

Safety Reports Series

No.31

**Managing the Early
Termination of Operation
of Nuclear Power Plants**



IAEA

International Atomic Energy Agency

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MANAGING THE EARLY
TERMINATION OF OPERATION
OF NUCLEAR POWER PLANTS

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FOREWORD

The International Atomic Energy Agency (IAEA) has the statutory mandate to seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world. However, it has become more and more apparent that many States are facing the decision of closing nuclear power plants (NPPs) before expiration of their operating licences. Some NPPs have already closed and the owners are evaluating the effects on their staffs, the local economies and safety at the sites.

It is evident that safety aspects and management strategies are important factors to be reviewed and monitored throughout the process of early termination and closure. The owners and employees of the NPPs are realizing that they are entering into very difficult phases of the plant life cycle with significant safety concerns.

Although a great deal of work has been done to review and process information on technical aspects of early termination prior to decommissioning, far less attention has been given to the management and organizational issues involved in maintaining the required safety level in such nuclear installations. It is important that when decisions are made to terminate operation early, the same safety measures are applied to management concerns for strategic planning as are applied to technical reviews. These management and organizational issues are fundamental to any future decommissioning process. Managers at sites that decided to close early may be working to cope with management of change issues arising during the transition from operation to decommissioning as they monitor resource and competence needs, as well as staff morale and technical issues. If these issues are not treated satisfactorily they can have significant safety consequences. The organization often must address all these challenges with little guidance or experience and with reduced resources.

This Safety Report has been developed with the support of experts from regulatory, operating and engineering organizations and is intended for managers dealing with the decision to shut down plants prior to the expiration of their licences. It provides guidance for senior managers in the area of strategies, personnel involvement, communications, interface with the regulatory body and experiences that may be used as States face challenges in managing the multiple tasks associated with early closure decisions.

In thanking all the contributors to this Safety Report the IAEA would like to acknowledge the special efforts and valuable assistance of R. Mellor and G. Bismarck. The development of this publication was co-ordinated between the Department of Nuclear Energy and the Department of Nuclear Safety and Security. The IAEA officers responsible for this publication were C.R. Clark of the Division of Nuclear Power and B. Hansson of the Division of Nuclear Installation Safety.

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1. INTRODUCTION

1.1. BACKGROUND

The issue of early termination of operation of nuclear power plants (NPPs) has become increasingly important over the past several years in a number of States. For most of these States, closure due to political, economic and safety considerations represents a clear example of the shutdown of an NPP before the end of its established operating life or the early termination of operation.

Early termination of operation of an NPP, or the sudden transition from operation to a permanent shutdown mode, may be the most difficult and sensitive change during the entire lifetime of a nuclear plant. The reasons for the closure are often hard to face by the staff involved. They may feel that the installation is a good plant that has been closed down for reasons beyond their control and before the end of the operating life of the plant.

In the case of early termination of operation, sensitive management and organizational issues will arise that managers at the site will have to cope with in a situation in which their own or the staff's future is uncertain. The sensitive issues are, for example, rumours giving rise to insecurity among the staff, decreasing availability of resources and loss of competence through the departure of staff. Declining morale and the nature of these issues could very easily affect the safety of the plant. Each plant's situation is unique and needs to be treated as such, but several of the issues have similarities and therefore the plant management can be supported and assisted, through information exchange and benchmarking activities, in dealing with such a situation.

Although a great deal of work has been done to review and process information on technical aspects of an early termination decision that will result in decommissioning, far less attention has been given to the management and organizational issues involved in maintaining the required safety level of the nuclear installations prior to commencement of the future decommissioning process. These management and organizational issues are fundamental to any decommissioning process. Managers at these sites are working to cope with change issues, resource and competence needs, morale and technical issues during the transition from operation to decommissioning. If these issues are not treated correctly and professionally they can lead to significant safety consequences. The organization often must address all these challenges with little guidance or experience and with reduced resources.

In December 2000, the IAEA organized a workshop under its technical co-operation programme in Greifswald, Germany on 'Managing the Early

Termination of NPP Operations'. The participants presented information about their strategies and the challenges faced in meeting the demands of early termination. The main theme put forward by the representatives from Germany, Sweden, the United Kingdom and the United States of America centred on focusing mainly on personnel issues during these times of early termination, and managing those issues by communicating, involving personnel and listening to the staff as decommissioning proceeds. A number of key challenges and recommendations evolved from this workshop. Primary among them were:

- (a) Organizational functions and management skills during the transition: sustaining organizational memory, retaining staff competence, and sustaining safety culture and morale during the transition;
- (b) Control of the risk to health and safety once an early termination announcement is made and during the transition;
- (c) Providing a forum for the establishment of working groups to develop solutions to early termination issues using a self-assessment approach for operating organizations and regulatory bodies.

The transition from operation to permanent shutdown may be the most difficult change during the entire lifetime of a nuclear plant, with significant safety concerns. To maintain its focus on this important area of early termination of operation, the IAEA held a follow-up workshop in Vienna in November 2001. Its objective was to integrate the information, challenges and recommendations of the Greifswald workshop with information, updates on specific plant experiences, additional challenges and recommendations to produce guidance for senior managers.

1.2. OBJECTIVE

This publication provides guidance in the areas of early termination strategies, personnel development, communications, regulatory interface and issues, and specific plant experiences. States may use this information and guidance as they face the same challenges in early termination of NPP operation. Each decision on an NPP's early termination of operation will present unique challenges. The objective is not to provide a prescriptive set of actions that must be taken but to review broad areas that may be identified by plant operating organizations, regulatory bodies and States to ensure that an aggressive assessment process is ongoing. It is likely that this guidance will be modified as more States gain experience with the process of early termination of NPP operation.

1.3. STRUCTURE

Section 2 elaborates various issues and challenges that many organizations might face in the case of early termination. The guidance given on how to deal with these issues is based on the experience of the participants in the referenced meetings, mainly senior management personnel of nuclear plant operating organizations and regulatory bodies. Section 3 highlights the importance of information exchange in different forums, benchmarking and visits to other plants that are facing similar situations. Section 4 gives guidance on readiness assessment for dealing with the actual situation and on extending such assessment beyond the traditional areas that affect safety.

Annex I details the experiences of three units of the Chernobyl NPP in Ukraine, whose operations were terminated early, culminating in the shutdown of the last Chernobyl unit on 15 December 2000. The experience of unit 1 of the Barsebäck NPP in Sweden is presented in Annex II. Its experience is unique because unit 2 is still in operation. Annex III details the experience of the Italian plants at Trino and Caorso. The management of these plants faced many of the same issues but also had to deal with unique aspects not encountered by other units that terminated operation early. These experiences highlight many of the issues discussed in this publication. States and plant operating organizations are encouraged to view these examples as benchmarks and to contact the workshop participants to arrange for visits to these plants. To the extent possible these examples have been referred to and discussed in the present publication.

