government listened.

E.A. ATHERTON (United Kingdom): Young people are tomorrow's stakeholders, and I think it is important to engage them while they are still young. I like what is being done by K. Sullivan, by the SKB and by Nirex in that connection. The SKB has produced an information package for schools, on CD-ROM, and Nirex together with Lancaster University have designed a web site especially for young people.

In my view, broad environmental issues should be included in the national school curriculum, so that future generations are socially more aware, and young people should even be invited to participate in events like this conference.

P.A. BROWN (Canada): In Canada, the Nuclear Fuel Waste Bureau has a web site (www.nfwbureau.gc.ca) with a section designed essentially for young people.

Y. Le BARS (France): The topic of radioactive waste is controversial, and teachers are not always in favour of radioactive waste issues being introduced at schools. ANDRA stopped trying to introduce such issues at schools some time ago, as it was being regarded as an advocate of nuclear power. It is now trying to gain the support of independent external bodies.

R. NOCILLA (USA): In Nevada, several Governors, Congressmen and Congresswomen, and Senators have over the years been elected on an anti-nuclear platform, so that it has been very difficult to persuade school district authorities to invite pro-nuclear speakers on radioactive waste management issues.

I believe that the Oak Ridge National Laboratory has a very successful programme for engaging high school students.

C. THEGERSTRÖM (Sweden): It is very important to engage young people, but we must be careful when dealing with persons, groups or organizations claiming to speak for future generations. All of us, with our multitude of values and perspectives, must speak for future generations, each with its multitude of values and perspectives.

I.R. HALL (United Kingdom): Young people are among the targets of our Scotland web site (www.Scotland.gov.uk/publications).

On that web site, you will find the results of a survey which we carried out in Scotland and from which we concluded, after detailed discussions in focus groups, that people did not want to decide themselves what should be done with radioactive waste — what they wanted was 'ownership' in the decision.

We also found that young people obtained a lot of information from the media but treated that information with a healthy scepticism. Another disquieting point, however, was that they seemed to obtain much of their 'information' from films featuring the cartoon character Homer Simpson, who works at a fictitious nuclear power plant in the United States of America and does things like taking spent fuel rods home to show to the children.

The survey showed that young people were well aware of the huge technological advances made in recent decades, and in that connection I was wondering whether the support among stakeholders and in the general public for retrievability was based on the assumption that further huge technological advances will open up new possibilities for dealing with radioactive waste.

C. MURRAY (United Kingdom): That is a possibility, but it could also be based on a profound distrust of science and scientists. Stakeholders and the general public would like to have flexibility in order that what has been done may be undone. However, having brought scientists who used to firmly maintain that repositories would have to be closed to the point where they admit that closure is not a scientific necessity, stakeholders and the general public may decide that they do not want retrievability after all.

M. AEBERSOLD (Switzerland): I should like to make three points.

Firstly, I think it would be useful to agree on what we mean by ‘young people’.

Secondly, in a country where the public elects people to serve in a parliament or a similar legislative body and also takes part in referendums, it is not clear whether it is more democratic to leave the decision making to the elected politicians or to decide by referendum. That is a question which we are currently discussing in Switzerland.

Thirdly, when we talk about ‘public acceptance’, it is not clear whether we are thinking of acceptance at the local level, the regional level or the national level. What does ‘public acceptance’ mean in the case of, say, Nevada?

R. NOCILLA (USA): In Nevada, there are very few people participating in the consideration of radioactive waste management issues, but they constitute a fairly good cross-section of the general public — everything from activists through engineers and physicists to housewives.

M.V. FEDERLINE (USA): Regarding M. Aebersold’s point about the decision making process, I would note that the decision making process varies from country to country. In the USA, it is based on a system of checks and balances involving the executive branch and the legislative branch. That system has been applied with regard to the Yucca Mountain site, with the focus on the people in Nevada who have opposed the site’s being used for radioactive waste disposal.

C. THEGERSTRÖM (Sweden): Regarding M. Aebersold’s point about ‘young people’, the SKB is trying to involve people aged 15 years or more in discussions and information exchange. However, it is prepared to interact with younger people if they so wish.

Regarding M. Aebersold’s point about decision making, the SKB wants the process in Sweden to be based on the country’s long standing system of representative democracy, local acceptance being ‘signalled’ by a decision of the municipal council and national acceptance being ‘signalled’ by a governmental decision enjoying parliamentary support.

However, there is a mechanism whereby representatives elected at the local or the national level may call for a local or a national referendum, and two referendums have been held in Sweden. For its part, the SKB just has to adapt to the rules of the game.

In addition to what I have called ‘local acceptance’ and ‘national acceptance’, which constitute formal acceptance by elected representatives, there has to be ‘informal acceptance’ by the people in the host municipality who will be directly affected by, for example, nearby construction work and/or will ultimately have a deep geological repository beneath their homes.

P.A. BROWN (Canada): The meaning of 'public acceptance' depends on the circumstances: in the case of a local cleanup, local acceptance is extremely important; in the case of a national programme, things become more complicated.

A few years ago, for example, a proposal for disposing of nuclear fuel waste in the Canadian Shield was deemed by a government appointed panel not to be publicly acceptable. Two questions not answered, however, were what was meant by 'the public' (the local population, the regional population or the nation as a whole?) and what was meant by 'acceptance' (for example, acceptance by 50% plus one of 'the public'?). The Government remained silent on those two questions.

We are now thinking in terms of 'public confidence' in an open, transparent process.

K. SULLIVAN (Educators for Social Responsibility): I should like to ask once again whether we are interested in public acceptance of what the nuclear industry wants or a true participatory process where all parties are prepared to modify their positions in the interests of a compromise.

The question of engaging young people is a tricky one. The educational material produced by, say, the American Nuclear Society is going to differ from that produced by, say, the Friends of the Earth. How can the issue of radioactive waste management be addressed responsibly when there is educational material reflecting many different points of view?

I was pleased to learn from P.A. Brown that in Canada, a great deal of attention is being paid to the knowledge and expertise of aboriginal communities. Some of you may know that aboriginal people in North America, when taking a decision with a possible long term impact, consider how it will affect the seventh future generation. Perhaps the nuclear industry should think likewise and abandon all ideas of building new power plants — the 'no new build' approach.

C. THEGERSTRÖM (Sweden): K. Sullivan talked about people modifying their positions in the interests of a compromise. That is highly desirable, of course, and it can happen. One should remember, however, that the different participants in a consultation process about radioactive waste management may well be bearing different burdens of responsibility. In Sweden, for example, the SKB bears a heavier burden of responsibility than many of its interlocutors.

Y. Le BARS (France): The process of involving stakeholders must be a genuine interaction without a predetermined outcome. It should be an iterative process, and for that plenty of time is necessary.

We in the nuclear industry need to learn from past failures, and we need to be organized for the dialogue in such a way that we can follow the stakeholders' agenda.

With the involvement of stakeholders, the optimum solution will differ from the technicians' solution. It may not be the solution making for the highest level of safety, but society can cope with that, through measures such as monitoring.

I am pleased with the way in which stakeholders have become involved interactively in decision making processes at the local level in France, but feel that there has been less success at the national level.

C. MURRAY (United Kingdom): Further to what I said just now about stakeholders and the general public bringing scientists to admit that the closure of repositories is not a scientific necessity, I would mention that for about ten years, we at Nirex maintained that retrievability was a bad idea. Then we were forced by people to look at it more closely. We asked our scientists whether retrievability with adequate safety was feasible, and we saw how their mindset changed. Ultimately, we had to admit that we had been wrong.

Regarding K. Sullivan's comment about the 'no new build' approach, I would mention that Nirex is not a proponent of 'new build'; there are people working for Nirex who favour 'new build' and people who favour 'no new build'. However, Nirex, which has a responsibility for dealing with the nuclear waste that already exists, believes that it would be irresponsible not to prepare to deal with the nuclear waste that will arise if the United Kingdom opts for 'new build'.

J. GREEVES (USA): We have been talking about, inter alia, retrievability and future generations. In my view, the best thing we can do is to build retrievability into the geological repositories that are going to be constructed, getting the science right. That means trusting future generations to educate themselves so that one of them will be able to close those repositories safely when it decides that the time has come to do so.

L.R. SCHNEIDER (Germany): As an illustration of the changes that can occur from one generation to the next, I should like to recount briefly what happened with the Morsleben repository for low and intermediate level waste in the former German Democratic Republic.

During the site selection process, we did not have stakeholder involvement of the kind being discussed here; the local people welcomed the repository as a source of employment.

After German reunification, it was established that there were no technical problems associated with the operation of the repository. For the people of the former German Democratic Republic, however, reunification brought with it new laws and regulations and, following a 'religious' confrontation between the Socialist–Green Federal Government of Germany and the Christian Democrat Government of the 'Land' of Saxony-Anhalt, where Morsleben is situated, a decision was taken to close the repository, although it was only about 60% full. The decision was taken on purely political grounds.

A. NIES (Germany): When should stakeholders become involved in the siting process? In my view, they should become involved at the very beginning, when the ‘rules of the game’ are being worked out.

At the same time, it must be clear from the very beginning that the end point of the siting process is to be the designation of a site for a repository. Only in that way can one ensure that the process will not break down, resulting in a return to square one — as has happened in the UK.

M.V. FEDERLINE (USA): I now invite concluding remarks from each of the Panel members.

T. FLÜELER (Switzerland): I agree with what A. Nies and R. Shropshire just said about the end point of the siting process. We should make it clear to the stakeholders what the end point of the siting process is to be.

P.A. BROWN (Canada): Uncertainties about the future are one reason why in Canada it is the Federal Government that takes siting decisions. It is felt that, although governments change as part of the democratic process, a decision taken by the Federal Government is likely to stand the test of time.

With regard to Port Hope, the community did not want the waste to be put into caverns below the surface; it preferred a mound on the surface. The Federal Government decided that, as long as all health and safety requirements were met, the community’s wishes should be acceded to, and that is what is happening.

C. THEGERSTRÖM (Sweden): Nuclear waste is a national problem, whereas the solution has to be a local solution. This means that strict siting rules may well be established before any potential sites have been identified, without the involvement of the people living near the potential sites. We have tried to be flexible and involve local people in the formulation of some of the siting rules, and the results have been encouraging.

Another problem is that some stakeholders do not know that they are stakeholders — or do not know in what way they are stakeholders — until the siting process is perhaps well under way. However, that is a problem we simply have to live with.

Lastly, I would emphasize that our consultation process is not a consensus process. All stakeholders have the right to express their opinions and to be told what influence their opinions have had, and in that connection it is important that there be a clear time frame — so that the stakeholders know that certain decisions have to be taken by certain dates. The process should be transparent, but in the interests of transparency, we should tell the stakeholders that not everyone will necessarily agree with what is finally decided.

C. MURRAY (United Kingdom): If you opt for retrievability, you will need monitoring of the waste by a long lived organization that renews itself, that it is an honour to belong to, and that is seen to have high environmental standards; and there will also have to be monitoring of society.

I do not agree that from the very beginning of the siting process, it must be clear that the end point is to be the designation of a site for a repository. In my view, in a democracy there must be consultations about options and, if most people want the country's radioactive waste to be left on the surface for whatever reason, that is the option which should be implemented.

Y. Le BARS (France): It is expected that the OECD/NEA Forum on Stakeholder Confidence will provide a framework within which countries can learn from one another's experience, due regard being paid to the historical, political and social context in each country.

Through the Forum, I have learned a lot about the stakeholder involvement process in France — the problems already solved, the weaknesses and the new challenges — and I imagine that others have also learned a lot about the stakeholder involvement processes in their countries. I hope that there will be a useful exchange of lessons learned at the Forum's next meeting.

P.J. HALLINGTON (United Kingdom): The consultation process now under way in the UK will last until 2007, and the consultations are only on how to begin addressing the major issues. The existing waste is being managed safety, so there is no time pressure. We in the industry would like to see a move towards increasingly passive storage for, say, 100 to 150 years, to allow time for the necessary decisions to be taken and the necessary institutional arrangements to be made.

INTERNATIONAL REGIME FOR THE SAFETY OF RADIOACTIVE WASTE MANAGEMENT

(Session 10)

Chairperson

A.-C. LACOSTE
France

THE NEED FOR A BINDING INTERNATIONAL SAFETY REGIME
The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (the Joint Convention)

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1. INTRODUCTION

The aim of the present paper is to discuss the binding international undertakings in the field of nuclear safety with special reference to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (the Joint Convention). The main questions considered are the following:

— What led to the adoption of these instruments?
— What benefits are expected to derive from their implementation?
— What, in particular, led to the adoption of the Joint Convention?
— What may result from it in the longer term?
— Has a binding international safety regime now been achieved?

2. THE JOINT CONVENTION: STATUS, STRUCTURE AND MAIN PROVISIONS

The Joint Convention entered into force on 18 June 2001, that is, pursuant to Article 40 on the 90th day after the day of deposit of the 25th instrument of ratification, including the instruments of 15 States, each having an operational nuclear power plant. To date, the Joint Convention has been signed by 42 States and has 30 Contracting Parties. The Contracting Parties are predominantly from Europe: 14 of them are members of the European Union, 8 are European Union enlargement countries, others are neighbours on the European continent (Croatia, Belarus, Norway, Switzerland, the Ukraine). It is, however, by no means a European convention. Other regions are represented at present by one country per region only: Argentina (Latin America), Canada (North America), Morocco (Africa), Republic of Korea (Asia). The geographic composition of the group of Contracting Parties, though not addressed in the

Convention, is not irrelevant for its implementation. Notably, it may be expected that in the foreseeable future, the closely knit group of the European Union, plus European Union enlargement States, will further develop in the area of nuclear safety a stronger bond of common legal denominators, binding directives and agreed regulations, than will exist among geographically distant separate States.

To recall briefly the structure and content of the Joint Convention: it is set out as a 'joint' legal structure by combining two discrete subject matters, namely spent fuel management and radioactive waste management. Common and separate Chapters address the two subjects. The Preamble covers the subject matter of both, as does Chapter 1 on 'Objectives, Definitions and Scope of Application'. In order to define the purposes of the Joint Convention, three sets of objectives are announced:

— General nuclear safety objective,
— Radiation protection objective,
— Technical safety objectives.

Article 3, which provides for the scope of application of the Joint Convention, reflects (as analysed below) the compromise reached regarding the wish for comprehensiveness.

The obligations to be undertaken by Contracting Parties are of two different types, similarly to those provided for by the Convention on Nuclear Safety. The first category of obligations are of a general nature, also called 'obligations de moyens' or 'best efforts' obligations. They are laid out in Chapters 2, 3 and 4. The second category, defined as 'obligations de résultat' further described below, are of a strict nature, directly binding on the Contracting Party. Under the first type of obligations, each Contracting Party is required to take the appropriate legislative, regulatory and administrative measures as set forth in the Joint Convention. These measures are based on the IAEA Safety Series Document No. 111-F, The Principles of Radioactive Waste Management. The phrase used in introducing these measures, "within the context of its national law", simply refers to the national legal order. It could, however, also be interpreted as dispensing the State from enacting new legislation to comply with its obligations under the convention, if relevant legislation is already in place. Chapters 2 and 3 contain parallel sets of requirements governing the "safety of spent fuel management" and the "safety of radioactive waste management". Chapter 4 on "General Safety Provisions" regroups all requirements which apply to the safety of both spent fuel management and radioactive waste management. Chapter 5 "Miscellaneous Provisions" provides for a further expansion of the scope of application of the

Joint Convention by including the transboundary movement of spent fuel and radioactive waste and, in a separate Article, added provisions concerning disused sealed sources.

Chapters 6 and 7 apply again to both spent fuel and radioactive waste. Chapter 6 provides for the "Meetings of the Contracting Parties" and their preparatory process. The obligations laid out in that chapter are, however, of a different nature from the obligations described above: both the obligation to attend the Review Meetings and the obligation to submit national reports to them are directly binding on the Contracting Parties. The Contracting Party must attend the Meeting and must report to it. These obligations also involve compliance with detailed guidelines for reporting. Article 32 on Reporting reflects the broad scope of application of the Joint Convention by requiring national reports to address, inter alia, radioactive waste and spent fuel management policies and practices, to include lists of facilities and inventories of spent fuel management facilities, of radioactive waste storage, disposal, location of past practices and a list of nuclear facilities in the process of being decommissioned.

The final clauses cover "resolution of disagreement", a phrase that replaces the usual settlement of dispute clause of most international instruments by a specific consultation mechanism within the framework of the Meeting of Contracting Parties. It can be argued that this provision well reflects the 'peer group' spirit of the Joint Convention. Only as a last resort, recourse can be made to mediation, conciliation and arbitration as provided for in international law. This Chapter also covers "Reservations, signature, ratification, acceptance and approval, accession". (The latter, Article 29 4. (i), also provides for accession by regional organizations of integration or other nature, i.e. a reference to the European Union. In this context, the European Commission may claim competence in respect of matters covered by the Joint Convention, notably under Article 35 et al. of the Euratom Treaty.)

The provisions concerning the Secretariat (Article 37) do not create a special convention secretariat but, modelled on the Convention on Nuclear Safety, establish that the IAEA shall provide the secretariat for the Meetings of the Contracting Parties. The duties incumbent upon the IAEA are listed, i.e. to act as the conference secretariat at costs included in the IAEA's regular budget, and to provide other services if requested to do so by consensus and, if financed, either under the regular budget or through voluntary funding. The conditions can be seen as further limiting the potentially substantive role of the Secretariat.

Five years after its adoption, the Joint Convention has now reached the stage of implementation: in fact, the first step required by the Joint Convention, the Preparatory Meeting of the Contracting Parties (provided for in Article 29) was held in December 2001, six months after entry into force of the Joint Convention. The Preparatory Meeting approved the documents needed for the functioning of the first Review Meeting, including:

— The Rules of Procedure and Financial Rules;
— Guidelines regarding the Review Process (which also establishes a tentative time chart for submission of the national reports);
— Guidelines regarding the Form and Structure of National Reports. After the Organizational Meeting of 7–9 April 2003, the First Review Meeting is scheduled to take place in November of the same year.

3. THE NUCLEAR SAFETY REGIME

The Joint Convention is the fifth international instrument concerned essentially with matters of nuclear safety which has entered into force over the last 15 years [1, 2, 3]. To recall briefly, these instruments are the following:

— The Convention on the Physical Protection of Nuclear Material 1987, CPPNM (which is both safety and security related);
— The Convention on Early Notification of a Nuclear Accident, 1986;
— The Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, 1987;
— The Convention on Nuclear Safety, 1997;
— The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, 2001.

Other conventions adopted in the 1960s, originally on a regional rather than a universal basis, that now constitute the international nuclear liability regime are usually not included among the nuclear safety conventions. These instruments concern liability and compensation for damage caused in case of nuclear accidents and establish relevant rules and procedures. Their origins, initial motivations and legal structure, however, are different from the safety conventions.

The five conventions listed are the pillars of what is referred to here as 'the international binding nuclear safety regime'. They have broad common objectives and common characteristics. In particular, the two conventions adopted after the Chernobyl accident have been elaborated together; the Convention on Nuclear Safety served as a model structure for the Joint Convention. The CPPNM, presently under revision, is a somewhat different instrument. An important common denominator is the process which led to the adoption of these conventions: all drafted and negotiated by government appointed legal and technical experts convened under the auspices of the IAEA, the conventions were adopted rapidly by short diplomatic conferences. The conventions are universal in outlook and are based on specific existing internationally established safety standards, guides and guidelines which determine their substantive technical content. In fact, the conventions could be seen as international non-binding safety standards elevated to international binding safety norms.

A further common point is that despite the dominant part played by the IAEA in the initiative, the process of establishment, and the substantive travaux préparatoires of these conventions, the specific role attributed to the IAEA's Secretariat in their implementation is extremely limited. The Director General of the IAEA is the Depositary of the Convention, and the Secretariat acts as the convenor and conference service for the meetings of the Contracting Parties, and transmits relevant information among them. Other functions performed by the Secretariat in the preparation and implementation of meetings of the Contracting Parties are of an ad hoc nature.

No general international monitoring or control, and no international supervision or verification of the national reporting obligations are provided. It may be worth noting in this context that despite the influence of current international environmental law on the contents and the preparatory processes, notably for the Convention on Nuclear Safety and the Joint Convention, none of the United Nations Environmental Programme type convention secretariat mechanisms (as, for instance, the Basel Convention Secretariat or the Climate Change Conventions Secretariat) has been introduced in the relevant provisions. The main reason being, arguably, that regardless of the high level of international co-operation aimed at in these conventions, the prime responsibility of the State for all nuclear activities and safety related responsibilities has been fully upheld. So far, this is also true for the European Union (EU) legislation which has excluded all attempts at introducing supranational concepts or international mechanism of verification or monitoring into the agreed nuclear safety norms. The State assumes the responsibility for making 'best efforts' in applying 'best practices', thereby complying with its legal obligations under the international instruments.

However, an innovative approach to create a transparent review of compliance by the Contracting Parties was introduced in the Convention on Nuclear Safety, and followed by the Joint Convention, namely, the Peer Review mechanism. Instead of entrusting an international Secretariat with the task of monitoring compliance, the Peer Review ensures mutual and collective monitoring and control of and by the Contracting Parties in the framework of the strict obligation to report to the (regular) Review Meetings of the Parties.

None of the nuclear safety conventions provides for any form of international sanctions. The provisions of the Convention on the Physical Protection of Nuclear Materials (CPPNM) regarding duty to arrest in case of violations, punishment of offences, etc. are implemented exclusively within the national legal order. The legal obligation of the Contracting Party is to enact provisions in its penal law that make certain offences punishable and to act, if necessary, on the basis of bilateral treaties to be concluded separately. The absence of a mechanism for the verification of compliance and the absence of international sanctions also stand out as a fundamental difference between the nuclear safety related conventions and the Treaty of the Non-Proliferation of Nuclear Weapons based safeguards agreements. Proposals made during the travaux préparatoires for the Convention on Nuclear Safety and, again in the context of the Joint Convention, to introduce elements comparable to the verification of non-proliferation commitments have in both cases been rejected by a majority of the negotiating States.

The binding nature of the safety regime, that is, the obligation of the Contracting Party to comply, is therefore vested exclusively in the review process. It is the mode of operation of the conventions, coupled with the intent of the Contracting Party to abide by its commitments through submitting its national report to the scrutiny of the Peer Review, that are determinant for the binding nature of the safety regime. The contribution of the conventions to creating an international binding regime will be measurable through the reality of State practice.

4. ORIGINS AND MAIN ELEMENTS OF THE JOINT CONVENTION: THE DOMINANT ISSUE OF SCOPE

During the negotiation process of the Convention on Nuclear Safety, a few States and with them, environmentalist movements, argued that all safety issues related to the production of nuclear energy, including those related to the management of radioactive waste, should be covered by that convention. No consensus was reached on such a comprehensive approach. The political will for rapid adoption of the convention, notably by countries with larger nuclear programmes as well as by the States with reactors built to earlier standards, led to agreement to limit the scope of the convention to “civil nuclear power plants”. It was, however, also agreed to include in Paragraph (ix) of the Preamble of that convention a somewhat unusual commitment “to begin promptly the development of an international convention on the safety of radioactive waste management as soon as the ongoing process to develop waste management safety fundamentals has resulted in broad international agreement".

In September 1994, the General Conference of the International Atomic Energy Agency took the decision "to commence preparations for a Convention on the Safety of Radioactive Waste Management". In 1995, the Board of Governors of the International Atomic Energy Agency approved the convening of an Open-ended Group of Technical and Legal Experts and, separately, adopted the relevant Safety Series Document on the Principles of Radioactive Waste Management (No. 111-F), the sine qua non basis for the drafting of relevant technical norms. The Group of Experts open to all States met in July 1995 and elected A.J. Baer, then Director General of the Swiss Federal Office for Energy, as its Chairperson.

It took the Group of Experts and its indefatigable Chairperson six sessions to resolve the technical, political and legal issues of the convention. First and foremost, however, was the question of the convention's scope of application. Agreement was reached on a delimitation of the scope of application in relation to the Convention on Nuclear Safety, in order to avoid gaps and overlaps between the two instruments, a technical problem easy to translate into legal terms. However, contrary to the Convention on Nuclear Safety, a number of political issues regarding the scope of application emerged and became the most controversial and multifaceted question of the preparatory process.

In fact, several distinct questions regarding the scope emerged. Finally, all were settled in an almost holistic mode by way of inclusion and agglutination: the potentially most divisive issue was whether an instrument covering radioactive waste should also include safety issues associated with spent fuel. Could, indeed, spent fuel — which is considered by some countries as a valuable resource and part of the energy production cycle — be legally included in any definition of radioactive waste, or even loosely associated with the standard definition of waste, i.e. "material for which no further use is foreseen"?

Contrary to the spirit prevailing among the experts who negotiated the Convention on Nuclear Safety, it was the wish to achieve an all inclusive instrument, and to cover all related matters, rather than leaving unfinished business and postponing the issue of spent fuel to another international law-making exercise that prevailed. The Group of Experts reached consensus on a proposal submitted by France for a single convention with two parallel sets of requirements: on the safety of spent fuel management and on the safety of radioactive waste management, respectively, reflecting the logical sequence of the nuclear fuel cycle.

An equally difficult question of coverage to be solved was whether and if so, to what extent, radioactive waste and spent fuel resulting from military or defence programmes under the jurisdiction of States with nuclear weapons could be included under the scope of the convention. After much negotiation conducted with unusual transparency in open-ended subgroups, essentially among the States with such programmes, radioactive waste and spent fuel were dealt with as a package and included with a combination of voluntary submission and mandatory inclusion.

A further controversial issue in the negotiation was that of drafting binding norms regarding the transboundary movement of spent fuel or radioactive waste. First, it had to be clearly established that 'transboundary movement' was not the same as 'transport' and that therefore, as was later formulated, "nothing in [this] Convention prejudices or affects the exercise by ships and aircrafts of all States, of maritime, river and air navigation rights and freedoms, as provided for in international law" (A article 27 (3)(I)). The Joint Convention was not intended to create new international law in the field of transport or navigation. Moreover, many States had enacted national laws which had to be taken into account, prohibiting final disposal of foreign origin waste, the export and even transit of waste. Also, the 1990 IAEA Code of Practice on the International Transboundary Movement of Radioactive Waste [4] had to be integrated into the instrument. Another item that was not covered by any international instrument had to be taken up: the so-called disused sealed sources which, depending on the applicable technical definition, may be considered to be or not to be radioactive waste but which, in any case, involved radiation safety hazards that had to be addressed.

Thus, the broad scope of application of the Joint Convention provides an essential contribution to closing the gaps left by earlier instruments in the international safety regime. At the same time, however, the diversity of waste management activities and the variety of radioactive wastes covered by this instrument may have acted for countries with a large nuclear programme as a hurdle for a rapid ratification. After adoption of the Joint Convention by the Diplomatic Conference, it had indeed been expected that the convention would enter into force without much delay, following the example set by its sister convention. It took five years, however, for the Joint Convention to enter into force. The diversity of subject matters included in the scope of application may also render implementation of the convention more cumbersome, notably with respect to the reporting obligation and the review process in the Meeting of Contracting Parties. Whereas the main object of reporting for the Convention on Nuclear Safety is the safety of civil nuclear power plants for the States where they are located and their neighbours, the Review Meetings of the Joint Convention will address reports covering a very wide array of materials, facilities and situations.

5. ORIGINS OF THE INTERNATIONAL SAFETY REGIME: WHAT LED TO THE ADOPTION OF THESE CONVENTIONS?

It is a simplification to trace all international norm making regarding nuclear safety to the 1986 Chernobyl tragedy. The IAEA's Statute authorized establishment or adoption of standards of safety and their application. From its beginnings, the nuclear industry in co-operation with governments have promoted civil liability norms. The comprehensive and coherent body of safety rules and guides created since the development of peaceful nuclear activities demonstrate the desire for establishing safety rules for nuclear activities to be applicable worldwide.

It is a fact, however, that for a very long time the international approach to nuclear safety norms remained that of harmonization of technical know-how and 'gentlemen's agreements' on common standards, understood as rules of good conduct that are both adopted and applied by an essentially closed group of nuclear technicians and regulators. Neither lawmakers nor the public were involved.

The main obstacle to the establishment of binding international instruments versus harmonized standards was, and remains to some extent until now, the generally accepted rule — or real doctrine of international nuclear law — that the prime and ultimate responsibility for nuclear safety rests with the sovereign State having jurisdiction over the nuclear installation. The transboundary nature of nuclear accidents created a perception of safety interdependence of sovereign States, calling for internationally binding rules.

"The evident need for greater cooperation in nuclear safety" and the intent to "draft on an urgent basis, international agreements" was not readily accepted before 1986, when the Board of Governors of the International Atomic Energy Agency considered the accident in the Chernobyl Nuclear Power Station "and other accidents in the past". In this context, Chernobyl was no doubt in today's language, the nuclear safety wake-up call. The ensuing international effort at establishing international law remained, however, limited to filling the gaps perceived in the post-Chernobyl disarray, namely, the question of information exchange (the source of information, the nature of data and the transmission procedures) before the Internet; the need to at last embody in positive law the notification obligation of States; and the absence of widely established emergency assistance procedures for such accidents.

However, it took the international community another few years to come to the conclusion that there was "a need to consider an integrated international approach to all aspects of nuclear safety", including safety objectives for radioactive wastes which would be adopted by all governments [5].

In the meantime, other developments had taken place which were to exert a strong but not always welcome influence on the nuclear community, and break a few former taboos. The holistic approach of environmental law-making successfully opposed the clean specialization by sectors and subsectors of the existing international nuclear norms; the new dogma of internationalization of all environmental concerns was anathema to the basic precept of national sovereignty regarding nuclear activities and the management of their safety.

It is, therefore, clear that the rapid development of international environmental law, assisted by a groundswell of political support worldwide since the late 1970s, provided a definite impetus for international law-making in the area of nuclear safety. It had led to the Basel Convention, the Montreal Protocol, the London Dumping Convention and its Amendment, the completion of the United Nations Convention on the Law of the Sea (UNCLOS) and of course, in 1992, the United Nations Conference on Environment and Development (Agenda 21, often referred to as the Rio Declaration). The international environmental regime in the making threatened to take over and cover issues of nuclear safety wherever their promoters perceived gaps. In this context, legal provisions concerning the transboundary movement of radioactive waste were originally included in the Basel Convention, with the proviso that this should remain so until another international binding instrument would specifically address this matter. This was satisfactorily dealt with under the Joint Convention. Moreover, the concern about accidents in nuclear power plants was accompanied by the 'fear of waste', first motivated by cases of illicit disposal of chemical and toxic waste — the horror of uncontrolled or criminal waste dumping on the shores of victimized developing countries. The call for binding international nuclear waste law was on the international agenda.

6. A COMPREHENSIVE BINDING INTERNATIONAL NUCLEAR SAFETY REGIME?

Could it now be concluded that the international community has finally created a comprehensive nuclear safety regime covering the siting, construction and operation of nuclear power plants, the physical protection of nuclear material (so far in international transport), the notification of accidents and procedures for mutual assistance should such accidents occur, as well as the safe management of radioactive waste and of spent fuel?

Without creating a specific nuclear law definition for 'regime', as the term is used rather loosely, it may be useful to clarify what is understood in the present context as 'binding international safety regime'. In fact, the term ‘regime’ is most frequently used in political science with reference to forms of government, for example, a democratic or military regime. In international law, ‘regime’ implies a set of rules applicable to a specific situation, such as UNCLOS which refers to the “regime of passage through straits”; generally, the term is found in the context of international navigation. More recently, the concept of ‘international regime’ has been applied to describe a set of norms in international environmental law [6].

In the present context, the concept of ‘international binding regime’ is meant to include the conventions discussed, and the national implementation legislation adopted, as well as — at both the international and the national level — the ‘soft law’ instruments, i.e. the Standards, Guidelines, Guides and Codes, developed and applied by States in the nuclear safety area. The regime in place is in fact made of the plurality of norms and rules, positive law and State practice combined, aimed at the same objective, namely, to enhance the safety of all nuclear activities.

7. BENEFITS EXPECTED FROM THE JOINT CONVENTION

As noted above, the fear of radioactive waste, ignorance about its possible hazards, its location, its transportation and final disposal have contributed to the development of anti-nuclear sentiments in all regions, including in a large number of countries which are Party to the Joint Convention. Accidents and incidents that occurred in distant locations even without any possible transboundary effects have triggered irrational concern. Measures taken at the national level are today not sufficient to respond to these public concerns.

To react to public concern, a binding international instrument that is transformed into national law after being debated and ratified by a national parliament would rightly be perceived by public opinion as a message of transparency. A convention that is adopted by many States, by the neighbours and by countries with similar nuclear programmes, will demonstrate that there are common solutions to common problems, and that the experience acquired in one country may be applied by another one. It also shows that the same ground rules apply in a verifiable manner to different countries with different nuclear programmes.