2. EARLY TERMINATION OF OPERATION OF AN NPP

The decision to cease power operation early may be the result of many factors ranging from issues of economics of operation to the cost of maintaining adequate safety, or even the national interest. Operation may be terminated suddenly, as is often the case with decisions based on economic factors, or may be planned over time as might be the case with termination in the national interest. However, such decisions on early termination generally have one common outcome: major changes that must be properly managed to ensure safety and a responsible transition to decommissioning activities.

These changes will affect a number of groups that will be stakeholders in the shutdown processes. Governmental bodies may be involved in the termination decision and/or in establishing laws and policies relating to the impacts on society, decommissioning and the processing, handling and disposal

of radioactive waste. Regulatory bodies will be responsible for developing the necessary regulatory framework and inspection processes needed to ensure that early termination activities are carried out in compliance with the appropriate safety regulations. Plant management will be responsible for ensuring safety at the site, managing personnel, implementing and monitoring changes, establishing appropriate organizational structures and maintaining adequate numbers of competent staff (see the examples in Annex I). Workers will be concerned about the potential loss of work, with a possible loss of motivation and lower morale. The surrounding public may know little about the early termination and future decommissioning processes and will be worried about plant safety, loss of local revenues from plant payments and lower employment in their area. Other issues may affect the plant owners and contractors.

Guidance in these areas, based on best practices of several States that have been involved in early termination activities, is provided in the next several sections. This guidance is to be used with a word of caution. Each early termination decision will result in a set of circumstances unique to the plant under consideration. It is important for managers to be able to adapt the guidance to their particular circumstances. Some examples that draw upon the experiences of contributing States are provided in the annexes. Again, the examples must be used with caution. They are not intended to be the only way to manage the early termination of operation. Managers are urged to contact the cited State organizations for more insights.

2.1. GOVERNMENTAL ISSUES

A number of issues affect the early termination of a nuclear plant and may require action on the part of national governments. A government might decide on a national energy strategy that includes the permanent shutdown of all or specific NPPs. In making these decisions a government might wish to consider the issues of finance, replacement power, radioactive waste disposal and the environment. Prior to deciding on early termination, a government may need to pass appropriate laws and acts to govern the period of early termination of operation.

2.1.1. Shutdown decisions

Governments in some States with operating NPPs have made decisions to terminate their operation early based on a national strategy. Prior to making these decisions, it is important that the national strategy takes into account

plant safety, the development of future decommissioning plans, waste disposal, available funds, environmental consequences, financial and economic factors and a replacement energy strategy. Thus a government may use the available information and the safety evaluation by the national regulatory body to assist in determining whether continued operation of the plant is acceptable or whether its shutdown supports the national strategy.

A national strategy of early termination of operation can have serious economic, environmental and social consequences. Before such an important decision is finalized good communications must be established between the government and the operating organization, between the government and the regulatory body and between the government and the public to achieve a common understanding that such a decision is beneficial. This is especially important when the national strategy weighs safety, economics, a replacement energy strategy and the environment differently.

2.1.2. Replacement power

Nuclear power plays a significant role in providing electricity in many States. Nuclear power plants may generate 40–80% of a State's total energy. Replacement of this energy by other sources may require an extensive investment programme. Some States may not have adequate national sources of energy and thus may consider a strategy that relies on the import of fuel or electricity from neighbouring States. To ensure an uninterrupted power supply a replacement power strategy may be included in the overall national strategy. That strategy might therefore factor in the economic, social and environmental consequences of the replacement power source. These factors may be evaluated in detail and then used as the bases for the decision to terminate operation. Annex III gives insights into how the need for electric power figured in the early termination of operation of the Trino and Caorso plants in Italy.

2.1.3. Financial issues

The plant operating organization may be responsible for all decommissioning activities. This may include ensuring that adequate funds are available to complete decommissioning safely. Early termination of the operation of a nuclear power plant has a financial impact with the following major components:

- (a) The cost of releasing staff,
- (b) The cost of replacement power,

- (c) The maintenance cost of maintaining the safety level of the plant through different stages,
- (d) The provision of funds for decommissioning,
- (e) The return on recent major investments in safety upgrades.

The need to fund the release of staff, plant maintenance, decommissioning, etc. needs to be taken into account from the beginning of the plant's operation and appropriate financial means need to be secured. The funds are usually generated by good financial management over the design lifetime of the plant. Early termination can lead to a shortage of funds needed to complete decommissioning. The government may envisage a flexible financial scheme that will prevent an early termination decision from having a serious financial impact.

The plant's maintenance programmes are followed normally and regular maintenance activities are carried out to maintain a high safety level. The cost of maintenance is usually included in the funds for keeping the plant in operation up to final shutdown and during the various phases of decommissioning.

Some plants make major safety upgrades immediately before deciding on early termination with a view to improving the safety level of the plant and prolonging its lifetime. Other plants are given lengthy advance notice of closure and will continue to invest in safety upgrades. The decision makers may consider a return on these investments in their accounting practices and the possibility of paying them back may be negotiated.

Regardless of the reason for permanent shutdown, there are several options for decommissioning. Which option is chosen may depend on the funds available for decommissioning and for completing the associated activities (construction of a radioactive waste treatment facility, final repository for high and low level radioactive waste, etc.).

2.1.4. Final waste repository

Waste management is an important part of the decommissioning process. Prior to the decision for early termination, it is necessary to ensure that the generation, conditioning, storage and, where appropriate, disposal of wastes from the decommissioning process is or will be conducted in a manner consistent with waste minimization and the acceptance criteria of disposal facilities. If none exist, adoption of a national policy and a national strategy for the safe management of spent nuclear fuel and radioactive waste is desirable. The purpose of such a strategy is to develop a unified national system for

management of radioactive waste and spent nuclear fuel in accordance with the recommendations of the IAEA [1].

2.1.5. Legal provisions

All States with nuclear programmes have laws governing nuclear and radiation safety in all nuclear activities, including early termination. The operating organization responsible for the nuclear plant has primary responsibility for all the necessary technical and financial measures when a decision for early termination has been made. Where the nuclear legislation in a State does not consider early termination of operation of nuclear plants, it is desirable that such provisions be adopted. In some States prescriptive regulation of safety is a tradition and the practice is to adopt a set of regulations related to early termination and future decommissioning, radioactive waste, and spent fuel management. Adoption of such regulations or another form of interpretation of safety requirements related to decommissioning is considered acceptable. See Annex I for an example of the development of laws in Ukraine to deal with issues relating to early termination of operation.

2.1.6. Development of safety regulations during the early termination of operation

Prior to a decision on early termination, the government may consider whether the existing directives to the regulatory body, the available resources and the country's regulations are sufficient to ensure safety during an early termination of operation and the stages following the shutdown of the plant. Regulatory requirements, licensing procedures and the list of technical documentation to be submitted for licensing may be determined, together with definitions of the stages from early termination through decommissioning and the need for organizations to ensure safety during each stage of the process. The structure and contents of the early termination, transition and decommissioning plan and the relevant safety analysis reports may be included, in accordance with each State's regulations.