The Joint Convention, in particular, contains a number of provisions that address directly some of the major public concerns. This includes, notably, the siting of waste management facilities (‘not in my backyard!’), rules applicable to past practices (a broadly shared concern of all environmentalist movements), administrative measures after the closure of facilities, the concern for future generations, transboundary movement, disused sources and, above all, the obligation of Party States to report to other States about their activities, to compare technologies and to assist each other. None of these basic issues has become obsolete since the Joint Convention was drafted.

8. OUTLOOK

It is difficult to foresee the immediate impact of the Joint Convention, considering its background and history, the relatively slow ratification process and the absence among the Contracting Parties, so far, of some of the major 'nuclear' countries. On the other hand, the Joint Convention is not in conflict with current environmental concepts and approaches, and could therefore contribute much to increase needed transparency of the radioactive waste disposal debate. It could thereby ease anti-nuclear sentiments and facilitate relevant dialogue at the national and international levels. The Meeting of Contracting Parties can set the stage for innovative technological developments by comparing common problems. The Joint Convention is also an instrument that has technical and political validity for countries regardless of the importance of their nuclear activities: the Joint Convention is relevant for States with comprehensive nuclear programmes — including military programmes — and for small, less developed countries, as it provides for the essential checklist of government institutions to be set up, principles to be observed and practical safety measures to be taken.

The Commission of the European Communities recently took an initiative aiming at creating binding law for European Union members (and the European Union enlargement States) on nuclear safety and radioactive waste management by establishing the "draft proposal for a (Euratom) Directive on the management of spent nuclear fuel and radioactive waste". In its presently available version, the draft proposal follows the letter and the spirit of the Joint Convention. This development, if implemented, may strengthen the international relevance of the review process and attract new Contracting Parties.

The first meeting of the Contracting Parties, to be held before the end of 2003, will set the pace of the Convention's own dynamics and, most probably, create a sense of common interest among the Contracting Parties.

Inevitably, new issues regarding the security of sources and of other radioactive materials can no longer be excluded from the radioactive waste agenda, and will have to be dealt with in a satisfactory manner.

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Discussion following paper by O. Jankowitsch-Prevor

G. CSULLOG (IAEA): Will the Contracting Parties to the Joint Convention make the full texts of their reports to the First Review Meeting publicly available?

O. JANKOWITSCH-PREVOR (Austria): I do not know. That is up to the individual Contracting Parties.

The Contracting Parties to the Convention on Nuclear Safety have decided, without being pressured by the IAEA's Secretariat, to make the reports prepared by them, pursuant to the Convention, available on the Web. That may come to serve as a precedent.

I would mention in this connection that the Joint Convention and the Convention on Nuclear Safety each contains an article on confidentiality.

Y. Le BARS (France): Are you aware of any information about accidents and incidents at radioactive waste management facilities like the information that is available about accidents and incidents at reactors?

O. JANKOWITSCH-PREVOR (Austria): No, I am not. I would suggest that you contact people who are familiar with the technical aspects of the Joint Convention.

During the drafting of the Joint Convention, there was general talk about accidents and incidents at radioactive waste management facilities, but I do not think that there was any discussion of specific accidents or incidents.

A.-C. LACOSTE (France): As far as I can remember, there was no such discussion.

J. HULKA (Czech Republic): Does the Joint Convention apply to NORM?

O. JANKOWITSCH-PREVOR (Austria): It can do. Article 3 (Scope of application) reads "...this Convention shall not apply to waste that contains only naturally occurring radioactive materials...unless it constitutes a disused sealed source or it is declared as radioactive waste for the purposes of this Convention by the Contracting Party."

O. JANKOWITSCH-PREVOR (Austria) [in reply to an opinion expressed concerning a degree of uncertainty about the nature of the reports which have to be prepared pursuant to the Joint Convention by the Contracting Parties, and the suggestion that the IAEA Secretariat convene a meeting of representatives of the Contracting Parties for the purpose of clarifying matters]: In December 2001, at a preparatory meeting of the Contracting Parties to the Joint Convention, "Guidelines regarding the Form and Structure of National Reports" were adopted; they have been issued in IAEA document INFCIRC/604. Also adopted at that meeting were "Rules of Procedure and Financial Rules" applicable to any meetings of the Contracting Parties (INFCIRC/602) and "Guidelines regarding the Review Process" (INFCIRC/603). These various guidelines and rules were based largely on experience gained in implementing the Convention on Nuclear Safety.

R.P. PAPE (United Kingdom): Countries that are Contracting Parties to the Convention on Nuclear Safety have already gone through the reporting process twice and have learned a lot which will be useful to them when reporting pursuant to the Joint Convention.

A.-C. LACOSTE (France): From meetings which I have had with colleagues I feel that a lot of progress has been made in the preparation of France's report for the First Review Meeting pursuant to the Joint Convention.

THE ACHIEVEMENT OF GLOBALLY APPLICABLE SAFETY STANDARDS

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Abstract

The safe management of radioactive waste is of international interest because of its implications for current and future generations. International confidence will be boosted by the introduction of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. However, the ability of Member States to demonstrate their compliance with the Joint Convention will be greatly enhanced by the availability of globally accepted safety standards. The IAEA's Commission on Safety Standards, in conjunction with the United States Department of Nuclear Safety, have been reviewing the adequacy of the current IAEA Safety Standards programme and has recently developed its policy for the delivery of universal standards for the 21st century. The vision is simple: to provide the global community with a complete and practical suite of safety standards which, when applied universally, will provide consistent standards of public and worker safety, and environmental protection worldwide.

1. INTRODUCTION

Since the beginning of the 20th century, research and development into the peaceful uses of nuclear science and technology has led to widespread applications in research, medicine, industry and the generation of electricity by nuclear fission. Nuclear technology is now universally used and, like any other industrial activity, it both yields benefits and incurs risks. Society is concerned about the hazards associated with exposure to ionizing radiation and the potential damage to the environment. There is, therefore, a need to ensure that there are appropriate levels of protection, for both the public and the environment, being applied at the international level.

The safety of transport of radioactive materials has always been regarded as requiring international standards, and the influence of the International

Commission on Radiological Protection (ICRP) has meant that radiation protection has been addressed at the international level. The accident at Chernobyl clearly demonstrated the global importance of the safety of nuclear installations. The subsequent globalization of business, technology and information has underlined the need for international safety standards to adequately ensure the protection of the public and the environment.

The IAEA has the mandate to establish such standards in the fields of nuclear safety, radiation protection, radioactive waste management and the transport of nuclear materials. Standards in all these areas have been developed and continually improved in line with experience and advances in knowledge since the 1970s. There is now a comprehensive architecture for the IAEA's Safety Standards programme. At the highest level are the Safety Fundamentals that define the key safety goals. Next are the Safety Requirements that are both facility specific and thematic, and that define the key requirements to ensure safety. Supporting these standards are the Safety Guides that provide guidance on how best to deliver the safety requirements. The architecture is completed by Safety Reports and Tecdocs which, while not subject to the same review process as the above, provide a means of rapid dissemination of safety related information.

Although the standards for nuclear power plants are comprehensive and, for the most part, up to date, there are significant gaps in other parts of the programme, notably in the area of nuclear fuel cycle facilities. These gaps, together with the need for any world class organization to check continually the quality of its products and to make improvements when necessary, have caused the IAEA to review its Safety Standards programme and make sure it is comprehensive, up to date and fit for purpose, as the world's nuclear industries progress and public expectations increase.

The aim of the present paper is to set out both a vision and a strategy for meeting the above requirements and to review the current progress with Radioactive Waste Standards.

2. VISION

The vision is simple: to provide the global community with a complete, comprehensive and fit for purpose set of safety standards which, if adopted and implemented in Member States, will provide consistent standards of protection for those who work with ionizing radiation, the public and the environment. The challenge is to convert this vision into a practical suite of documents which meets the needs of the users and which can rapidly gain universal acceptance.

The aim is to build on the substantial foundations of the current standards. However, a number of important issues will need to be addressed, which include the following:

— The architecture of the Safety Standards programme;
— The scope of the programme;
— The quality aims of the Safety Standards;
— The Safety Standards review cycle;
— The use and applicability of the Safety Standards;
— The global acceptance of the Safety Standards;
— The communication strategy to engage governments, industry, workers and the public.

If the vision is delivered, the international community will be given the Safety Standards framework it needs. However, although the framework is necessary, it will not be sufficient by itself to deliver the required standards of health, safety and environmental protection. The IAEA Safety Standards will need to be supported by an infrastructure of industry standards, including operator and vendor safety design guidelines. These industry standards, will define and deliver the detailed plant and process specific guidelines to enable plants to be designed, built and operated, and equipment processes and procedures to be produced. However, the IAEA Safety Standards framework will define the goals and inform the development of the industry standards.

3. ARCHITECTURE OF THE PROGRAMME

The current architecture of the Safety Standards programme has been developed over the years. There is considerable benefit in retaining the existing architecture that has the following main categories:

— Safety Fundamentals;
— Safety Requirements;
— Safety Guides;
— Safety Reports and TECDOCS.

4. SAFETY FUNDAMENTALS

The Safety Fundamentals are at the top of the pyramid. They present the basic objectives, concepts and principles of safety and protection in the development and application of radiation techniques, and in the use of nuclear energy for peaceful purposes. The intention is to replace the current three documents with a single document that has separate chapters devoted to the key areas of general safety, nuclear power plant safety, radiation protection, radioactive waste management, nuclear fuel cycle facility safety and nuclear materials transport.

5. SAFETY REQUIREMENTS

The Safety Requirements establish the requirements that must be met to ensure the required levels of safety and environmental protection. The Requirements are primarily standards that establish the level of performance below which the objectives and goals of the Safety Fundamentals cannot be met. The Requirements therefore use ‘shall’ statements to make it absolutely clear what is needed. It is proposed to extend the range of the Requirements documents to include both facility specific and thematic standards.

6. SAFETY GUIDES

The Safety Guides provide the more detailed actions, conditions or processes that are necessary in order to deliver the Requirements. The recommended course of action, in the form of Guides, is advisory and hence uses ‘should’ statements. The Guides include indications of current best practice among Member States. The implication is that it is necessary to take the measures recommended (or the equivalent alternative measures) as far as reasonably practicable in order to achieve locally. The intention is to mirror the Requirements and produce new Safety Guides as necessary on both facility based and thematic issues.

7. SAFETY REPORTS AND TECDOCS

Safety Reports and TECDOCS are produced as a means of providing rapid dissemination of information. These documents are not Safety Standards because they have not been produced with the same level of consultation and peer review as the Fundamentals, Requirements and Guides. However, they are regarded as a valuable contribution to the aim of enhancing international knowledge, and it is proposed to bring them more formally into the Safety Standards programme by bringing them into the Safety Committee and Commission on Safety Standards scrutiny process.

8. THE SCOPE OF THE PROGRAMME

Currently, the Safety Standards programme primarily embraces a mixture of facility specific and thematic standards. The general structure seems to be appropriate but has gaps in a number of key areas. The intention is to plug these gaps, thereby ensuring a comprehensive range of Requirements documents to include:

- Safety Management/Safety Culture;
- Quality Assurance/Quality Management;
- Legal and Governmental Infrastructure;
- Emergency Preparedness;
- Safety of Nuclear Power Plants: Design/Operation;
- Safety of Nuclear Fuel Cycle Facilities: Design/Operation;
- Safety of Research Reactors: Design/Operation;
- Safety of Radioisotope Production Facilities: Design/Operation;
- Safety of Radioactive Waste Treatment Facilities: Design/Operation;
- Safety of Radioactive Waste Storage Facilities: Design/Operation;
- Predisposal Management of Radioactive Waste including Decommissioning;
- Discharge of radioactive waste from operating installations;
- Near Surface Disposal of Radioactive Waste;
- Deep Underground Disposal of Radioactive Waste;
- International Basic Safety Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources.

9. THE STANDARDS REVIEW PROGRAMME

The Review of the Safety Standards has two main elements: the review and scrutiny of the production of the Standards, and the periodic review to reflect the need for continuous improvement.

10. SCRUTINY

The IAEA Safety Standards programme is characterized by a robust production process which ensures international acceptance and quality. The new Safety Standards are produced using a rigorous process. First, once a need has been identified, a detailed proposal is produced and submitted to the Commission on Safety Standards (CSS) for approval. Once the proposal is approved by the CSS, a draft standard is produced by consultants under the control of IAEA staff and then successively reviewed by the appropriate Safety Standards Committee. The committees include the Nuclear Safety Standards Committee (NUSSC), the Radiation Safety Standards Committee (RASSC), the Waste Safety Standards Committee (WASSC) and the Transport Safety Standards Committee (TRANSSC). These committees comprise eminent nuclear safety, radiation protection, radioactive waste and transport experts, mainly drawn from Regulators in IAEA Member States. Once the Safety Standards Committee deems the draft document suitable for external consideration, the draft is sent to Member States for comment. Only when comments from IAEA Member States have been considered, and the text has been endorsed by the appropriate committee, is the Standard submitted to the CSS for endorsement. The CSS comprises senior nuclear regulators from those IAEA Member States which have significant nuclear power programmes. The CSS has the final say on most of the Standards. However, in the case of the higher level Safety Standards, the approval of the Board of Governors of the International Atomic Energy Agency is also needed.

It is the intention to continue to involve specialist committees on nuclear, radiation, transport and waste safety. However, with the need to plug the standards gap for fuel cycle and radioactive waste facilities, there may be a need for a new committee to review Standards in these areas. Also, if there is to be greater use of cross-cutting thematic Safety Standards, the co-ordination between the committees will need to be developed further. Regulators are well qualified to review and approve the Standards. However, in the development of Requirements and Guides that are aimed at not only regulatory best practice but also industry best practice, it is necessary to involve the industry, operators and users in the process. In general, the further the Standards delve into detailed issues about how to achieve safety, the greater one would expect the involvement of operators/users to be. In the case of Safety Reports and TECDOCS, it will be expected that the operators/users will be more closely involved in the production and review process.

11. REVIEW AND CONTINUOUS IMPROVEMENT

The completeness of the Safety Standards is always a concern. The committees are best qualified to identify gaps and overlaps within their specialist area, but the CSS is in a better position to address the more demanding question of identifying gaps and overlaps between or beyond the areas covered by the four committees. It is essential to keep the Standards up to date with scientific and technological developments. However, it is also important to balance this need with the needs of the users for stability in the Standards. For external reasons, Transport Standards follow a two-year revision cycle, but this is too short for the other areas of safety. For the areas of nuclear safety, radiation protection and radioactive waste management, it is generally agreed that each Standard should be reviewed around five years after its publication and, if sufficient reason is found, the process of revision may commence. Taking into account that the revision process would take at least two years, a new revision cannot appear earlier than seven years after the original publication. If, on the basis of review after five years, it is decided that the Standard is still appropriate, it should be reviewed after a further five years.

12. SAFETY STANDARDS WORK OF THE NUSSC AND THE WASSC

To date, the NUSSC has dealt predominantly with the development of standards for nuclear reactor safety. Recently, it has also taken the lead in the preparation of fuel cycle facility safety standards. As a result, there will be several new standards to better cover the diverse range and particular hazards of nuclear fuel cycle facilities that are in operation worldwide. This extension in the NUSSC scope does not extend to installations which process, store and dispose of radioactive waste, but it will deal initially with ore conversion and enrichment, fuel fabrication, reprocessing and isotope production facilities.

The WASSC oversees the standards related to radioactive waste safety which are collectively termed the RADWASS series. These standards are divided into three main themes (known as thematic standards) covering predisposal, disposal and rehabilitation. They set out broad recommendations aimed at fulfilling the principles of radioactive waste management as set out in the IAEA Safety Series Document No. 111-F, published in 1993.

Although the WASSC leads on the waste safety standards, the NUSSC is also involved in the production of those standards relevant to its work and has therefore been consulted on several documents listed in Table 1.

13. NEXT STEPS

The WASSC is reviewing its programme with a view to developing an overall structure for the safety standards on the topic. For example, the two published Safety Requirements (WS-R-1 and WS-R-2), while repeating many objectives and general requirements from the Safety Fundamental on Waste and the Basic Safety Standards for Radiation Protection, lack the more specific requirements for various aspects of waste management. This lack of detailed

TABLE I. SAFETY STANDARDS INVOLVING NUSSC INPUT

Title of Safety Standard	Category and reference	Status
Radiation Protection and Radioactive Waste Management in the Operation of NPPs	Safety Guide NS-G-2.7	Published 2002
Decommissioning of NPPs and Research Reactors	Safety Guide WS-G-2.1	Published 1999
Decommissioning of Nuclear Fuel Cycle Facilities	Safety Guide WS-G-2.4	Published 2001
Predisposal Management of Low and Intermediate Level Radioactive Waste	Safety Guide WS-G-2.5	Publication imminent
Predisposal Management of High Level Radioactive Waste	Safety Guide WS-G-2.6	Publication imminent
Storage of Radioactive Waste	Safety Guide DS 292	With MS for comment
Safety Assessment for Nuclear and Radiation Facilities other than Reactors and Waste Repositories	Safety Guide DS 284	Final drafting stage

guidance has also been reflected in the supporting Safety Guides. For example, the three Safety Guides dealing with decommissioning approach the topic of decommissioning as an exercise in generating waste with little attention paid to the engineering aspect of decommissioning.

In general, the Safety Standards for Radioactive Waste do not provide the same level of guidance as those prepared for nuclear power plants. In addition, the use of the term ‘predisposal’ and its definition (any waste management steps carried out prior to disposal, such as pretreatment, treatment, conditioning, storage and transport activities), which also includes discharges and decommissioning, has proved to be a difficult concept to work with. Development of new safety requirements on the management of radioactive waste would help in concentrating all activities related to the topic in one document. This would open the way for developing facility specific requirements, which would focus on the design and operation of radioactive waste facilities.

The Safety Standards, by virtue of the process established for their development, do have a high degree of international acceptance. At a Meeting of the Senior Regulators during the General Conference of the International

Atomic Energy Agency, the opinion commonly expressed was that the IAEA Safety Standards are and will be the only global safety standards. However, the challenge is to broaden the perception and recognition by all governments, regulatory bodies, operators and users, as well as the public, that the application of the IAEA Safety Standards ensures a globally consistent and high level of protection of people and the environment.

The Contracting Parties to the safety related conventions — notably the Convention on Nuclear Safety and the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management — should be encouraged to use the Safety Standards as a basis for assessing their compliance with their convention obligations when preparing their national reports and conducting the reviews pursuant to these conventions. Again, this would result in more widespread use of the Safety Standards and, through the national reports, would give an indication of the extent to which the goal of universal application is being achieved.

The IAEA's Statute prescribes that the Safety Standards be applied by the IAEA to its own safety services and to assistance offered to the Member States. It is therefore the IAEA Secretariat's policy that all safety related services and assistance activities systematically make use of the Safety Standards for evaluating compliance or performance, and that all training activities in safety areas, including nuclear, radiation, waste and transport, be conducted in accordance with the Standards. This not only raises the profile of the Safety Standards but also provides opportunities for valuable feedback on their quality and usefulness. All the Safety Standards are now freely available on the IAEA web site.[1] There are, of course, various trends and issues that will provide additional stimulus to the programme of standards development. For example, the increasing rate of decommissioning giving rise to waste management issues, the need for finance to permit proper waste management, stakeholder involvement, radiation protection to the environment (examples include the European Commission's Framework for Assessment of Environmental Impact, known as FASSET, and new ICRP recommendations in 2005), the debate on long term management options (such as surface storage or deep disposal), the impact of OSPAR, the impact of IAEA developing exclusion levels, will all increase the need for understanding and competence among both operators and regulators in Member States.

[1] http://www.iaea.org/ns/committees/drafts/SStandardsPublished.htm.

14. CONCLUSION

The recent revision cycle of the IAEA's Safety Standards is moving to completion. The Standards dealing with the safety of radioactive waste management are largely complete and will be used to assist in the drafting of the new fuel cycle facility specific suite of documents, which will be overseen by the NUSSC and the WASSC. Although no plans currently exist to include waste processing, storage and disposal facility specific guides, there might be speculation that the ongoing review of the architecture of the Safety Standards may alter this position.

Discussion following paper by L.G. Williams and R.P. Pape

D.P. HODGKINSON (United Kingdom): How are cross-cutting issues like quality assurance dealt with in the IAEA's Safety Standards?

R.P. PAPE (United Kingdom): Most IAEA Safety Guides contain a couple of paragraphs about quality assurance, and there is a set of Safety Guides each devoted entirely to quality assurance in one or other of the areas covered by the Safety Standards. Some other cross-cutting issues, for example, institutional requirements, are dealt with in a similar manner.

One cross-cutting issue, safety culture, is dealt with in a report by the IAEA's International Nuclear Safety Advisory Group entitled "Key Practical Issues in Strengthening Safety Culture" (INSAG15).

T. FLÜELER (Switzerland): Has any thought been given to broadening the membership of the IAEA Safety Standards Committee so as to include stakeholders?

R.P. PAPE (United Kingdom): I would mention first that it was recently decided that representation in the committees should be open to all IAEA Member States wishing to be represented in them, not just to certain Member States.

As regards the representation of stakeholders, it is for individual Member States to decide how they will take stakeholders' views into account. In the United Kingdom, when we receive a draft safety standard for comment, we consult with a wide range of stakeholders and pass their views on to our national representatives in the Safety Standards Committees. Obviously, however, there has to be a reconciliation of differing opinions.

PANEL

AN INTERNATIONAL SAFETY REGIME — IS IT DESIRABLE? IF SO, HOW TO ACHIEVE IT?

Chairperson: **A.-C. Lacoste** (France)

Members: **J. Greeves** (United States of America)
A. Suzuki (Japan)
S. Carroll (Greenpeace International)
O. Jankowitsch-Prevor (Austria)
R.P. Pape (United Kingdom)

Panel Discussion

A. SUZUKI (Japan): I should like to address three questions: (i) What contribution can the Joint Convention make to a global safety regime? (ii) How could a global safety regime be made acceptable? (iii) How could acceptance of the regime be broadened?

Regarding the first question, I believe that the Joint Convention will make people focus on the legacy created by the various activities that have generated radioactive waste and on the need for governments to deal with it. Also, the obligation on Contracting Parties to make information available to members of the public may result in the degree of transparency necessary for public acceptance of radioactive waste management facilities.

Regarding the second question, I believe that the IAEA is doing a good job in this connection, but should play a leading role. In my view, there is a need for unification of the conceptual approach to assessing the long term hazards associated with nuclear facilities and that to assessing the short term ones. Their unification in a single, coherent approach would, I think, promote acceptance of a global safety regime.

Regarding the third question, I believe that a broader range of parties should be brought into the process of developing IAEA Safety Standards. I should like to see the establishment of a mechanism providing for more sharing of information about the nature of the Safety Standards, their content and the process by which they are developed. I should also like to see more people from outside the nuclear sector participating in safety standards development and approval.

In my view, there is a need to demonstrate the robustness of radioactive waste management facilities more systematically and more formally. Also, I believe that we need a comprehensive set of safety standards for all radioactive waste management facilities and that the IAEA should facilitate its development. However, just having the standards in place would not guarantee safety; countries would have to ensure that their facilities and activities complied with them. There would need to be flexibility in the adoption and application of the standards, but their objectives would have to be achieved. Consideration should be given to the approaches adopted for assessing and demonstrating the robustness of nuclear facilities in respect of the short term hazards which they present and the robustness of radioactive waste management facilities vis-à-vis longer term hazards.

A.L. RODNA (Romania): I like A. Suzuki's probabilistic approach to the safety assessment of radioactive waste management facilities, but I have doubts about its applicability in the case of very long lived radioisotopes, where one is talking about low probabilities but also about periods running into the millions of years.

A. SUZUKI (Japan): I appreciate your comment. It is extremely difficult to assess the probability of very long term scenarios. Making the assumptions requires a great deal of expertise.

R.P. PAPE (United Kingdom): The IAEA has issued a safety guide (WS G-1.1) on the safety assessment of near surface disposal facilities which recognizes the uncertainty problems associated with very long time periods and offers what I consider to be good advice on how to deal with those problems.

J. GREEVES (USA): I believe that the international regime consisting of the Joint Convention, international safety standards and national regulatory processes could significantly increase public confidence in the safety of radioactive waste management facilities.

The Joint Convention — the Contracting Parties to which will be holding their First Review Meeting in November 2003 — requires Contracting Parties to demonstrate the safety of their relevant facilities and activities, and in that connection we need a comprehensive set of internationally agreed standards as an international point of reference for the country reports which are to be peer reviewed at the First Review Meeting. Many of the necessary standards are at advanced stages of preparation, but a lot more work still needs to be done.

The development of safety standards is a long and complex process, as the standards have to be subjected to broad international scrutiny by IAEA Member States before being submitted to the Board of Governors of the International Atomic Energy Agency for approval. The role of the IAEA's Safety Standards committees and Commission on Safety Standards is very important in this context. The involvement in the process of a wide range of parties demonstrating a high degree of competence should help to bring about broad international acceptance of the standards.

H. FERNANDES (Brazil): I have the impression that some developing countries are put under greater pressure than 'advanced' countries to accede to the Joint Convention, and to base their national regulations on IAEA Safety Standards. Is this impression correct?

R.P. PAPE (United Kingdom): The IAEA's Safety Standards are not legally binding on the IAEA's Member States. Moreover, the IAEA's Safety Standards committees, in which developing countries are represented, are well aware of the difficulties which some developing countries have in basing their national regulations on IAEA Safety Standards.

J. GREEVES (USA): If a country has radioactive material, it is responsible for managing that material safely. If that country is an IAEA Member State and cannot manage its radioactive material safely, the IAEA will help it. In doing so, the IAEA will base itself on the safety standards developed under its auspices, so it is helpful if the country's national regulations are based on those standards.

That having been said, I would emphasize that the national regulations which a country ends up having should be regulations which the country feels comfortable with. One should just bear in mind that a lot of thought has gone into the IAEA's Safety Standards.

O. JANKOWITSCH-PREVOR (Austria): Regarding H. Fernandes's reference to 'developing countries' and 'advanced countries', I would like to say that in the nuclear field more than in most other fields, the conventional distinction between the two groups of countries is not valid. There are several countries belonging to the Group of 77, including Brazil, which are more advanced in the nuclear field than many European countries, for example.

The IAEA's Secretariat sometimes reminds an IAEA Member State that it has acceded to this or that safety related convention and might benefit from acceding to the other safety related conventions, but I do not think that constitutes putting pressure on the State.

A.-C. LACOSTE (France): I would add that countries stand to benefit quite a lot from just being represented in the committees which develop IAEA Safety Standards. However, participating in the work of those committees does cost money and take up a lot of time of national representatives.

While I have the floor, I would like to mention that I was unhappy with the title of R.P. Pape's presentation: "The achievement of globally applicable safety standards". In my view, the aim of the work currently under way is to produce a set of comprehensive reference safety standards, the word 'reference' meaning that it is for each country to do what it likes with the standards — from adopting them exactly as they stand to rejecting them outright.

P. METCALF (IAEA): In order to make use of IAEA Safety Standards, which are available on the IAEA's web site, one does not have to adopt them or base regulations on them — one can simply incorporate them into conditions of authorization.

A.-C. LACOSTE (France): The long time necessary for converting international standards into national ones is a problem for all countries. For example, it took a long time to convert the BSS into a European directive, and France has still not reflected the European directive in its national standards.

A. SUZUKI (Japan): In my view, the value of IAEA Safety Standards to individual countries derives not only from the standards themselves but also from the standard development process. A country which envisages using a particular standard should, if possible, participate in its development, thereby gaining a real understanding of what the standard means.

N.A. CHAPMAN (Switzerland): I have heard people say that international repositories would be a means of facilitating the dumping of radioactive waste. This has disturbed me, as international repositories would, I think, clearly have to be built to the highest possible safety standards. I should be interested in hearing Panel members' views as to whether the safety standards for international repositories would differ from those for national repositories.

J. GREEVES (USA): Without commenting on what I think about the idea of international repositories, I would say that I do not see any reason why the safety standards for international repositories should differ.

R.P. PAPE (United Kingdom): I do not see any reason why they should differ either, as far as technical matters are concerned. However, the IAEA Safety Standards deal also with institutional matters, where there would presumably be differences depending on whether one was considering an international repository or a national one.

O. JANKOWITSCH-PREVOR (Austria): When one uses the term 'international repository', one is presumably not talking about a national repository in a country which is prepared to accept radioactive waste from other countries under bilateral arrangements of some kind. Such a repository would continue to be a national repository. To me, an international repository would be a repository operating on the basis of an international agreement — a kind of international institution which just happens to be located in a particular country.

A.-C. LACOSTE (France): I am nervous about the idea of international repositories since, in my view, it runs counter to the idea that each country should take care of its own radioactive waste.

S. CARROLL (Greenpeace International): Further to what A.-C. Lacoste just said, I would note that there seems to be a pattern in other areas whereby waste is shipped not to countries with high safety standards but to countries with low safety standards — and low prices. I would like those who promote the idea of international repositories for radioactive waste to explain the advantages of shipping such waste to countries with higher safety standards rather than introducing the higher safety standards in one's own country. To me, it always seems to boil down to minimizing costs and evading responsibilities.

M. VESELIC (Slovenia): As a relative newcomer to the nuclear industry, I appreciate what S. Carroll said about international repositories. Outside the nuclear industry, there is constantly talk about economies of scale and the sharing of costs. Perhaps the nuclear industry should take into account the possibility of economies of scale and the sharing of costs when considering the idea of international repositories?

R. HEARD (South Africa): In Africa, there is already a need for an international repository, as there are several African countries unable to deal with their radioactive waste, which in some cases includes spent research reactor fuel that has started to leak.

A.-C. LACOSTE (France): The spent fuel at abandoned research reactors is a difficult issue.

A. SUZUKI (Japan): The Japanese Government is interested in Japan's hosting the International Thermonuclear Experimental Reactor and is considering what the safety standards should be for such an international project. The lessons learned from this exercise might be useful when one is considering the question of safety standards for international radioactive waste repositories.

T. FLÜELER (Switzerland): I should have liked to see among the panellists also a representative of the OECD/NEA and a representative of the European Commission. They might have helped to clarify a number of issues.

Regarding A. Suzuki's probabilistic approach to radioactive waste management, the OECD/NEA has done some interesting work, including work based on Canadian studies.

In the area of risk harmonization, about two years ago, the European Commission launched — at Ispra, Italy — the so-called RISCOM project, which may now need to be revitalized.

J. GREEVES (USA): Further to what T. Flüeler just said, I would mention that the OECD/NEA has supported a number of studies relating to geological disposal. Also, it is represented in the IAEA's Waste Safety Standards Committee (WASSC).

P. METCALF (IAEA): The European Commission is also represented in WASSC. The IAEA co-operates closely with both the OECD/NEA and the European Commission in the area of radioactive waste management.

T. FLÜELER (Switzerland): I should like to see co-operation among them on issues such as risk harmonization.

Y. NISHIWAKI (Austria): People have been talking about risk harmonization for several decades without making much progress. The issue arose in Austria when nuclear power plants started to be built in the former Czechoslovakia. The problem was that Austrians living near the Czechoslovak border were going to be exposed to virtually the same risks as people in Czechoslovakia living near the plants, but without benefiting from the electricity generated by the plants.

Regarding the probabilistic approach to the safety of radioactive waste management, we must bear in mind its limitations. In the area of power reactor safety, it used to be stated that the probability of a major reactor accident was extremely low, with a major reactor accident occurring only once in 100, 1000 or 10 000 years. Then we had the Three Mile Island accident and the Chernobyl accident within less than ten years of each other. Perhaps one should apply fuzzy set theory when considering the safety of radioactive waste management. In that connection, I would mention that in Belgium, there is a group dealing with fuzzy logic in nuclear science and industry — a group, incidentally, with only one member from the United States of America.

A.-C. LACOSTE (France): I think that a useful message from what Y. Nishiwaki just said is that we should not forget what has happened in the past.

SUMMARIES OF SESSIONS AND PANEL DISCUSSIONS

(Session 11)

Chairperson

A.J. BAER
Switzerland

Summary of Session 2

CONTROLLING DISCHARGES OF RADIOACTIVE EFFLUENTS TO THE ENVIRONMENT

Policies and trends

Chairperson
R.G. HOLMES
United Kingdom

Rapporteur
M. BALONOV
IAEA

New international legal instruments influencing the control of radioactive discharges to the environment

The first major international agreements on the control of the disposal of waste into the marine environment concluded 30 years ago, namely, the Oslo Convention and the London (Dumping) Convention, were quickly followed by regional agreements on land-based discharges for the North-East Atlantic and the Baltic and a series of other regional agreements. By 1992, the emphasis had moved from protective measures dealing with specific contaminants in isolation to an approach to the conservation of the marine environment as a whole. Radioactivity was seen as a separate issue; the emphasis on the role of global organizations — in particular, the IAEA and the ICRP — in establishing principles and guidance in this field is a significant feature.