As a plant approaching early termination of operation has to carry out operation and maintenance activities in parallel with preparations for closure, the government may consider giving sufficiently long advance notice to the plant managers or operating organizations in order to avoid operational and organizational actions being taken under time pressure, which could affect the safety of the plant.

2.1.7. Development of safety regulations on the management of radioactive waste

It is generally advisable to implement the related provisions of the IAEA Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management [2]. Each State may consider implementing safety regulations or requirements on the management of radioactive waste. The provisions of Ref. [2] provide guidance in establishing these regulations.

2.1.8. Development of regulations on the safety of spent fuel storage

A regulation on the safety of spent fuel storage can provide, in advance, the safety requirements needed to safely store spent nuclear fuel, particularly when an independent approach to fuel storage is used. The regulation may provide general technical requirements. The related provisions of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management may be used as a basis for the regulation.

2.2. REGULATORY ISSUES

Regulatory bodies, by establishing appropriate regulations, implement the laws of the State. For some States, the existing regulatory framework governs the early termination of operation. In States where there are no laws regarding early termination, the following regulatory issues relating to early termination may be considered:

- (a) Development of the regulatory framework,
- (b) The regulatory inspection process,
- (c) Training for regulatory staff,
- (d) The licensing process for the decommissioning phases.

2.2.1. Development of a regulatory framework

The primary focus of the regulatory framework on early termination is to provide the regulatory requirements for this process. In some States the same regulatory framework applies throughout the lifetime of the plant, including decommissioning. In others there will be a need to develop legislation and appropriate regulations. In many cases decommissioning was expected to follow the design lifetime of the plant, and this is reflected in the legislative documents. Failure to address early termination issues within the regulatory

framework can lead to serious problems for the operating organizations. Problems such as the inability to properly plan shutdown operation, initial decommissioning activities, acceptable approaches to spent fuel storage and appropriate staffing levels can have an impact on the safe operation of the plant.

The regulatory framework for early termination of NPP operation may be the same as that developed for the end of lifetime shutdown for decommissioning. If national regulatory documents are not available for end of life shutdown of NPPs, they need to be developed as soon as possible. States developing such a regulatory framework may consider evaluating the experience of other States that have an established regulatory framework addressing early termination of NPP operation. See Annex II for insights into how the Swedish regulatory body dealt with the early termination of operation of unit 1 of the Barsebäck NPP.

2.2.2. The regulatory inspection process

Based on an established regulatory framework for early termination of a plant's operation, the regulatory body may ensure that the operating organization of the facility maintains the required level of operational safety during the early termination process. Prior to any decision on the early termination of an NPP's operation, the regulatory body may gather experience, continuously follow developments in other States and set up an inspection process for early termination. In addition, consideration needs to be given to increasing the number of staff to manage the process and to how this goal can be reached most efficiently. This process may cover:

- (a) Staff morale, to be monitored together with operating organization measures towards addressing the future career prospects of the staff.
- (b) Planned inspections, to be carried out more frequently at the beginning of the early termination period in order to point out any negative trends in safety culture. If negative trends are detected, ad hoc inspections may be performed to monitor more closely and improve the situation. See Annex II for insights into how the Swedish regulatory body implemented the inspection process during the early termination of operation of unit 1 of the Barsebäck NPP.

2.2.3. Training of regulatory staff

Training of the regulatory staff for inspecting early termination activities is slightly different than for end of life decommissioning. In particular, attention

may focus on maintaining proper safety margins for plant equipment, and on worker morale and its effect on the safety culture. The inspectors may be trained to recognize negative tendencies when carrying out inspections. Other training with which the regulatory staff might be provided includes training on the management of change, on the process of early termination of operation, on decommissioning in general, and on details of the future decommissioning of the specific plant (when available). Experienced specialists from States with proven experience may provide practical aid at the beginning. IAEA fellowships might be considered for training regulatory staff.

2.2.4. Licensing

Early termination may be licensed according to existing regulatory documents. Some States may use a regulatory framework that already licenses decommissioning as part of the existing operating licence. Others may use a framework that requires licensing of established phases of decommissioning, including the early termination phase. The current licensing approach may be reviewed to ensure that the period of early termination of operation is appropriately addressed. Where needed, new licensing requirements may be developed. Following is a discussion of a possible relationship between the early termination and the future decommissioning phases.

2.2.4.1. Decommissioning phases following a decision on early termination

Decommissioning phases may be established in order to explain the decommissioning strategy of the plant about to undergo early termination. These may be determined in the relevant regulatory documents. Regardless of the regulatory approach, the regulatory body may need to ensure that funds are available to safely carry out the planned early termination of operation and the resulting decommissioning actions. This may be a condition of the licence or required by regulations or laws.

2.2.4.2. A 'cradle to grave' approach

Early closing down of a plant for an unforeseen reason might be considered from the start of a plant's design and licensing process. This is the so-called cradle to grave approach. Special provisions might be inserted into the national legislation on existing plants that have no decommissioning planning. Reasonable terms for completing licensing activities may be determined as early as the design stage of the plant in order to provide time for planning through to final closure.

2.2.4.3. Document approvals

Documents covering early termination of operation may be approved according to the procedures adopted by the State's regulatory body. If lower tier documents for early termination (such as specific instructions or procedures for day to day operation) do not exist, these may be developed in due time by extracting them from existing decommissioning guidance.

2.3. CHANGE IN OWNERSHIP

Some utilities reorganize when entering into an early termination phase, as the staff could be reassigned to another owner and be expected to assimilate another organizational culture at the same time as they are preparing for a premature closure of the plant. Such a step can challenge the safety of the plant. Changes have to be well discussed, prepared and communicated to reduce unnecessary concern among plant staff.

Following the challenges of an early termination decision, there are a few examples of the future decommissioning phase being entrusted to another owner or an organizational unit of another utility. In such cases it is important that the licence holder is redefined and that its duties and responsibilities are acknowledged, including the senior manager responsible for safety. The required competence of the new licence holder's staff must also be understood, acknowledged and ensured. See Annex II for an account of the concerns of the Swedish regulatory body concerning change of ownership issues.

2.4. PLANT MANAGEMENT ISSUES

2.4.1. Ensure safety up to permanent shutdown

During the period covering early termination of operation, the primary objectives are safe operation of the plant until permanent shutdown, a safe and orderly shutdown and safety of the remaining spent fuel. The required safety levels are to be maintained during all these stages. Challenges to safety must be continuously evaluated and, if needed, extra human or technical barriers need to be put in place to ensure defence in depth and the safety of the plant. Such challenges could be the spread of rumours, a sudden distraction of staff for reasons beyond the plant's control (such as political decisions), or unexpected information in newspapers before the plant has been able to communicate the information.

2.4.2. Nuclear safety

During the early termination period, safety must be ensured as long as the NPP qualifies as a nuclear installation or there is a real possibility of an unplanned release of radioactive material or other hazardous substances which could be harmful to the population and the environment. General safety requirements for the NPP during its operation are regulated. However, the special circumstances during early termination of operation have to be considered and assessed to reveal risks to safety and introduce mitigatory actions.