Within OSPAR, the issue of land-based discharges of radioactive substances has continued to be significant. The reasons for this are probably to be found in the way in which ‘fear factors’ amplify perception of the risks, which objectively are not seen as being as serious as some other problems. The first Ministerial Meeting of the OSPAR Commission at Sintra, Portugal in 1998 adopted strategies to guide the future work of the OSPAR Commission and set the target of not increasing the concentration of human-made radionuclides in the environment by reducing the human-made radionuclides in sea water to zero, and of natural radionuclides to background level. At present, much of the international law on the environment is to be regarded as a process rather than a steady state.

An assessment of the implications of a regional convention on discharge control policies

Nuclear facilities located in the OSPAR region have to regulate discharges into the sea based on the legal requirements under the Euratom Treaty, the OSPAR Convention, national regulations and international regulations (IAEA). The Sintra Statement of 1998 sets new targets for reducing environmental concentrations resulting from discharge practices.

To meet new strict discharge limitations, La Hague reprocessing plant improves technologies for the purification of liquid discharges, despite the present level of radiological impact on the population being already negligible. Thus, in 2003, the discharge authorization restricts the population dose at the level of 0.03 mSv. In the first place, the discharge of radionuclides mostly contributing to the population dose, i.e. alpha emitters, will be reduced. Technologies to reduce the discharge of less radiologically important radionuclides, e.g. T, ^{14}C and ^{129}I, will be elaborated later. Thus, French nuclear facilities follow new strict international discharge limitations and search for the most justified technological solutions to reduce discharge and associated population exposure.

The development of new policies on the protection of the environment from the effects of ionizing radiation

The ICRP has, up until now, not dealt with environmental protection, except in those situations where exposure of non-human organisms to radionuclides has been of interest for the radiological protection of humans. Protection of the environment is developing rapidly both at national and international levels. The ICRP has recently set up a Task Group with the aim of developing a protection policy for, and suggesting a framework of, protection of the environment that could feed into its new recommendations.

The Task Group has concluded that a systematic approach to the radiological protection of non-human species is needed in order to assess and manage radiation effects in the environment. The Task Group recommends that the ICRP develop a framework for the protection of non-human species that is harmonized with the proposed approach for the protection of humans. To achieve this, an agreed set of quantities and units, a set of reference dose models, reference dose-per-unit-intake data and reference organisms will be required. The Task Group does not define dose limits for biota, nor give recommendations on what to protect. The proposed system does not intend to set regulatory standards. The Task Group rather recommends a framework that can be a practical tool to provide high level advice and guidance in prospective situations, and help regulators and operators demonstrate compliance with existing legislation.

Implications of the new trends in discharge policies for the nuclear industry worldwide

The Panel discussed three presentations along with other issues relevant to the present regional (OSPAR) and international discharge policies, and the development of the biota protection system.

The discussion clarified that the OSPAR concept of the reduction of radioactive discharges (currently) and concentrations (in the long term) in the sea to the level 'close to zero' has not been formulated in technical terms, which complicates its understanding. The concept goes beyond the internationally recognized principle of radiation protection, i.e. optimization, and will result in substantial costs without visible quantifiable benefits. The decision to press for 'close to zero' discharges and/or concentrations is of a non-technical nature, based on a general desire of the public to avoid any contaminant in the environment regardless of impact or cost. Nevertheless, it was recognized that technical capabilities to reduce discharges of the number of radionuclides do exist. However, there was a feeling that rather than simply accept a 'near to zero' policy, most nations not currently covered by OSPAR would initially seek to challenge the concept using a sound scientific understanding of discharges. The following two negative implications regarding the implementation of the 'close to zero' concept were identified. Firstly, reduction of the discharge means that radionuclides should be stored or disposed of in the terrestrial environment. This may lead to exposure of humans and terrestrial biota without radionuclide dilution in a large volume of sea water. Secondly, a wish to achieve 'near to zero' discharge may result in unjustified expenditure and use of resources without a clear understanding of benefit.

The nations directly affected by recent OSPAR decisions (Sintra, Portugal, 1998), in particular France and the United Kingdom, have been developing strategies to satisfy the aims of OSPAR. A particular difficulty, however, lies in defining 'close to zero' discharge and combining this concept with a cost benefit analysis, i.e. to identify and justify the improvement from the reduction in discharges. Discussions continue to clarify the meaning of the 'close to zero' approach.

The nations not currently directly under the auspices of OSPAR have generally criticized the 'close to zero' approach, seeking guidance on how to move to this goal, bearing in mind that discharges are already substantially below acceptable levels in most countries. There was also some confusion over the basis of such reductions.

The ICRP concept of biota protection per se did not raise major objections with the implicit acceptance that a system based on human protection did not axiomatically guarantee environmental protection. There is social demand to account for possible harm of radiation for fauna and flora based on ethical principles. The task of the radiation protection community is to develop an adequate system of biota protection based on scientific knowledge, which is also compatible with the protection system for humans. More emphasis should be put on identifying biological effects in organisms located in different ecological levels which could be considered as indices of 'environmental health'. The present proposal of the ICRP, that selected reference organisms will adequately indicate the level of 'environmental protection', is not convincing. The meeting recognized the need to identify and study reference species before implementing an environmentally based regime.

The present trends in the field of regulation of radioactive discharges to the environment reflect societal balancing between national energy policies and international safety ambitions; the discussion continues. This manifests itself in the shift for scientifically underpinned discharge limits based on the impact on humans, to pressure to consider absolute concentrations of contaminants and broadening consideration to the environment.

Discussion following summary

A. ZURKINDEN (Switzerland): I should like to ask what might be called a philosophical question. Why should we be concerned about radiological protection of the environment in cases where human health is not at risk? After all, there is a biblical tradition of human domination over animals and plants.

A. SIMCOCK (OSPAR Commission): Besides that biblical tradition, there is a very prevalent belief that humans are part of the ecosystem and should ensure that it functions properly. That belief justifies concern about radiological protection of the environment, with its fauna and flora, even when human health is not at risk.

A.L. RODNA (Romania): I fear that the 'zero discharge' requirement will have a huge negative impact on nuclear activities. In my view, the IAEA should develop a clear definition of the 'zero discharge' concept.

G. LINSLEY (IAEA): The OSPAR Commission does not talk about 'zero discharges' — it talks about 'close to zero environmental concentrations', which is a difficult target but not the same thing as 'zero discharges'. This is a discussion to which we in the IAEA will be contributing during the next few years.

S. CARROLL (Greenpeace International): Non-nuclear industries are facing the challenge of reducing concentrations of artificial substances in the environment by reducing discharges. As indicated by A. Simcock on a couple of occasions, the nuclear industry should try to learn from the environmental protection experience of other industries rather than trying to apply the experience which it has acquired within a fairly restricted area to a much larger area.

Summary of Session 3

LONG TERM STORAGE OF RADIOACTIVE WASTE

Chairperson
A. NIES
Germany

Rapporteur
J.H. ROWAT
IAEA

The Chairperson opened the session by pointing out that the more long term storage becomes a trend, the more it becomes an issue.

Many of the fundamental differences between storage and disposal were covered in the three presentations; summarized briefly, they are as follows. The safety and security of storage facilities is dependant upon active measures, while the safety and security of disposal facilities depends upon inherently passive measures. To assess the safety and security of long term storage or disposal, predictions are made about future performance, which introduces uncertainty. Uncertainty is correlated with the speed of a process. Social change is much faster than geological change (orders of magnitude faster); hence, predictions about the safety and security of long term storage are weak. Not all structures are treated equally — societies tend to assign them a material value and an ideological value. Nuclear installations appear to be assigned both a high material and high ideological value. Social and political events are the leading cause of damage to structures with a high ideological content, which is further indication that it is difficult to offer assurances for the safety and security of long term storage structures. It was also noted that the durability of structural materials is not sufficient to guarantee the safety of long term storage.

There are situations where interim storage is intended to be a bridging practice, or intermediate step, pending policy decisions on how and whether to proceed with disposal. The system in the United Kingdom for the management of radioactive wastes is one example of such a system. Because of the 1997 decision not to proceed with the Rock Characterization Facility at Sellafield, a new strategy for the interim storage of intermediate level waste had to be created. The interim safe storage (ISS) concept was developed to permit waste generators to retrieve, treat and store their wastes with reasonable assurance that the wastes would be accepted in future waste disposal facilities. The need for a strategy such as ISS is pressing in situations where there are legacy wastes that have not been properly treated, characterized and stored. The timely reduction of the risks and hazards associated with these historic wastes is important for the present generation, as well as future generations. Strategies such as ISS lessen the financial burden on future generations yet still leave them with decision making flexibility.

The concerns and points of view of those in favour of perpetual storage were also presented. A series of Nuclear Guardianship Principles was described that call for monitored retrieval storage of radioactive wastes at reactor sites; severe limits on the transport of radioactive materials; transmission of radiation protection knowledge to future generations; and a complete cessation of all nuclear activities that generate radioactive waste. Pictures from the early years of Hanford operations showing unmarked trenches for low level waste and a decrepit and poorly marked outfall structure were presented as evidence that surface markers will not effectively warn the public about the dangers of deep geological disposal facilities. It was emphasized that citizens' groups can provide constructive alternatives for the management of radioactive wastes, which technical experts can further enhance. The trend that non-governmental organizations, government and industry groups are increasingly meeting to discuss issues pertaining to the management of radioactive wastes was lauded as a promising development.

Opening statements and remarks from the Panel

In some countries, spent nuclear fuel is not regarded as waste, rather it is considered to be raw material for reprocessing. In the Russian Federation, for example, storage is simply the step before reprocessing. The Russian Federation presently generates about 850 t/a of spent nuclear fuel, however, the reprocessing capacity is much smaller (about 125 t/a). There are plans to construct dry storage to provide additional capacity (24 000 t) for spent fuel storage.

High level waste (HLW) management is fundamentally a risk management issue. The management of HLW is not one of either long term storage or disposal — both are essential steps in the management of these wastes. In future revisions of the Principles of Radioactive Waste Management, the IAEA may want to consider broadening the scope of Principles 4 and 5 to elaborate more upon the issues of institutional control and intergenerational equity. In this regard, the following should be considered:

— With disposal, there is really no requirement for institutional control;
— Intergenerational transfer of knowledge is essential to maintain safe institutional control;
— Future societies may be willing to accept some responsibility for management of radioactive wastes from previous generations.

At the Cordoba Conference, it was concluded that perpetual storage of radioactive waste is not a sustainable practice. The Cordoba Conference also placed an Action on the IAEA to "access the safety implications of extended storage of radioactive waste and any future reconditioning which may be necessary". The position paper drafted in response to this Action was reviewed at a recent Technical Meeting held in Vienna, where it was recommended that the document should:

— Emphasize that storage and disposal are complementary activities;
— State clearly that storage is a necessary phase of waste management and it is demonstrably safe;
— Explain that perpetual storage is not feasible for periods extending over the hazardous lifetime of the wastes;
— Elaborate more upon strategies for storage and disposal, considering issues such as retrievability and transport of wastes.

It was also concluded that the position paper should concentrate on the wastes categorized as high level waste and long lived intermediate level waste.

The question from the Chairperson to the Panel and conference participants was: *Is there an alternative to disposal in the long term?*

The technical community is convinced that geological disposal is safe and is the best solution for the long term management of high level waste, however, they have yet to convince many stakeholders and communities of this. A point of view expressed by some was that a geological repository could remain open for a very long period of time (as long as 300 years) to allow participation of future societies in the decisions concerning final disposition of the wastes. For example, this would not foreclose the reprocessing value of spent fuel to future generations. It was postulated that future societies may be willing to accept some responsibilities for the wastes generated by previous generations, provided there is no undue financial burden and provided there was a closure plan in place at the outset of repository operations.

The view was expressed that if geological disposal is not pursued, the risks associated with long term storage should be quantified. It was mentioned that some developing countries may not be able to afford long term storage.

Building trust with stakeholder groups was identified as a key issue to promote effective dialogue on long term storage and disposal. It was felt that the views of social scientists and historians should be integrated into discussions on long term storage, and that there should be more effective documentation of the non-technical attributes that enter into decision making. Models for the development of effective dialogue between various stakeholder groups should be examined.

The Chairperson summarized the main findings of the session as:

— Storage requires social stability to maintain institutional control.
— Over the long term, there is no alternative to disposal.
— The message should be communicated to stakeholders that there is no credible end point other than disposal.
— Storage is always an interim measure in contrast to disposal, which is final.
— The issue of public trust must be addressed. A true dialogue must take you from where you are to somewhere else.

Discussion following summary

K. SULLIVAN (Educators for Social Responsibility): Part of the problem of dealing with high level nuclear waste is that many of the people involved in the production of that waste have appeared to be waiting for a magic solution. That has had a negative impact on public attitudes both towards the production of high level nuclear waste and towards the geological disposal ‘solution’.

Scientific arguments have been advanced against deep geological disposal, and particularly the proposed Yucca Mountain disposal facility. The proponents of deep geological disposal, for example, the US Department of Energy, should examine those arguments and, if they can, come forward with a rebuttal, so that there may be a proper dialogue.

A. NIES (Germany): I would welcome a dialogue on that basis.

G. CSULLOG (IAEA): I do not see much difference between keeping the proposed Yucca Mountain facility open as a repository for 300 years and keeping it open as a storage facility for 300 years. My understanding is that when people say that storage is unsustainable in the long term, they mean surface or near surface storage. I have not heard arguments against deep underground storage.

A. NIES (Germany): The argument against long term storage, whether on or near the surface or deep underground, is that it requires institutional controls — and hence, social stability — over a very long time period.

M. BELL (IAEA): The point about the proposed Yucca Mountain facility is that it is being designed in such a way that it could be kept open for 300 years but could be closed at any time during the 300 year period in question if society decided to close it — perhaps because the institutional controls are deteriorating.

T. FLÜELER (Switzerland): I understand that the IAEA is working on a position paper about long term storage. I hope that in it, the IAEA will do more than just restate old general positions — that it will, for example, carefully analyse the implications of things like retrievability. In my view, what is needed is a document which really sets the stage, so that decision makers are well informed when they consider the long term storage option.

A. SIMCOCK (OSPAR Commission): I hope the debate about storage versus disposal will not obscure the issue of liquid radioactive waste. Not all liquid radioactive waste can be converted into solid waste.

Summary of Session 4

GEOLOGICAL DISPOSAL OF RADIOACTIVE WASTE

Chairperson
A.J. HOOPER*
United Kingdom

Rapporteur
M.J. BELL
IAEA

The conference was made aware of deep geological programmes at very different stages of their development with planned dates for receiving waste spanning 2010 to 2050. Nevertheless, there were clearly discernible commonalities and trends, which enable the international community to focus its efforts on this long term management option.

The fundamental science and technology of deep geological disposal is well established, including the methods for conducting safety assessments and for site characterization. The significant technical effort now required is to improve and build confidence in concepts, in particular, the way in which the engineered repository design is matched to site characteristics. Beyond that, there is a need to study the industrial implementation of design concepts so that deep disposal can be carried out safely and cost effectively.

The role of in situ investigations at prospective repository sites is recognized in most programmes, and much valuable experience is available from existing underground research laboratories. This enables developing countries to access the necessary information, particularly through the IAEA Technical Co-operation Programme. More generally, the scientific database is accessible through international collaboration under the auspices of the IAEA and other bodies.

The key issue for deep geological disposal remains the siting of facilities, and it is recognized that this is very much a societal issue. Generally, it was agreed that this issue is best addressed by a stepwise decision making process which allows all the questions posed by stakeholders to be addressed at the appropriate stage, including the question of proposed alternatives to disposal.

* On behalf of M.S.Y. Chu (United States of America).

The way in which decisions are made within such a process is worthy of further consideration, particularly in respect of the roles and responsibilities of the participants. The merits of voluntarism on the part of local communities are well recognized and the logical linking of such an approach to benefits to the community is an important area.

The question of an international disposal facility was raised. It was acknowledged that this should not detract from national programmes seeking a solution, but that an argument can be made that for countries having relatively small amounts of waste, this may be the only affordable route to ensuring its long term safety.

The specific issue of safeguards and the potential impact on repository design and post-closure management was considered. Safeguards specialists explained that subsequent to closure of a repository, the important factors are continuity of knowledge and surveillance to ensure that fissile materials are not exhumed from the repository. More active safeguards measures are required while the waste is more accessible. These were considered entirely consistent with envisaged operational controls but clearly require unprecedented institutional commitments over long time periods if a repository is left unsealed and backfilled for an extended period.

Importantly, safeguards specialists conclude that deep geological disposal is strongly favoured as the best means of making the fissile materials inaccessible. There was a general agreement that the IAEA should state this clearly and also formalize the position on safeguards requirements after repository closure. Key issues identified were the longevity both of institutional control and of the knowledge of the repository design and contents.

These considerations led to an overall conclusion that the earlier long lived radioactive waste is made inaccessible deep underground in a backfilled and sealed, passively safe repository, the better for safety, security and safeguards. This is a precise, technical conclusion and the influence of other aspects, especially political and public attitudes, must be recognized. Nevertheless, there is a clear responsibility to make available the information that justifies that conclusion and the beneficial outcome it proposes.

Summary of Session 5

MANAGEMENT OF DISUSED SEALED RADIOACTIVE SOURCES

Chairperson
N.K. BANSAL
India

Rapporteur
M. AL-MUGHRABI
IAEA

The Chairperson's introduction indicated that the applications of sealed radioactive sources (SRS) are on the rise, especially in developing countries, in spite of the fact that the infrastructure for dealing with disused and spent sealed sources is not getting proper attention. The overview indicated that the situation is much better in developed countries, discrepancy between known SRS (under control) and SRS believed to be there, suggests that there is room for improvement in developed countries as well. Several reasons and situations leading to this were elaborated. It also highlighted the importance of the recent development of the borehole disposal option, which can form a real solution for the problem.

The presentation highlighted the activities conducted under the auspices of the IAEA and its significant impact on the safety and security issues. The talk highlighted the importance to, wherever possible, take advantage of the option of returning the spent sources to the supplier, an activity emphasized by the IAEA.

The Panel concentrated on technical, economic and socio-political issues affecting negatively or positively the option of returning sources to suppliers. Sources are routinely returned to the manufacturer during source replacements, but a problem remains with the last source when equipment is decommissioned as much as 30 to 40 years after installation. There is a strong will from the manufacturers' side to take sources back, but clear examples were given where this is not possible due to reasons that go beyond the manufacturer and/or supplier domain. Some of these problems go beyond the national domain to involve international aspects such as international transport regulations and international transporters. At present, manufacturers typically offer a disposal service for these final disused sources at a cost, where possible. Means of financing disposal costs could be investigated, such as disposal bonds and national or international aid.

Utilization of international co-operation through regional disposal facilities was also mentioned. The facilitation of transport in the area of spent sources was clearly an important prerequisite to solve the problem, especially the legacy of old and historical sources. An overview was provided of the management options suitable for developing countries, and their pros and cons were highlighted. These options are well explained in recent documents of the IAEA on the subject. Desirability was expressed of proper temporary storage of spent SRS with users and transferring them to a centralized management facility pending conditioning and eventual disposal. The borehole concept developed by South Africa was addressed. While several Member States, including the United States of America, the Russian Federation and many others, have utilized the concept in one way or the other, the South African current project is attempting to demonstrate the economic, technical and safety aspects of the concept to be used in developing countries. This option appears attractive for solving the problem in many developing countries.

Due to much time spent on the large issues involved, the actual conditions of such spent or disused sources and the associated safety and regulatory requirements, there was little time left for the audience to fully cover many important aspects. The shortage of time available for discussion emphasized the importance of an effective and secure bond which will not only provide a means to properly manage the sources as waste but can be an incentive to the user to transfer the spent sources to a national waste manager or the supplier for proper management. A suggestion also came from the audience that the example of hazardous waste movement could be adopted on the international level when sources are to be moved between countries. Some comments indicated the essential need for having clear responsibility and close collaboration on the issue of safety and proper management of disused source. National government institutions, sources manufacturers and/or suppliers and major users as well as relevant international organizations need to co-operate closely in order that proper mechanisms are put in place to bridge the existing gaps in spent source management with a cradle to grave concept. At the end of the session, it was clear that many aspects of this important subject still needed to be discussed at an appropriate forum in order that clear solutions could be developed addressing the technical, economic and socio-political issues involved. The following items were mentioned by panellists and the Chairperson for inclusion in any future events:

— Development of activities that make source return to supplier more feasible;

— Facilitation of international transportation (carrier, container);
— Regional and international co-operation on source conditioning and disposal;
— Borehole disposal issues such as technical know-how, economic aspects, site selection, safety and feedback from the current technical co-operation project in Africa;
— The mechanism of international direct assistance.

Discussion following summary

R. HEARD (South Africa): I should like to emphasize that when manufacturers of radiation sources talk about 'disposal' of the sources they mean 'storage'. At the moment, radiation sources are not being disposed of.

Summary of Session 6

MANAGEMENT OF LARGE AMOUNTS OF LOW ACTIVITY RADIOACTIVE WASTE

Chairperson
J. HULKA
Czech Republic

Rapporteur
E. FALCK
IAEA

Background

The large volumes of residues containing long lived naturally occurring radioactive material (NORM) that were produced during history, and that continue to be produced, provide a challenge to waste managers and regulators alike. The industries and activities involving NORM are varied, ranging from (ore) mining and milling, to fuel production and use, including coal, oil and gas, to phosphate fertilizer production, to geothermal energy use and water treatment. Traditional radioactive management strategies and technologies often are not applicable and certain exposure pathways may be unavoidable. Because large quantities of long lived radionuclides are dispersed in large volumes of material, isolation and containment from the environment often is not feasible. In this context, the legacy wastes are a particular concern. On the other hand, observed doses to members of the public are sometimes high enough to be a regulatory concern. This is reflected, for instance, in recent guidance from the European Union on NORM. Hence, this indicates the need for international guidance.

Regulatory approaches

The scope and criteria for regulation are crucial, as there is the possibility that industries and/or waste streams may become regulated without a real net benefit in terms of risk and exposure reduction. Exposure scenarios may be quite region specific for the same type of industry. Similarly, the consequences and effects of regulation may be quite region specific. A clear distinction emerged between residues arising from ongoing operations and legacy residues. It was discussed whether these could be captured with the terms of practice and intervention as applied to licensed nuclear operations or other licensed industrial or medical facilities handling artificial radionuclides. Following the BSS logic of chronic exposure, in many cases, NORM residues could be deemed to arise out of practices.

It was discussed whether all industries should be licensed and/or regulated, but it appeared that a case by case decision would be more appropriate. It was stressed that the IAEA should be cautious in introducing the concept of 'practice', so as not to confuse the scope of regulation with what is applicable to the nuclear industry.

While there are certainly similarities in the approach, the treatment of NORM containing residues as 'radioactive waste' has far-reaching implications. The present (radioactive) waste classification schemes clearly have shortcomings with respect to large volumes of low activity wastes. It remains to be seen, however, whether and how Member States will report such wastes under the Joint Convention.

Current regulations in Member States are either based on predetermined dose levels or on a (site specific) assessment of risks or hazards. Predetermined dose levels have the advantage of a relative ease in application and enforcement, but may be inappropriate for certain scenarios and socio-economic circumstances. A case by case judgement was advocated by many participants. Predetermined dose levels may also not find the acceptance of the stakeholders and, therefore, have implications for the viability of institutional controls. Conversely, stakeholders might find single number dose rate levels easier to understand than risk based criteria for intervention or licensing. It appears that various views exist in the Member States and a need for harmonized guidance to develop a regulatory framework was noted.

Regulatory approaches should also take into consideration non-radiological hazards, as these may often dominate. It was noted that (mainly for historic reasons) radiological and non-radiological regulation often differ considerably, and the risks they are addressing are discussed in different scientific and regulatory communities. It is important to understand where the radiological and non-radiological contaminants go in the various process streams. Attempts to develop a coherent regulatory system for radiological and non-radiological risks are very limited to date, and more work will be needed. Hardly any risk comparison exercises have been undertaken yet. The IAEA should open the discussion on a holistic approach to all potential environmental and health hazards.

It was stressed that the IAEA should make sure that a net benefit arises from regulations developed based on the guidance given.

Waste versus commodity

Owing to the nature of certain residues and their position in the material flows in some industries, it is not clear whether they constitute a ‘waste’, a ‘residue’, or a ‘commodity’. The view may change with changing market conditions. A holistic understanding of processes and material flows appears to be the necessary basis for assessment, for the development of guidances and also for the development of disposal options. These aspects have also been addressed in a recent Technical Meeting on NORM and in an IAEA Technical Report in preparation. The conclusion from the Technical Meeting, that the IAEA should develop the understanding of materials and radioactivity flows in support of targeted guidance, was reiterated. Site specific multi-attribute analyses may be the tool of choice to optimize the management strategies.

International trade

Regulations may have an impact on international trade and consequently the questions of international harmonization of such regulations was raised in order to avoid building up trade barriers. The need for a common framework for guidance has been emphasized on various occasions.

Introducing regulations in only some countries, and in particular in the developed countries, could have the unwanted side effect of moving the waste arising from and ensuing disposal activities into regions and countries with less stringent regulations.

Disposal options

In situ isolation and stabilization appear to be the preferred option for many types of NORM containing residues. In many instances, this would not preclude an intrusion scenario, as these disposal facilities would be at or near the surface. This may entail the need for prolonged institutional control. Disposal solutions with assured long term stability have to be developed, but it is unclear how this can be assessed. The question was raised whether dilute and disperse should not be a viable option, as in many cases the NORM would end up in the oceans by natural processes anyway. In this respect, it was noted that reducing discharges and releases would lead to an increase in the solid waste stream. However, purposeful dilution of ‘radioactive’ wastes below regulatory levels is forbidden in many Member States. Site specific multi-attribute analyses may be the tool of choice to select between disposal alternatives.

Decision making

The issue of what the prevailing factors are and the basis for decision making on NORM residues was raised. In addition to environmental and health protection considerations, socio-economic and socio-political factors play a major role. In particular, for legacy residues, economic criteria are certainly of paramount importance for decisions on whether and how respective sites are to be remediated. The optimization process, balancing the radiation protection benefits with economic costs and other socio-economic aspects, is considered very important here. The treatment of the uranium mining legacies in various Member States may serve as an example. It was stressed that the IAEA should help to develop guidance, taking the broader socio-economic context into account. It has been found in many instances that public perception and political considerations are overriding criteria in decision making.

Finally, it was noted that 'regulation' means providing an assurance of protection, but it is evident that more in-depth discussions on the scope of regulations for NORM are needed.

Summary of Session 7

MANAGEMENT OF RADIOACTIVE WASTE FROM PAST ACTIVITIES AND EVENTS

Chairperson
T. NORENDAL
Norway

Rapporteur
B. BATANDJIEVA
IAEA

Introduction

Managing waste from past activities, such as nuclear R&D, processing of uranium bearing ores, disposal of waste in facilities designed, constructed and operated according to previous safety standards, represents a real practical problem faced by many countries. The need exists to make decisions on the long term safety of these wastes. This includes defining the safety standards and criteria that will be adopted for their management, as well as identifying and deciding upon appropriate options for the current and future long term management of these wastes that will comply with these criteria.

Main outcomes

The following five case studies were presented during the session, with the purpose of presenting the extent and nature of the problem:

— Improvement of the safety of management of spent nuclear fuel, solid and liquid LLW, ILW and HLW at the Andreeva Bay and Kola site in the Russian Federation, through the Contact Expert Group (CEG) initiative.
— Evaluation and improvement of safety of a radon type disposal facility in Hungary.
— Management of HLW from past practices at the Mayak PA (the Russian Federation) by making use of extraction techniques for reducing activity in HLW and subsequent conditioning of the wastes.

— Remediation of an existing site (Olen, Belgium) with waste from processing the uranium bearing ores to extract radium.
— Cleanup of contaminated USDOE sites, and in particular the Rocky Flats site in the USA, with a view to their further use for industrial and recreational purposes.

The presentations provided a broad overview of the wide spectrum of questions, issues and difficulties, as well as good examples of managing waste from past practices in different countries. They also provided a basis for the Panel in addressing the following questions:

— What lessons can we learn from past practices?
— How do we manage such facilities?

The discussion highlighted the following main issues requiring consideration:

— Should management of waste from past activities be treated as a practice or as an intervention;
— What standards and criteria should be used for the upgrading, remediation or cleanup of these facilities and sites;
— If intervention is required, when it is necessary and justified and what the basis is for decision making (e.g. partial retrieval of some waste);
— Whether human intrusion is of primary concern for long term safety;
— Effective dialogue between operators and regulators, in development and implementation of the approach for cleanup and further use of sites;
— The need for continuity in the implementation of waste management strategies adopted and maintaining the responsibilities of governmental organizations when exercising institutional control over sites;
— Whether it is always necessary and feasible to require the cleanup of sites to levels below dose constraints;
— How implementation of the new ICRP recommendations will affect the development and implementation of corrective actions strategies;
— Whether remediation would be a better and safer option for management of waste;
— What the basis and reason is for different levels of attention and consideration of importance of past practices (such as remediation and cleanup) versus high levels of radon in dwellings.

Lessons learned and recommendations

There is a need for further international support and co-ordination to effectively implement the measures identified within the CEG to improve the safety of waste and spent fuel management in the Russian Federation.

The role of the safety assessment in the re-evaluation of safety of past practices becomes a more important and essential factor for decision making in selecting appropriate options for corrective action. It is recognized that the level of conservatism adopted needs to correspond to the extent of the problem and knowledge of the waste management and disposal system.

The ICRP recommendations on the use of reference levels for intervention need careful interpretation when re-evaluating the safety of facilities from past practices, and the possible corrective or intervention measures for improving the safety of these facilities. An important factor to be considered in using these reference levels for the purposes of implementation of corrective action is the probability of the occurrence of disruptive events (such as human intrusion).

Remedial actions should be robust and performed with a sufficient level of confidence, and based on a comprehensive evaluation of the alternative options (e.g. increase of engineered barriers), as well as of the different estimated outcomes of these options after their implementation, so they will not give rise to more harm than good.

Remediation of existing sites effectively and in a relatively short time period can benefit significantly from the adoption of an approach that does the following:

— Deals with the problem locally in co-operation with other stakeholders (e.g. the public);
— Is aimed at risk reduction rather than risk management;
— Focuses on reaching targets instead of progress oriented activities;
— Defines potential use of the cleaned up sites well in advance;
— Sets an appropriate degree of urgency of the activities;
— Is aimed at final closure rather than continued monitoring of facilities or sites;
— Is well managed.

More effort is required in the identification of improved approaches and mechanisms for the transfer of knowledge and information to future generations on the status of activities undertaken to enhance safety and the basis for the decision made.

The acceptability of disposing disused sealed sources in near surface facilities needs to be demonstrated using recognized safety assessment techniques. Specific attention needs to be given to long lived sources.

There is an urgent need to finalize the process of establishing a framework of coherent international standards on clearance and intervention levels that could be implemented in remediation and release of materials, buildings and sites from regulatory control. This will also facilitate reporting of the Contracting Parties to the Joint Convention. The role of the IAEA in this area is very important and further work is encouraged.

There is a general recognition of the need for perpetual institutional control, especially for facilities with long lived radionuclides. Mechanisms to provide control over sites and the transfer of information on these facilities is equally important.

There must be a recognition of the fact that abrupt and significant changes in waste management policy influenced by political and societal considerations can occur, such as the banning of sea dumping.

Optimization is seen as a fundamental approach to the remediation of sites and facilities. This can lead to options that will give rise to radiation doses to humans that are higher than the limits and constraints for normal operations. This may have to be a financial reality in some countries. The acceptability of such options by all stakeholders involved needs careful consideration.

Much more emphasis needs to be given at the design stage to decommissioning and the release of facilities and sites from control, including management and disposal of the radioactive waste that will arise.

Discussion following summary

G. LINSLEY (IAEA): Before the end of 2003, the IAEA will issue two safety standards documents (based on ICRP guidance) dealing with the subject of environmental remediation. The documents will specify the basic safety related requirements to be complied with when remediating areas affected by radioactive residues from accidents, unplanned events or events in the distant past.

While I have the floor, I should like to mention the problem of applying safety standards which reflect health effects and risk. Experts develop them and governmental authorities adopt them, but people living in areas where they have to be applied often demand measures far more stringent than those which they provide for.

Summary of Session 8

PUBLIC ATTITUDES TOWARDS RADIOACTIVE WASTE

Chairperson
J. BARCELÓ VERNET
Spain

Rapporteur
L. JOVA SED
IAEA

There is no doubt that the public's perception of the nuclear industry and its future is heavily influenced by its concern over radioactive waste. Governments frequently encounter difficulties when making decisions on radioactive waste management (pre-disposal, storage and disposal), and this is a clear reflection of the controversy and disquiet that this topic engenders in the public.