After spent fuel has been unloaded from the reactor and the spent fuel pools some safety requirements may be relaxed, but only after a safety assessment has been carried out. The approval of the regulatory body may be obtained as required by the State. In the case of early termination, facilities for the storage of spent fuel and other waste will not yet be ready. For this reason, the State may choose to retain the operating staff for an extended period of time.

Decommissioning is normally preceded by an exhaustive, systematic safety assessment. The assessment must be properly supported by documentation, which may be continually updated in the light of decommissioning experience and significant new safety related information. It is ensured that all activities are within the conditions established in the safety assessment. All new decisions and changes in project requirements, limits or conditions must be assessed from the point of view of safety, and may be implemented only after the agreement of the regulatory body has been obtained, as required by the State. However, these safety assessments are often missing when a decision for early termination is made, and therefore have to be performed in parallel with safe operation of the plant. To avoid demoralizing the operating staff a parallel organization may be preferred to prepare for the future decommissioning process. It is also important that the advance notice of early termination given by the decision makers is long enough for the appropriate management of these activities.

2.4.3. Fuel safety

After a decision for early termination has been made, the objective is to refrain from carrying out any decommissioning operation until the spent fuel has been unloaded from the reactor and, ideally, from the spent fuel pools. Procedures required by the licence must be used to unload and remove the fuel. Quality assurance procedures must be carried out to confirm that all the fuel has been unloaded from the reactor. If the fuel remains in the spent fuel pool after the decision for early termination, all activities must be analysed for their safety in relation to the fuel. Before systems supporting NPP fuel cooling functions are disconnected, and before the spent fuel pools themselves are

dismantled, the resultant impact on the intermediate spent fuel storage facilities at the NPP site must be assessed.

2.4.4. Radiation safety

The early termination of the operation period may serve as an opportunity to review and modify the radiation protection programme. The existing radiation protection procedures and the organization established during the operating period may be used as a basis, but special attention must be paid to possible radioactive contamination due to the production and release of dust, aerosols and liquids during any subsequent phases of the early termination. By planning radiation protection measures in advance of later decommissioning, an NPP will be able to review and meet State requirements. In the case of early termination special resources will not have been prepared for starting the dismantling activities. Therefore a considerable amount of training and preparation will be needed to fulfil these requirements.

2.4.5. Industrial safety

After early termination and shutdown of a plant unit, activities may begin to be characterized as construction activities in a radiological environment. Both radiological and industrial safety play important roles in safe and successful work once the decision to shut down the plant is made. During the period of early termination of operation, planning for decommissioning work might include an awareness of the different industrial safety issues that may arise during subsequent decommissioning work. Trained workers using appropriate equipment and following appropriate instructions may carry out dismantling and decontamination work in a safe manner. This workforce has to be created in an early termination situation.

2.5. PERSONNEL MANAGEMENT

2.5.1. Leadership

Early termination of operation is a difficult period in a plant's lifetime, in which the leadership role of plant management is challenged and its trust among staff is tested. Plant management has to be more alert and sensitive to changes in political and industrial issues. It needs to be sensitive to the working environment and reactions from staff to all these social concerns. In addition, the regulatory body will put more emphasis on being informed and will observe

and interview workers more intensively. The leadership role might necessitate more attention to the items discussed in Sections 2.5.2–2.5.20.

2.5.2. Communication – open dialogue

Open communication between the organization's different levels is important. Senior managers may call meetings to provide briefings on current issues. It is very important to provide accurate information on what is going to be done, how it will be done and what may be the result of these senior management actions. Workers may also be encouraged to submit to management their suggestions on changing the working conditions, tools, etc.

An open dialogue may already exist. Nonetheless, the new situation requires that further attention be paid to the performance of the plant management in following the process of early termination. Coherent information must be given to staff at all levels and include open discussions and the weighing of different opinions. Time may be given to continue discussions after meetings and a chain of feedback created in management levels. All levels of management may be given training in effective communication.

2.5.3. Observing and listening

Plant management may establish a system to monitor the 'feeling of workers' in order to be aware of a possible impact on safety. This is necessary to identify, in advance, behaviour which may have a negative impact on safety. It is important that each person have the right and be encouraged to voice his or her concerns. In one plant all the managers formed a network to observe their staff and report to the next level of management on reactions from their staff when something happened or rumours were spread. Immediate reaction from upper management is important to nurture the confidence of the staff and the regulatory body in the manner in which they are handling the situation.

Periodic surveys using questionnaires may also be used to examine the working climate and staff satisfaction. Such surveys can also be used to obtain an indication of the staff's reaction to a certain change in the situation. These polls may be evaluated at different levels of the organization to gain an understanding of the causes underlying different reactions and to allocate resources to solve problems quickly.

2.5.4. Involvement of staff

Involving the staff in future developments or changes is even more important in a situation of early termination of operation than in normal

operational circumstances. It is vital to involve the staff in different projects that lead to changes in the plant, such as organizational changes, staff reductions, new business activities, etc. These projects need to be openly discussed so that the staff can gain confidence that the changes are the most suitable as the situation develops. See the examples in Annexes I and II.

A programme for managing change may be established [3]. Personnel are encouraged to be involved and know what management has done to plan the operating organization's future work. For its part, management may ask employees for assessments of its performance.

2.5.5. Ensuring safety and avoiding human errors

Early termination of operation may be difficult to face for the operating staff as they will lose their mission of operating the plant to produce electricity. Furthermore, some categories of staff are more specialized than others and some will be more worried than others about their future. In an early termination situation, shift staff spend more time without effective work. This raises a need for managers to review the activities of shift staff more regularly than during normal operation. Plant management has to ensure the safe operation of the plant. It is therefore important that it intensify communication with shift staff and implement new working methods such as 'shadow training' of operating staff to avoid human errors. It is also important to improve the level of debriefings and double check completed activities, especially those considered routine.

2.5.6. Replacement of staff leaving the plant after a decision on early termination

In the time period immediately following the announcement of the early termination of a plant's operation, some staff may leave the plant, especially the younger generation who will perhaps lose confidence in the future of the industry. Some highly qualified staff may do the same. The decision makers are encouraged to take this possibility into account and to decide on remedial actions to reduce the turnover of qualified staff. Incentive agreements with staff or guaranteed employment during an extended time period are examples of methods that may be used for staff retention.

It may be necessary to replace staff or achieve competence by other means as qualified staff with special competences may leave the plant. Other nuclear or conventional power plants within a system may agree to support one another with special competences. Contractors may also be used in some areas. Contingency plans may be developed and remedial actions taken. The

regulatory body may have set requirements for competences needed at the plant and is to be informed about the staffing situation. To replace operators who may be leaving, the plant may ask other staff working during the daytime to return to regular shift work.