The way the public perceives the health and environmental impact of radioactive waste and its management does not correspond at all to the real situation. For the general public, radioactive wastes present hazards that are perceived as the riskiest and that generate the greatest level of concern.

In any case, both the specialists and the decision makers should take into account the concerns of the public. Involving the public in making decisions and having an effective communication and information policy are the best means of fostering a climate of confidence which will facilitate the adoption of appropriate solutions.

Since the public does not constitute a homogenous group, and its various components and preoccupations need to be identified and understood, transparency of information is a fundamental element in achieving the necessary credibility in an area as controversial as radioactive waste. Information must be transmitted in language that is easy for the target audience to understand.

Conclusions

The majority of people in Europe would not object to the nuclear energy option if the waste can be safely managed. The public remains concerned about radioactive waste, and they consider themselves not very well informed about waste issues in general and they want to know more about radioactive waste. People also have limited knowledge about some basic facts on radioactive waste — sources of waste, level of hazard, and how the least hazardous waste is managed in their country. The public also does not know — or understand — that there are environmental benefits to nuclear energy production.

There is a gap in the communication between the specialists and the public. The importance of understanding the questions completely as well as the worries of the public, and the necessity to find out the best way to explain to the public the waste safety issues were recognized.

Few people trust the nuclear industry to supply this information, and the industry is also not considered very open. There is some indication that the waste management agencies are trusted, but appear to be most trusted in those States where they have spent more time in contact with the public. They are clearly regarded as separate from the nuclear industry as such. More efforts to be involved in the nuclear debate with the public are needed from some national agencies.

The industry, unfortunately, still seems to be linked in the public's mind to the culture of secrecy and cover-ups. Openness and transparency are the keywords here. Though gaining trust will still take many — blemish free — years.

Many people polled believe the reason why no disposal of high level radioactive waste has yet taken place is because there is no safe way to do it. However, the public continues to show overwhelming support for the view that radioactive waste should be dealt with by the generation that produced the waste and not left to future generations to manage.

While the technology exists for safe disposal of high level and long lived waste, it is a very common belief that no solution has been found. Only a minority of the public realizes that the main problem is much more a question of making difficult policy decisions. The public would like to see progress made in this area. Continuing failure to make significant progress endorses the public's present view and has a major influence on their overall perception of nuclear energy.

It was recognized that the stakeholders are not the general public, because they are those who have a stake in the proposal under consideration. It is important to make the correct selection of the stakeholders to meet the acceptance of the public through their direct participation in the decision making process.

In some parts of the world, public attitude is influenced by need. For example, where there is a chronic energy shortage, waste problems acquire a different level of importance.

Recommendations

The public should not only be informed, but must be involved in the decision making process. The decisions made in this respect should show how people's issues and concerns have been taken into account.

There is a need for more quality information about nuclear energy and radioactive waste. Following the international experience, it is recommended that information to the public should be developed by different organizations (implementers, regulators, etc.) working together to present different views.

New information systems, such as the Internet, should be used to disseminate information about the main issues of safe management of radioactive waste and for public information in this regard.

In the context of influencing attitudes in a local population being consulted in relation to a sitting proposal, this can be most effectively achieved by involving the most trusted people in local society such as physicians, nurses, local officials, etc.

It was suggested that special courses be organized for scientists and technicians on ways of communicating effectively to overcome the existing communication gap between specialists and the public.

The nuclear industry should look at other industries that have already been successful in the communication field, as was the oil industry in the 1990s. The benchmarking tools in this field should then be applied by nuclear industry.

The public's lack of knowledge should be tackled, and there must be at least some input into that process through the popular media on which many of them rely. In this instance, some efforts should be applied to involve and to work with the decision makers in the media, such as news editors.

Discussion following summary

E. ATHERTON (United Kingdom): In presenting his report, J. Barceló Vernet just spoke about information being provided to the public by 'the most trusted' organizations. I think what we need is the involvement of all kinds of organizations, including Green groups, in the development of information.

Also, J. Barceló Vernet used the verb 'convince'. In my view, we need to stop thinking that we are going to convince people and to think in terms of involving people. There are technical messages which we should try to convey, and we are entitled to look at things from our technical perspective, but the people whom we are addressing are entitled to look at things from their perspective.

A.J. BAER (Switzerland): Are those your personal views, or were those views the predominant ones arising out of the discussion during Session 8?

E. ATHERTON (United Kingdom): There was quite a lot of talk about involving the public, and I am fairly sure that nobody used the verb ‘convince’.

S. CARROLL (Greenpeace International): In my view, J. Barceló Vernet’s report reflected a nuclear industry attitude towards the public.

I believe that the assumption that the public is ignorant will never enhance the consultative process. If you set out to teach rather than to exchange ideas, you will never have a successful consultative process.

J. BARCELÓ VERNET (Spain): One of the recommendations in my report reads “the public should not only be informed, but must be involved in the decision-making process”. There was no talk about ‘teaching’ during Session 8.

K. SULLIVAN (Educators for Social Responsibility): Something which was not emphasized during Session 8 is that public attitudes towards radioactive waste management are influenced by the fact that nuclear waste derives not only from nuclear power generation but also from nuclear weapons production.

B. FROIS (France): The general public is very heterogeneous, whereas this gathering is rather homogeneous, and many of the technical people here believe that they know the truth and need to convince the general public. They may not have used the verb ‘convince’, but there was quite a lot of talk about ‘public acceptance’ — a concept which I consider to be completely inappropriate.

Radioactive waste management is a technical problem that unfortunately involves the public. Once you realize that the public is part of the solution, however, you will find that the problem is very simple.

Dealing with the public means dealing with other people’s emotions, and nobody in this gathering has struck me as being very good at dealing with other people’s emotions. There are people who know exactly how to play on other people’s emotions, as demonstrated after the Chernobyl accident, which such people exploited very cleverly. The scientists and technical people here need to ‘recalibrate’, because the nuclear industry has enemies who are all too ready to hit it ‘below the belt’.

Even in France, where there has been very little opposition to the construction of nuclear power plants, there is a need to talk with the public, in order to retain its confidence in the long term.

A.J. BAER (Switzerland): Clearly, the debate on the issue of public involvement is going to continue, with disagreements and misunderstandings.

Radioactive waste management is a technical problem with a big societal component. The IAEA should never forget that.

Summary of Session 9

INVOLVING STAKEHOLDERS IN DECISIONS ON THE SITING OF RADIOACTIVE WASTE FACILITIES

Chairperson
M.V. FEDERLINE
United States of America

Rapporteur
K. BRAGG
IAEA

General

The issue of stakeholder involvement has been a recurring theme throughout this conference. It is now widely recognized that establishing appropriate waste management facilities for radioactive waste necessarily involves taking account of a wide spectrum of interests within society. Although significant progress has been made in developing the technical basis and the safety assessment methodology for these facilities, in many countries, the issue of how and when to involve stakeholders effectively in the decision making process remains to be resolved.

Session 9 discussed both successful and unsuccessful national experiences in siting radioactive waste management facilities and how stakeholder involvement influenced decision making. National experiences concerning the involvement of a broad range of stakeholders with different values and viewpoints with respect to the siting of a radioactive waste management facility were described. These experiences suggest that establishing an effective process for the involvement of the stakeholders is critical at the earliest stages and throughout the development of radioactive waste management facilities. It is clear that national and cultural differences are important in determining the most important mechanisms for stakeholder involvement.

The overall objective for the stakeholder involvement process is to arrive at a state where all affected parties are given the opportunity to express their views, and that their issues and legitimate concerns are heard and addressed. The following paragraphs highlight some of the trends and possible future developments related to the involvement of stakeholders in the siting process.

Trends

Significant progress towards the siting of facilities to manage long lived radioactive waste has been made in several countries in recent years, notably Finland and the United States of America. In this context, the early and continued stakeholder involvement has played a major role in this progress.

It has become clear that stakeholder involvement is not necessarily about achieving a consensus but rather about providing arrangements for interested and affected individuals and groups to participate in, and influence, the decision making process. It is also evident that a balance has to be struck between the interests of local, national and regional stakeholders.

In the context of stakeholder involvement, each case and each site is specific and must be treated as such: there are no completely generic approaches to the issue.

Facility siting programmes are increasingly being structured in such a way as to ensure stakeholder involvement. This means that controversy will almost inevitably be encountered along the way but it must be accepted as a necessary part of the process. The siting programmes which have shown success are those in which the proponents have been willing to listen to different perspectives and to be responsive and flexible in their responses.

Development for the future

Stakeholders need to be involved in the development of the standards which will be used in the decision making processes to judge the acceptability of a waste facility. Further discussions are needed on this topic at both the national and international level.

Regulators need to continue to share experiences on balancing their role as the independent authority that ultimately must approve waste facilities while, at the same time, being open and responsive to the views of stakeholders.

Issues of long term storage and retrievability are subjects likely to require discussions with stakeholders on, for example, the possible need to place reliance on future generations for monitoring, security and information transfer.

Given the long time period which will be involved in siting, developing and closing a waste disposal facility, it is important to share experiences and to offer educational and involvement opportunities to young people to prepare for the time when they will be involved in decision making in this context.

Summary of Session 10

INTERNATIONAL REGIME FOR THE SAFETY OF RADIOACTIVE WASTE MANAGEMENT

Chairperson
A.-C. LACOSTE
France

Rapporteur
P. METCALF
IAEA

The session heard presentations on the Joint Convention, globally applicable safety standards and an environmental non-governmental organization perspective on waste management internationally. The Panel gave consideration to the desirability of an international safety regime and how such a regime could be achieved. Various issues in a number of topic areas were raised by participants and discussed by the Panel, and are summarized below.

International safety regime

An international safety regime for waste safety comprising the Joint Convention, internationally agreed safety standards and national mechanisms using those standards offered a number of desirable features. It would assist in addressing public concerns over the potential hazards associated with the management of radioactive waste. It would provide an assurance to countries that waste management activities conducted in neighbouring States were being carried out in a responsible manner. It would focus international attention on potential problem areas, and facilitate and promote the exchange of safety related experience.

Internationally endorsed safety standards provide a reference point for use in national programmes. In this regard, the standards could be used in a number of ways, including providing a basis for national regulations, or as guidelines for regulatory programmes or direct incorporation into national legal or regulatory instruments. Involvement of national representatives in the safety standards development process was also identified to be a major contributor to creating a global safety regime.

The nature of safety standards, providing fundamental safety principles, requirements that must be met and guidance on good (best) practice was generally agreed to be appropriate. It was also recognized that the international safety standards would have to be supported by industry standards for manufacture, construction, inspection, testing, etc.

Safety standards

The need to have a comprehensive suite of standards covering all aspects of the safety of radioactive waste management and disposal facilities was agreed to be important. Standards for the pre-disposal management of waste and near surface waste disposal facilities were in place, and standards for geological disposal, decommissioning and remediation were under development. The structure and extent of the waste safety standards were presently under review and revision.

Contracting Parties to the Joint Convention would need the safety standards as a point of reference when compiling their national reports for the Review Meeting of Contracting Parties — the first of which would take place in November 2003. The IAEA should make all efforts to progress development of the standards.

There is a need for wide dissemination of the safety standards to encourage and facilitate their use worldwide. Both Member States and the IAEA should take every opportunity to promote the standards. The standards should form the basis for appraisal missions conducted by the IAEA, and Member States are encouraged to make use of such appraisal missions in determining the adequacy of their national programmes. The training courses offered by the IAEA should adopt the safety standards as the basis for curricula.

The safety standards development process should be made open and accessible to potentially interested stakeholders. National regulatory authorities play a key role in the process but it is important to ensure that representatives of industry, research and development organizations, political decision makers and the broader range of interested and affected stakeholders are provided access to the process. The IAEA should continue to explore and adopt mechanisms to achieve this objective.

National and international responsibilities

The role of the IAEA is primarily to provide mechanisms for the development of international safety standards, and to facilitate their adoption and use worldwide. Member States have a responsibility to make use of the standards in their national regulatory programmes.

Such safety standards can be used in a number of ways nationally, and it is the responsibility of Member States to determine how to use the safety standards. In promoting the standards and their use, regulatory authorities have to maintain their independent role of ensuring the safety of radioactive waste management on behalf of the public.

It was recognized that the capacity to interpret and adopt standards varied in Member States — depending largely on national circumstances and the size of the nuclear industry — and the extent to which radioactive materials were produced, processed or used. The IAEA should bear this point in mind when structuring and offering appraisal and assistance services to Member States.

Compliance assurance

The need to have a reasonable assurance of achieving the objectives of radioactive waste safety was recognized to be of high importance. Mechanisms to establish this assurance need to be in place for all waste management activities.

In developing safety standards, the IAEA was encouraged to ensure that adequate and sufficient guidance was developed on the structure and content of safety cases and on approaches to safety assessment. In this regard, the need to evaluate the robustness of waste disposal systems was recognized as of equal importance as quantitative evaluation of the potential radiological risks associated with facilities and activities.

It was noted that in its co-ordinated research programmes, the IAEA was giving attention to the improvement and harmonization of approaches to safety assessment, to its application to various waste management facilities and activities, and to the related decision making processes. The IAEA was encouraged to provide due emphasis to this work.

Discussion following summary

R. HEARD (South Africa): During Session 10, A.-C. Lacoste expressed misgivings about the idea of international repositories on the grounds that every country should take care of its own radioactive waste. I would simply emphasize that there are a lot of developing countries which cannot take care of their radioactive waste and need access to an international or regional safe storage facility or something similar.

S. CARROLL (Greenpeace International): In my view, the building of international or regional repositories is not the only possible solution to the radioactive waste problems of those developing countries. Another possible solution is co-operation and capacity building.

A.-C. LACOSTE (France): Whether one is talking about an international disposal facility or about a national one open to waste from other countries, the most important thing is that disposal should be carried out in compliance with internationally agreed safety regulations.

R. HEARD (South Africa): I said ‘safe storage’ — not ‘disposal’.

A.-C. LACOSTE (France): What I just said could apply to storage as well as to disposal.

CLOSING SESSION

Chairperson

A.J. BAER
Switzerland

CONFERENCE PRESIDENT'S CLOSING STATEMENT

SUMMARY OF THE CONFERENCE

A.J. Baer
Belp, Switzerland
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One way to summarize the conference would be to say that there were 254 participants and 13 observers, that there were 46 countries represented and 13 organizations, that there were 10 sessions, 23 oral presentations and 52 panellists. But what I am going to try and do here is pull out some trends and issues as I see them. I am not going to try and go over what you have just heard and pick out things specifically from one session or another. So, my presentation is not complete, it is not politically correct and, at times, I must admit it is even blunt. It is an emotional impression, not a rational analysis; and I have not consulted with Session Chairpersons on what I want to say. So, if you think that what I'm saying is what they said, that's great; if you think I'm saying something that they didn't say, then that's all right, too.

There are two people I would like to thank before I start. One is Mr. I. Barraclough from the IAEA, because he gave me a very useful hand in preparing for this presentation. The other one is Mr. T. Flüeler, because yesterday morning he started his presentation by saying this: "You know, if I was a scientist here, sitting in the audience, I couldn't take it for more than five minutes because scientists have to react and be part of the game. I have been sitting through more than 20 hours." So thank you, Thomas, for your understanding. A number of times I have felt like intervening and have refrained from doing so simply because I thought I would have my chance at the end. Anyway, I'll beg for your understanding as well on what I have put together.

The debate on conventional radioactive waste management, that is, solid operational waste from the nuclear industry, is increasingly focusing on high level waste and spent fuel, if spent fuel is a waste. This either means that the problem of management of low level waste is considered to be solved, or that as a matter of prioritization, we want to concentrate on high level waste — but there does appear to be a trend towards concentrating efforts on high level waste, for whatever reason. On the pros and cons of disposal versus long term storage, you have just heard again some words about it, and it is definitely a major issue for debate. Not a new issue, incidentally, but some consider that geological structures are more stable and enduring than human societies, while others do not trust science and prefer human control. There seems to be a trend towards an acceptance of the fact that the 'non-disposal option', or whatever term is preferred, needs to be subjected to a safety assessment just as rigorous as a safety assessment for a disposal site.