2.5.7. The personnel selection process

As the planning for early termination of operation develops, it will become obvious that a reduced number of people are needed to operate the facility and decommission the plant after permanent shutdown. Initial organizational changes may be planned as part of the development of the strategy for early termination of operation.¹ Plant management may ensure that a fair and equitable process is in place for the selection of personnel to fill the majority of positions in the new organization. One possible exception might be those key management positions which, in the view of the utility, may be necessary to implement changes after the permanent shutdown. Senior management might wish to appoint people to these positions. For all other positions, one approach involves establishing written job requirements and qualifications for each position in the new organization. Plant workers can then read the qualifications and requirements and determine whether they are interested in and qualified for the position. Personnel can then be selected from those qualified people indicating an interest in the jobs. However, the selection process may be designed to select the most qualified person and be fair and impartial. Ideally, the selection process for all positions should occur immediately prior to the permanent shutdown. If this is not possible because of the suddenness of the permanent shutdown, it may be conducted as soon as possible thereafter. Annex II gives additional insight into this area based on the experience at unit 1 of the Barsebäck NPP in Sweden.

Programmes may also be considered to retain personnel after early termination for the future decommissioning of the plant. Programmes providing incentive payments above normal salaries have been used successfully by organizations in some States. Normally, a worker receives such a payment only after completion of a minimum number of years of service or completion of a set of tasks. In other instances, a guarantee of employment for a set number of years has been used successfully.

¹ See Ref. [1] for examples of organizations established at some NPPs that have been decommissioned. Additional organizational changes may be required during the decommissioning process.

2.5.8. Support for personnel not selected

Not everyone will be successful in obtaining positions in the new organization. It is important that those applicants who are not selected do not gain the impression that they are being treated unfairly. The perception of unfair treatment can lead to decreased motivation and lower morale for some workers, which may result in safety issues during the final phases of the early termination of operation process. Programmes may be established for fair treatment of the workers who have not been selected and may include the early retirement of unselected personnel who meet retirement requirements, transition of personnel to new jobs in companies that will support the decommissioning, and appropriate severance payments for personnel who will be leaving the plant. Funding for all these programmes needs to be arranged prior to their announcement. Examples of processes to deal with personnel changes arising from an early termination of operation are detailed in the experiences at the Chernobyl plant in Ukraine and the Trino and Caorso plants in Italy (see Annexes I, III).

2.5.9. Training

Personnel who will be asked to remain after early termination and who will be involved in the decommissioning phase at a later date may be given special training and education relating to decommissioning activities. Personnel who are involved in financial planning need training to evaluate the necessary financial reporting requirements for early termination and decommissioning. Training is also important for personnel who are to perform decommissioning, or who may be required to manage decommissioning projects or supervise specialized contractors. This training may be provided during the early termination, transition and decommissioning phases. For personnel who will be doing decommissioning work, the focus of training will be on how to complete work in a short time because of high radioactivity levels. A systematic approach to training or similar methods may be used to establish future job requirements.

2.5.10. Management of change

Operating organizations are responsible for the safety of their plants. Therefore, it is essential that a systematic approach to change be adopted in order to maintain and preserve the project's goals and objectives and to give confidence to the public, the stakeholders and the regulatory body. At the operating organizations, management recognizes that change is a continuous

process demanding long term perspectives. Effective management of change requires communication, knowledge of the culture and recognition of the impact on the morale of the people involved. Consequently, there is a need for an effective change process to identify, evaluate, plan, implement, monitor and learn to ensure that no changes have a detrimental effect on safety and performance. Changes may be monitored and assessed at appropriate levels in a utility and at all process steps of each change. This may be an ongoing activity. Senior management may oversee these activities and be actively involved in promoting learning and improving the change process throughout the utility. Management may issue a policy for promoting and managing the change that must:

- (a) Give priority to safety,
- (b) Address all types of changes,
- (c) Introduce the change management process,
- (d) Promote effective communication.

In an early termination situation, it is crucial for the success of changes that staff be actively involved in the process. Similarly, it is of the utmost importance to communicate the basis for changes to those levels of the organization that are affected so that all persons concerned can understand the changes and their importance in meeting the wider goals and objectives of the operating organization or licensee. Further information on managing change can be found in Ref. [3].

2.5.11. Management of uncertainties

When they face a significant change such as at the announcement of the early termination of plant operation and future decommissioning of the plant, it is apparent that both the organization and the workers will experience significant uncertainty about the future. This uncertainty adversely affects morale, reduces concentration on safe operation, leads to lower motivation to work hard, lower job satisfaction and loss of credibility for organizational leaders, and can lead to the loss of key staff. It is necessary to decrease this uncertainty to minimize negative psychological and physical effects on staff and on the decision making ability of the organization. An effective means of reducing uncertainty is increasing communication within the organization. Another effective means is to involve staff to a high degree in discussing the challenges in the uncertainties and to ask them to develop remedies to reduce their concerns. In this way staff often get a deeper insight into the challenges lying ahead and may see the uncertainties from a different and clearer perspective.

2.5.12. Reorganization

After the final shutdown of the plant, the organizational structure of the operating organization or licensee may be changed. If there are no systems to operate, units involved in the operation of systems may stop or change functions. Personnel from these units may be transferred to other activities and be requalified or severed in accordance with the social programmes established for the early termination of operation period. It is very important during the early termination of operation stage to pay attention to planning and developing technical guidance for putting equipment out of service, and at the same time to begin assessing the cost of all the work connected with decommissioning.

2.5.13. Maintaining competence and organizational memory

During the development of the new operating organization after final shutdown, an evaluation of the competences needed is crucial. Several ways exist to keep competences within the organization or to acquire them from outside. In this evaluation of needed competences an evaluation of the organizational memory may also be needed. It is important that personnel who may be involved later in the decommissioning process maintain their knowledge of the plant. For this purpose a special programme of individualized training for technical specialists and managers needs to be prepared. It is desirable that work experience of personnel who are leaving the job be passed on and preserved if possible. A special educational process may be used to upgrade the qualification of technicians and managers (e.g. seminars on exchanging experience, conferences). The operators may receive training on operating activities and training in response to accident conditions. It is especially important that the operators use individualized training programmes (see Annex III).

2.5.14. Determining decommissioning strategies for early termination of operation

Before the final shutdown of the NPP an opportunity exists to develop the decommissioning scenario, which may include:

- (a) What to do with nuclear fuel and when,
- (b) What to do with facilities and systems and when,
- (c) What to do with buildings and other structures and when.

During this early termination phase an opportunity exists for each step of decommissioning to be described and the appropriate safety analyses conducted. Possible corrections in the future decommissioning strategy may be envisioned in response to the availability of better technology, changes in the fuel storage strategy or changes in the management of radioactive waste.

2.5.15. Environmental issues

It is desirable that early termination and future decommissioning work do not lead to a deterioration of the environment. With this in mind the necessary evaluation of all post-shutdown issues, including the impacts of decommissioning on the environment, may be undertaken in accordance with State requirements. The impacts of radioactive materials, chemical substances and structural materials on the environment must be taken into account. Plans may include the collection and stabilization of all dangerous substances. The environment at the NPP may be monitored. The purpose of monitoring is to quickly detect the dispersion of radioactive materials and chemical substances and to allow action to be taken. The population needs to be openly informed about environmental conditions during decommissioning of the NPP.

2.5.16. Waste management

As a result of the deactivation of equipment, additional radioactive substances may appear. The changing environment has to be taken into account during preassessment of tasks and risk analyses.

2.5.17. Plant maintenance

Plant maintenance may be carried out according to an existing programme through the early termination period to ensure functionality and availability of all needed safety functions. After the shutdown of the plant some equipment and systems may not be needed but systems and components required to ensure safety have to be maintained. Many of the systems and components at the plant may have reached the end of their lifetimes or exceeded them. When these systems and components are required for ensuring safety during a certain stage, it is necessary to either replace them or prolong their lifetime by taking appropriate measures. The plant may decide to establish a system for managing equipment ageing. Some of the systems and components needed have an overcapacity with regard to the requirements of the shutdown operation mode. To minimize costs and save energy it may be reasonable to reconstruct the equipment. The focus here needs to be on ensuring safety and

on saving energy, material and human resources, as in some decommissioning strategies the plant will be left in a shutdown condition for a considerable length of time before the start of decommissioning.

2.5.18. Quality assurance

A quality assurance programme that better serves the needs of the early termination period and any planned decommissioning may be developed from the existing programme. It needs to meet any national requirements and be applied to equipment, processes and personnel activities that are important to ensuring safe operation during the early termination period and decommissioning. Additional areas of focus for quality assurance programmes may be found in Ref. [1].

2.5.19. Market for spare parts

In an early termination, components have not reached the end of their lifetimes and may be of interest in a market for spare parts. It is important that such components are preserved and that their technical documentation is accurate.

2.5.20. Documentation

During operation and the early termination of operation period, the NPP must maintain and store operating documentation and records since they could contain valuable information for the decommissioning period. These may include drawings, descriptions of systems, procedures, engineering calculations, activity inventory, descriptions of new systems and documentation relating to event investigation calculations, with special attention paid to events which led to system or component damage or could have led to radioactive contamination, and information about site monitoring before the construction of the plant and during its operation. Care is needed to ensure that these documents are easily and quickly accessible during all planned stages of closure, including the decommissioning phases. It is important to choose in what form and how this documentation may be saved and retrieved. After shutdown, documentation showing which facilities have been removed and which are in operation must be prepared and maintained.

The personnel management programme is to be documented. Programmes for personnel training and requalification, for establishing pensions and for small business development (if planned) may be documented.

2.6. COMMUNICATIONS ISSUES

The early termination of operation process, from its conception to final shutdown and implementation of the early termination of operation plans, will require a heightened degree of communication among all involved parties. Undoubtedly rumours will surface during the entire early termination of operation process. One way to limit rumours is to communicate with all the interested parties and provide the currently available information in an open and forthright manner. It is imperative that the communications are open and forthright to ensure that confidence and trust exist to the maximum extent possible.

The primary responsibility for communicating what is happening and what is planned during the early termination of operation process to all of the stakeholders (interested parties) rests with the plant management. The key stakeholders are the plant staff, the regulatory body, contractors, the public, the government and politicians, and the media.

2.6.1. Maintaining public trust

Maintaining public trust during the early termination process is extremely important. During all phases of the operation of an NPP, enhanced public trust and confidence can only be achieved by providing all the information, both positive and negative. This remains true for the early termination period. States that have gone through the early termination process have experienced an increase in public attention to the safety of the plant and an increasing interest in what will happen during the subsequent decommissioning. Few members of the public are aware of the reduced safety risks to the public of a nuclear plant that has been shut down. It is important for the plant to communicate to the public these reduced risks and the continued high level of focus on safety by the plant organization. Other issues of potential concern to the public are the loss of jobs that will occur during the transition from early termination to decommissioning. They may also show an increased interest in the loss of revenue that can occur when an operating plant permanently stops producing power. This may impact them directly, for instance, in the amount of taxes local citizens may have to pay to the community hosting the NPP.

2.6.2. Routine communication

Consideration may be given to routine communication with the public to keep them informed of issues and progress during the early termination of operation period. Some States have been successful with open meetings with

the general public, while others have had good success in establishing advisory committees made up of local officials, the academic community, medical professionals, representatives of environmental groups, service organizations such as hospitals, antinuclear activists and local citizens. There are benefits to both approaches. In the former, all interested members of the public have an opportunity to provide input to the plant management. In the latter approach, a consistent group of local citizens maintains an awareness of what is going on at the plant and can provide input to the public and bring public issues before the plant's management.

2.6.3. Use of communications media such as the Internet

The Internet provides an alternative means of communicating with the public. Some States have established their own web sites and posted information about the early termination of operation process and decommissioning activities. It is important to understand that information on the web site must also be accurate and thorough and that not all members of the public have access to the Internet. Therefore, it should not be the only means of communicating. Other mechanisms, such as newsletters, press releases, advertisements in newspapers and letters to the local community may also be considered.

2.6.4. Local, regional and national politicians

In communicating openly, it is important to include local, regional and, at times, national politicians in the communication plans. Politicians routinely deal with the public and need to be aware of the early termination of operation activities. Providing them with accurate and timely information will allow them to assure the public that they are aware of the plant's activities. It is also important to include the media in any communication strategy. The media play an important role in informing the public. Briefings, reviews and printed material may be provided to the media frequently.

2.6.5. Communication with workers

Communication with the plant workers is essential (see Annex II for more information on communication). These communications must be open and honest. Information about the decisions being considered and those that have been reached are important to this group of people. They will understandably be focused on maintaining their jobs and will be anxious. Without accurate and honest information, they will construct their own theories. Such fabrications may not be correct and can create additional anxiety among

workers. Most personnel will appreciate open communication about management decisions. Decisions about organizational structure, changes in union agreements, shutdown dates and staff selection methods may be made known to the workers as soon as possible. The issues of loss of employment or limited employment possibilities have a serious potential to cause a lack of motivation and lower morale. Effective communication with plant workers helps people to understand what is about to occur and gives them the opportunity to make decisions regarding their future. A person who understands what will occur and has an opportunity to act will be less likely to have lower morale and is more likely to remain motivated.

2.6.6. Public knowledge

A key part of public confidence and trust comes from the public's knowledge that the plant is being regulated and that the regulatory body is watching over activities at the plant. Communications from the regulatory body to the public are especially important to assure the public that the regulatory body is involved, understands what is occurring and has determined that the plant is continuing to operate safely. For the regulatory body to communicate effectively with the public, the plant operating organization must provide it with accurate and timely information. It is then incumbent upon the regulatory body to establish a routine method to communicate with the public. During these communications it is important that the regulatory body openly provide information on what it has observed and determined during the inspection processes. Favourable and unfavourable information must be provided. Questions from the public may be invited and answered as openly and directly as possible. Further information on communications can be found in Ref. [4].

2.7. CONTRACTOR ISSUES

Many operating NPPs use contractors to support operations. Based upon the qualifications of the individual contractor, the specific tasks required and ongoing operational needs (e.g. outages) this may also be true during any early termination of operation period. The early termination of operation issues associated with contractors may be viewed from three distinct perspectives: the individual contractor performing services, the contracting company providing the services of the individual and the operating organization of the NPP.