In the same general context, there is a trend towards greater acceptance of provisions for retrievability and reversibility, and what they should be, and that they should be part of a repository design. At Cordoba, if those of you who were there remember, these were relatively new issues. They were debated and the balance of opinion supported the 'yes' — fine. But really, that is not what we want. What we want is to go for final disposal. Now, it seems to me that these concepts are taken as part of the normal expectations: this is a realistic option, it is not necessarily technically ideal, but it is politically very important and, therefore, it is part of the picture. And in that sense, I see a trend towards the increased acceptance of retrievability and reversibility.

I have also perceived a trend towards developing what I would call a 'middle of the road' solution, an idea which has come up again this morning. Strict disposal (meaning that you put your stuff in there, you lock the door and walk away) is not particularly good. Simply leaving the stuff at the surface in whatever condition 'indefinitely' is not particularly good either. Can we not find something somewhere in between? This sort of final repository remains open for 100 years, 200 years, 300 years — or at least until some future generation decides that it is time to close it. This seems to be an option that is being considered and that perhaps needs to be considered further.

The technical arguments for safety and safeguards would support a repository that is open (and retrievable, and so on) as briefly as possible. But if, on the other hand, we consider the socio-political reasons, the answer must be no, it should be open as long as is necessary. We have this sort of paradox: the technical approach saying 'close it', the socio-political approach saying 'leave it open'. Somehow, we have to deal with that issue, and find a way of knowing what is acceptable and what is preferable. At any rate, if we lose one of these 'middle of the road' solutions, rather than the straight standard disposal, we have to take a few precautions. We have to make sure that the waste is packaged in a 'final' form. We do not want the waste to be packaged and repackaged and repackaged — whatever happens to it, it has to be packaged once and for all. The information that accompanies it, that will accompany it, and that must accompany it, should be in a form that can be passed on to future generations to use in a standard form. The same future generations should be told how we think the site should be closed. We have a certain technological knowledge of what we think should happen to a disposal site. We should not simply let this knowledge disappear and say to ourselves that the others will find a way. We should make sure that the information we have is passed on to whoever will have to close the site at some time in the future.

These various aspects all bring me to what I think is an interesting shift in the understanding of the phrase ‘no undue burden for future generations’ — what exactly is it? If you think back in time, it was quite clear, originally. It was absolute: ‘no undue burden for future generations’ meant that any one generation takes care of its waste, has a final way to dispose of it and the next generation never has to worry about it. That was the start of the idea. Then there was the beginning of a shift, say, at Cordoba. People suggested that that was all very well, but what is ‘undue’? Well, maybe ‘undue’ is not what we thought; maybe ‘undue’ means that there are some ‘due’ burdens. It used to be absolute law — now, it is getting to be a relative recommendation. Now, we talk about ‘not foreclosing options’ for future generations, which is fair enough, but there is some vagueness built into this combination of ‘no undue burden’ and ‘not foreclosing options’, and I believe that this vagueness should be dug into — we should try and see a little more of what really is behind it. Did we make a mistake by saying ‘no undue burden’? Or do we want to go back to a strict, narrow definition? These are issues that are open, as far as I am concerned. But the trend, too, is towards opening, as I see it.

At this stage, I would like to make a parenthetical observation on the long term opening of a final site: keeping the site open for 200 or 300 years. When we do that, we are, in effect, extrapolating present social conditions 300 years into the future, and I think extrapolation is a very risky game. I will demonstrate how and why, very simply. These are the conditions that we are talking about: 2000 minus 300 is 1700 — we all agree. In 1700 or 1702, Louis XIV was on the throne in France, and on the east coast of North America, there were a few European colonies trying to make a living. Now, if we think of what they could have imagined about society 300 years hence, they just could not imagine what is happening today. So, I am sorry, but I cannot believe that any one of you or any one of us can imagine the social situation 300 years down the road. If we extrapolate 300 years and say that society will do this or do that, we are kidding ourselves. We don’t know (which, of course, brings me to say that geological disposal is a better option, but that’s the other side...).

There is also, I think, in this discussion of institutional control and long durations, a need for clarification of terminology. This is a side issue but frankly, when we start talking, we have to talk about regulatory control, active institutional control, passive institutional control, and the Waste Convention talks about active monitoring and passive monitoring. There is a need to clarify this because between ourselves, we are not necessarily all agreed on what they mean. If we do not agree between ourselves in this room, we are never going to be able to explain to anybody what the difference really is — if there is a difference. We have to be careful with terminology. It is very nice to use the words and it sounds very important, but let's be careful about using these words and explaining to others what they really mean.

There is another trend that I perceive, being the trend towards what I would call 'public acceptance based solutions' in the field of discharges. We had a discussion about OSPAR, about the trend towards 'zero' emissions. I am not going to repeat that, but I think the general lesson on that is that there is a strong need for a more holistic approach. Not only should waste management be considered in the context of nuclear energy — that is obvious; it's been said and repeated many times. In the context of societal impact, however, it goes well beyond nuclear energy. I am sorry to say that, to me, too many people do not see beyond the edge of their plate, don't realize the implications of their proposals. The trend towards 'zero' emissions rather than optimization is exactly that kind of discussion. I would add one thing here, namely, that if you think of the countries party to the OSPAR Convention, the governments (or the administrations) of these countries have a ministry for the environment, or similar, where people push towards 'zero' emissions — but the same government in the same country has another ministry that is in charge of nuclear energy, which says 'this is crazy, we can never do that'. The structure of the country is such (or the structure of the administration is such) that within the administration of that country, there are certainly two opinions. If they cannot agree between themselves, how should we agree? That is an issue that needs to be discussed further and cannot be resolved now, but it does need to be resolved in the end.

There is another point I would like to make. You have seen downtown Vienna, you have seen the horses and buggies, and you have seen that many of the horses still wear blinkers. Now blinkers, as you know, are meant to prevent the horse from being distracted by what is happening on either side, to stop it from becoming frightened, and are worn in order for the horse to go straight ahead. That's fine. What I am saying is that people, too, still wear blinkers — some people don't know they can take them off, and other people don't want to take them off. It is very difficult to know which ones are which. Some seem to do it on purpose, and others do it because they don't know better. All this may be far from radioactive waste disposal and long term storage, but it is a general issue: it affects what we are saying and doing in this particular area.

Disused sources. The non-controversial theme of the week. It is not a new issue but it is certainly an issue that is gaining in importance, especially since 11 September 2001, and it probably is now gaining the importance that it should have. For a long time, it was known about but nobody did much about it. Disused sources are very widespread, and this is still the area where most accidents occur. Safe and cost effective management options are needed. Boreholes are a possible solution; we heard this morning, again, about that possibility. Where I see a trend is towards encouraging return to the manufacturer. There is a lot of talk about it. There are difficulties, legal and other, but it seems to me that there are a number of actors who should and probably could do more than they are doing to encourage this return to the manufacturer. I think concerted efforts by all interested parties would bring some results, and I believe not only that this needs to be resolved but also that it can be resolved. To me, it is not an impossible thing to do. It takes a little goodwill, probably some money and a general effort, and the results will be tremendous if we think of the number of accidents which could be avoided by making sure that we do not lose sources, as we do now.

There is another important issue that was discussed this week: NORM waste. Again, it is something that a few years ago people did not know about, and now everybody knows what NORM is. Everybody agrees that this is a problem; I don't think anybody says it's not the nuclear industry so we don't want to know about it. I think the problem is recognized as such, and that is an important trend. Dealing with NORM is certainly an issue. What came to me loud and clear is that because of the great variety of situations involving different types of NORM — different countries, different geographies, etc. — each case needs to be considered on its own merits, and this was said again in the summary this morning. What we should use is radioprotection principles, sound radioprotection principles and, please, common sense. I believe that in this case, this is the better way to approach the problem. And I would add a personal comment: don't get lost in discussions on intervention and practices and what have you. There is a problem to be solved. There are rules and regulations on how we could try to do it. Let's get down to work rather than spend our time discussing it.

There is a recognition that at least some types of NORM will have to remain at the surface under institutional control in perpetuity, and I would like to tell you what I think 'perpetuity' means in this case. I think it means as long as we have not found the means to handle them differently. To me, this means 100 to 200 years. I would be willing to take bets that in 200 years, the problem will be solved and nobody will worry very much about it, because there will be some sort of technology that can take care of the so-called perpetual storage. Again, extrapolating present society to the future is interesting and funny, but not necessarily very reliable.

The issue of NORM is closely related to the issue of restoration of earlier sites. This brings us to the issue that was discussed: the cleanup of sites from past practices. ICRP 82 provides intervention levels, but what is happening is precisely not that. The trend is towards saying: 'No, that is not good enough. We want to go further down.' This is fine, any country can decide what it wants to do, but this option of going further down — to the sort of levels required for current practices — is an expensive option, and that's where the trouble comes. Some Member States can afford to do it, but others cannot: what does that do for the IAEA? The IAEA is an international agency for all Member States. Now, is it going to say that rich countries go on this side because they want to have this particular level; poor countries go on that side because they cannot afford anything better? There is an issue here that the IAEA itself has to tackle. It is a serious issue, and I don't think we can let it go like that, saying: 'I have money, therefore I'm going down here'; or 'I don't have money, therefore I will stick by that particular level.' This is a tricky issue.

Still on that NORM business, a lack of clear guidance has been recognized on how to handle NORM waste, site remediation and the related areas. A number of you said we need some recommendations on the part of the IAEA on how to handle this particular issue. But you remember at the same time how I said, and it was said before, to go for a case by case approach because it is so difficult. This is an attempt to get some guidance from the IAEA, but at the same time, guidance that would allow case by case flexibility. This is not easy to do, but seems to be what is required.

There is another topic that I think we have not discussed enough, and that is finances — money. We have talked about it, some of you have talked about it in your presentations, but money or financing is an important issue in any one of the areas being discussed. Lack of money is a problem — it is not just an issue, it's a problem — and we should have more open discussion of it. You will say that IAEA conferences are not here to discuss budgets — of course not — but they are here to discuss financing. We have done a lot towards financing future waste disposal or long term storage, as you know, but we are being faced with a problem of all the stuff that is still on the ground from earlier activities, and we have no money to do anything with it in some cases. This is another issue, but it is still a financing issue and I must tell you financing is a language that politicians understand. So there is a need, I think, for more discussion in that area.

In this conference, there has been a conscious effort to open the discussion on waste management to non-technologists. I say 'non-technologists': I am not going to get into 'stakeholders' discussions, but I mean non-technical specialists. It is not a new trend, but I think it has been more marked, it has been clearer than in the past: there are more participants here who are not 'technologists', and I think it is a very good thing. It says two things to me: firstly, that technologists are opening their minds, which is one good point; and, secondly, that they recognize they need help. They need help on things such as trust, acceptance and credibility; all these non-technical areas where we are a little bit hesitant because we are not too sure what really is covered. Now we say: 'If you could give us a hand we would appreciate it.' So this is, I believe, going in the right direction. And in the same general context, there is a fair bit of talk about dialogue — and dialogue is essential, it should be promoted and I am not going to repeat everything good you can say about dialogue. But some set of common values at bottom is needed if there is to be a dialogue, otherwise, there will be two monologues, or three or four or five. Somewhere, there needs to be a common place for discussion. That does not mean you have to agree from the start. The common base can be general recognition that there is a problem with the waste, but if one person says there is no problem with the waste, and the other one says there is, you are not going to get anywhere. I believe that it is important to recognize not only that dialogue is needed — I think we readily recognize it now — but that dialogue implies a number of basic conditions, and if these basic conditions are not realized, there is no dialogue.

The relationship of technologists to others interested in or affected by radioactive waste management — meaning stakeholders — is an issue, but we have to be very careful about different groups having different needs. It has been said in various ways during the week that 'the public' is not a stakeholder: if you are siting a repository, the people affected by that siting are not at all the same people as those who, in theory, like or do not like what you are doing. You have to be careful about the different groups, you have to address the interests of each group differently. I think this is a positive trend among technologists to recognize that we live in the real world of emotion and politics, and not in the protected world of science. I think this is slowly beginning to sink in for most technologists, and I believe that this is an area of great progress over the last ten years or so. Cordoba certainly talked about societal issues, but this conference has gone further, and to me this is definitely one further step in the right direction. I would imagine that future conferences at future times will go even further than that.

I have one last point, which is really a question, or an issue that I believe affects the IAEA first of all. This conference has recognized and discussed the essential role of the socio-political component involved in the issue of waste management. Now, the issue is not going to go away: the technologists and technology cannot resolve it, and progress towards final disposal depends critically on socio-political considerations. I think the whole week has shown that, again and again. So if we take this as a given, we get to the work of the IAEA. The IAEA has built its reputation on the quality of its technical work. Is it able, or is it willing, to help us progress towards a resolution of socio-political issues standing in the way of radioactive waste disposal? Can it do it? If it can, how will it do it? I think these are difficult questions. I know that they are not new questions for members of the Secretariat. I know that they have been raised before and I know that success has not always been what some people would have liked it to be. I believe that this conference has shown very clearly that we cannot forget about the socio-political side of the waste management issue, and on many things we would expect the IAEA to help us out. Can it help us out on this if it says it is a ‘technical agency’? This is a fundamental question with respect to what the IAEA can do, should do, is able to do, is willing to do. And when I say the IAEA, I am not aiming at the Secretariat, I am aiming at the Board of Governors of the International Atomic Energy Agency, because the Board, made up of Member States, is the body that decides on IAEA policies. If the Board says ‘we are purely technical’, the Secretariat will have to say the same thing. So, this is a fundamental question for the work of the IAEA, and I believe that this is one which has to be asked and, hopefully, answered at some time.

CLOSING STATEMENT

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During the course of this week, you identified and discussed a number of issues in radioactive waste management involving safety, technology and societal issues, and the processes by which organizations and Member States address the management of radioactive waste. It is evident that we did not have the time to digest the outcomes of the discussions this week.

We understand that an important theme throughout the conference has been 'communication'—a subject on which the IAEA has been encouraging greater emphasis. It seems to us that only by means of improved communication, in all its senses, and also by means of greater transparency in the work that we do, can we expect to obtain the trust of those who may be potentially affected by nuclear developments, including waste management.

The IAEA itself functions as an authoritative source of information on radioactive waste management that is useful in informing the public and government officials. The IAEA is also envisaging new means of 'mining', analysing and communicating information on radioactive waste matters.

We are pleased to know that the conference has had a separate session entitled the International Regime for the Safety of Radioactive Waste Management. You will be aware of the new initiatives within the IAEA on this subject and, in particular, the efforts of the Commission on Safety Standards to increase the awareness and use of the Safety Standards in the world.

The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management was also an issue that was discussed this week. The effect of this convention on the global waste management scene is one of great interest and one to follow up. As you will have heard, the first of the regular Review Meetings of the Contracting Parties will be held in November 2003.

We observe an increased impetus to move forward with disposal programmes, one of the most critical issues in nuclear energy. We also observed looming decisions in waste management programmes. Indicators of further decisions to be taken soon, one way or the other, on disposal combined with storage include:

(a) The recent decision of the United States of America to proceed with a spent fuel and high level waste repository at Yucca Mountain;
(b) Finland's approval, in principle, of a final repository project at Olkiluoto;
(c) Canada's Nuclear Fuel Waste Act, which has just come into force and which requires Canada's three nuclear fuel waste owners to come up with a plan within three years;
(d) The proposed directive of the European Commission's Directorate-General for Energy and Transport requiring member states to decide on repository sites by 2008 and to have the sites operational by 2018.

While management of high level waste and spent nuclear fuel is often viewed as the most significant waste management issue facing the nuclear industry today, issues also exist with the management of disused radioactive sources, large volumes of low activity wastes, including naturally occurring radioactive waste, and legacy wastes. Member States, industry and the IAEA are grappling with these issues and we look forward to seeing more progress in these areas.

Also discussed at this conference were selected technical aspects of radioactive waste management indicating good practices in managing radioactive waste and appropriate technical approaches in the application of Safety Standards, taking due account of security, environment, cost efficiency, sustainability as well as the involvement of stakeholders.

It is evident from what I said before that the outcomes of this week's conference will help the IAEA improve its activities in a way that focuses on the most significant issues and reflects the current trends in radioactive waste management internationally. After this conference, the IAEA will review its results and conclusions, and report on the outcomes.

My main task now is to acknowledge the contribution of all those who have been actively involved in making this a successful conference: the speakers, the panellists, the chairpersons, the poster contributors and the members of the Conference Secretariat. Last but not least, I would like to thank the members of the Programme Committee for the excellent programme they put together, and to give special thanks to A.J. Baer for his salient summary of the conference. On behalf of the Director General, I declare this conference closed.

CONFERENCE PRESIDENT

A.J. BAER
Switzerland

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