2.7.1. Perspective of individual contract employees

The perspective of the individual contract employee is similar to that of the plant worker. The primary focus of the individual may be on loss of work. This may be mitigated somewhat by the ability of the contractor to provide other work for that individual. If the employee has been performing long term work, he or she may harbour many of the same feelings as the workers. Thus, loss of motivation and reduced morale may also be evident in some contract employees. The same techniques used to communicate with workers may be used to help contract employees understand the personal impact of early termination decisions.

2.7.2. Perspective of contracting companies

It is most likely that contracting companies will ultimately lose work as a result of a decision to terminate operation early. Even under these circumstances, a contracting company has responsibilities to its employees and to the client NPP. As with plant workers, low motivation and morale can result in poor work. Routine communications with the individual contractors may be increased to determine whether motivation and morale remain high. Qualifications of the individual contractor(s) must be maintained while the work is being done. Training can be maintained current for existing tasks and added for any new tasks that may occur during the early termination of operation period.

2.7.3. Plant perspective

The NPP continues to be responsible for all aspects of safety on the site during the early termination of operation period, and so must retain the competence needed to be an ‘intelligent customer’ of the goods and services provided by contractors. The procedures and processes in place to control the work of contractors must continue to be used during the early termination of operation period. The NPP operating organization must recognize the communication needs of the contractors and ensure that the early termination decisions are communicated effectively. These communications must be coordinated with the contracting companies to ensure that all parties understand the decisions. The NPP operating organization may also monitor the motivation and morale of the contractors. They may work with the contracting companies to ensure that motivation and morale remains as high as possible. Further information on the control of contractors can be found in Ref. [5].

3. INFORMATION EXCHANGE

Operating NPPs routinely benefit from the exchange of information in many areas including the technical aspects of operation, managing change, control of contractors, communication and safety culture. Forums such as those conducted by the IAEA, the World Association of Nuclear Operators (WANO), the OECD Nuclear Energy Agency (OECD/NEA) and various professional societies have been useful in allowing operating organizations to understand the successful and unsuccessful efforts of others. Visiting other NPPs to share experiences and insights into specialized areas (benchmarking) has become routine among NPP operating organizations. These activities have been an important part of the continuing improvement culture that now is common to the majority of operating reactors worldwide.

This continuous improvement approach may be maintained after early termination and shutdown and onward through all stages of decommissioning. As States face the decision of whether or not to terminate NPP operation early they may attempt to understand the experiences of other NPPs and national regulatory bodies that have gone through the early termination of operation process. Visits to plants in various stages of decommissioning may be planned and conducted to ensure that the early termination process implemented reflects the experiences of others. Visits to plants that have recently completed the early termination of operation process are invaluable and may be included. Generally, these visits allow the most recent early termination and decommissioning experience to be translated into continuous improvement benefits. On the basis of the experiences observed, NPP operating organizations or regulatory bodies must then review the experiences and adjust their strategy to ensure that unique aspects of the plant or the regulatory environment are considered during the planning and implementation phases of early termination.

4. READINESS ASSESSMENTS

Assessing the readiness to begin and continue the early termination of operation has been described by many States as being essential while an NPP operating organization or regulatory body prepares for and implements the early termination of operation. The sudden transition to permanent shutdown from operation may be the most difficult change during the entire lifetime of a nuclear plant. It is important that early termination be well planned and managed from the beginning. Self-assessments and independent assessments

may be part of the plan. Through these processes, the NPP or regulatory bodies can determine whether the plans are comprehensive, are functioning as designed, and will result in a safe and effective permanent shutdown of the plant.

In conducting assessments, the NPP and regulatory body's focus may extend beyond the traditional areas that directly affect safety. The effectiveness of the processes designed and implemented to address the social, environmental, cultural (including nuclear, industrial and radiological safety culture), communication and financial aspects of the change from operation to shutdown must be assessed. Wherever possible, objective criteria may be used to measure effectiveness. However, it is recognized that subjective criteria may be needed in certain of the key areas noted above.

Each area of the NPP and regulatory staff may conduct self-assessments of their organizations (see Ref. [6] for further information on self-assessments). These self-assessments may be planned into the early termination of operation process and may be conducted frequently during the planning and implementation to ensure that the process is proceeding as desired. The frequency of self-assessments may be adjusted on the basis of the results. More frequent self-assessments may be considered if significant mid-process corrections are required. A separate self-assessment may be conducted to establish the adequacy of the integration of the recommendations made in self-assessments.

Independent assessments may also be planned and conducted as an important part of the early termination of operation process. Personnel with national or international experience may conduct independent assessments. These independent assessments may also evaluate the effectiveness of the self-assessment process as it has been applied to the early termination of operation. Assistance from the IAEA can be requested if the NPP operating organization or regulatory body is having difficulty locating the expertise to conduct such independent assessments.

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Annex I

EARLY TERMINATION OF OPERATION OF THE CHERNOBYL PLANT, UKRAINE

All nuclear power stations in Ukraine are under State control and are administered by the Department of Nuclear Energy of the Ministry of Fuel and Energy. The nuclear energy company Energoatom, an independent nuclear operating organization, is responsible for the technical and commercial management of these plants, except for the Chernobyl NPP. The Cabinet of Ministers of Ukraine decided to close the Chernobyl plant (which consists of the three remaining RBMK 1000 reactors) early and definitively. The three units were shut down in December 2000.

In an effort to ensure effective closure and decommissioning of the three units the government developed the guidance provided below to be implemented for pre- and post-shutdown activities. These guidelines were established to take care of the personnel at the time of final shutdown. It should be noted that a large number of personnel will continue to work at the present site to maintain the facilities.

I-1. ESTABLISHMENT OF A NEW MAINTENANCE COMPANY

An independent maintenance company called Atomremontservice was established based upon the centralized maintenance unit of the Chernobyl NPP. The task of this maintenance company is to provide complete maintenance service to all Ukrainian NPPs, namely the Khmel'nitskiy NPP, the Rivno NPP, the Zaporozhye NPP and the South Ukraine NPP. Approximately 700 persons started working for the newly established company. According to an optimistic forecast, this number might rise to 1000.

I-2. ESTABLISHMENT OF OTHER NEW COMPANIES TO SUPPORT THE CHERNOBYL NPP

A new service company has been established with approximately 80 employees. Its main task is to repair the electrical equipment, i.e. the transformers, high voltage switchgear, electrical reactors and autotransformers. The company will have approximately 150 employees in the future.

A radiation and ecology laboratory has been established along the lines of the International Chernobyl Centre. The staff is composed of some

40 persons and up to 80 additional employees may be hired at a later date. The laboratory will study and evaluate radiological and ecological issues in Ukraine. Another new company being established is a joint venture with the Brandschutz Company. Its purpose will be to apply fire resistant coatings to cables and civil structures.

Senior management is planning the establishment of an expert organization based upon the technical control service of the Chernobyl NPP. It will perform entry and post-maintenance control of equipment and other services. The industrial safety authority will license this organization. It will employ approximately 30 people.

I-3. EARLY RETIREMENT SCHEME

On 13 September 2001 the Cabinet of Ministers of Ukraine adopted Decree No. 1155 on the Additional Payment to Pensioners Related to the Cessation of Operations of the Chernobyl NPP. Employees who have to retire due to the shutdown of the Chernobyl NPP and are unemployed will receive an additional payment if they are more than 47 years old. This is intended to encourage people to opt for early retirement.

I-4. RETRAINING PERSONNEL TO NEW SPECIALIZATIONS

Retraining of personnel is being carried out using the existing training centre at the Chernobyl NPP and the Atomremontservice Company. Personnel will work on decommissioning activities and transformation of the site into an ecologically safe system. The goal is to train personnel to work safely and efficiently in an environment of increased radiation hazard. Approximately 100–150 persons were to be retrained in the course of 2002.

I-5. SMALL BUSINESS DEVELOPMENT

An agency for business development is operating in the town of Slavutich. It provides small loans (up to US \$5000) to encourage private business startups by employees leaving the NPP. A so-called ‘business nest’ is being operated by the trade union committee at the Chernobyl NPP. Its task will be to provide consulting services during the establishment of small private companies in the area.

I-6. EDUCATION

In the town of Slavutich, colleges associated with Kiev State University will focus on specific topics like the effects of radiation on the ecology and sociology. The Technical University of Kiev will also provide educational programmes focusing on topics such as NPP programmes and automatic control systems.

Colleges have also been opened which accept schoolchildren who have passed entrance exams. The children will have a chance to study foreign languages, mathematics and social sciences. This may act as an incentive for the younger generation to stay in Slavutich. It is expected that these programmes will provide a safety net and structure to balance the early termination of operation of the Chernobyl NPP. It is planned that other programmes will grow out of the ones discussed.

Annex II

EARLY TERMINATION OF OPERATION OF THE BARSEBÄCK NPP, SWEDEN

In February 1997, the three political parties with a majority in the Swedish Parliament reached an agreement to close down Barsebäck 1 in July 1998 and Barsebäck 2 two years later. There were some obstacles. The parties needed to pass a new law through the Parliament and the owner, Sydkraft, claimed that closing down the plant violated Swedish laws, European laws and human rights. A complicated legal process started and in parallel, Sydkraft and the Government started negotiations on an economic agreement for closing unit 1 of the plant. Both these processes continued until October 1999. The timeframe between the political agreement and the actual closing down of unit 1 was 34 months.

II-1. IMPORTANT EARLY ISSUES IDENTIFIED BY COMPANY MANAGEMENT

- (a) Ensure the presence of a sufficient number of competent employees to maintain operation at both units.
- (b) Manage the plant based on 'business as usual'. Continue with the maintenance programme, reinvestment programmes and modernization plans.
- (c) Create a strong information and communication programme to avoid rumours about the legal and negotiating process.
- (d) Organizationally, focus on continued safe operation, rather than decommissioning planning. If the threat of early termination of operation became real, and unit 1 was closed down, the problem would still be to secure competence rather than deal with a personnel reduction.
- (e) Maintain a focus to convince the employees that the company was working to ensure operation.
- (f) Improve communication with the regulatory body and emphasize that the plant was still focusing on safe operation.

II-2. ACTION PLANS IN THE FIRST TWO YEARS AFTER THE POLITICAL AGREEMENT

Two days after the political agreement was reached, the Sydkraft board established a five year employment guarantee. This guarantee gave social

security to all employees, and as a result the staff turnover rate did not increase. Personnel of all age groups reasoned that they still had interesting jobs and would have time to wait and see.

The company continued its maintenance and reinvestment programmes, including some expensive investments like changing the entire turbine control system. Management created the spirit for a ‘success story’: “It is not we who are going to close the plant”.

The company arranged special seminars for middle management focused on supporting their personnel and observation training to monitor staff and identify people who were developing problems with the uncertain situation. The annual personnel questionnaire was maintained and the focus on human–technological–organizational questions continued with routine analysis of licensee event reports and monitoring for a degradation in safety culture. Special interviews were conducted with employees leaving the company to find out the reasons for their leaving and giving them the opportunity to provide feedback for improving management strategies. Monthly information meetings were held with all the employees. Lawyers and executives from Sydkraft were invited to these meetings to give the latest news. In cases of media speculation, approximately once each week the chief executive officer sent out E-mails to all the employees, commenting on the issues and giving facts on the background of any speculation.

After the first 18 months, the employees’ concerns began to increase. Time passed and the value of the employment guarantee decreased. The board accepted management’s recommendation to change it to a rolling five year guarantee, meaning that every morning each employee was still guaranteed five full years of employment.

II-3. THE SIX MONTH PERIOD PRECEDING THE FINAL SHUTDOWN OF UNIT 1

In June 1999 Sydkraft lost its case in the highest administrative court, but the closure date was changed to 30 November 1999. Some legal processes were still going on in the European Union and the rumours were becoming stronger that the negotiations between Sydkraft and the Government were approaching agreement.

II-4. ACTIONS TAKEN AT THE PLANT

The court's decision came just one month before the annual outage. Management decided to go through with the outage, including refuelling as planned, based on the motto: "It is not we who are going to close the plant".

The routines for operation and maintenance were sharpened. Recognizing that an operator's mind could easily be elsewhere, a 'shadow' was used whenever possible for double checking.

A project to analyse various scenarios was started involving more than 25% of the staff from management to workers. The unions were invited to be observers but not to be involved in the process, in case negotiations became necessary later. The project analysed three different scenarios:

- (1) Unit 1 closes down as decided and no decision is taken for unit 2,
- (2) Unit 1 closes down as decided and a time limit is set for closure unit 2,
- (3) Both units are shut down on 30 November 1999.

The aim of the analysis was to examine:

- (i) How to be organized,
- (ii) What kind of competence and how many persons would be needed in the new organization,
- (iii) Whether a closed plant could be used for other purposes such as becoming a research centre or a training centre,
- (iv) How to deal with redundant personnel,
- (v) How other companies in the region had dealt with similar situations.

The project was successful. Many good ideas that were useful for the period to come were presented. It also helped the employees to orient their minds in advance as to what the situation would be for the different scenarios.

II-5. THE PERIOD AFTER THE SHUTDOWN OF UNIT 1

A five month period started when the company reorganized for the new situation. An organizational goal was set to reduce the number of employees from 430 to 350 persons by means of the following:

- (a) Early retirement was offered to personnel older than 60.
- (b) The company had a use for 15 design engineers to replace consultants.
- (c) Redundant people could apply for re-education.
- (d) The number of employees leaving the company of their own accord increased from 4 to 9 per cent in 2000.

Two years after the closure of unit 1, the company reached the number of employees set forth in the organizational goal.

II-6. STATUS OF THE PLANT DURING THE GREATER PART OF THE YEAR 2000

As a result of the negotiations between Sydkraft and the Government, Barsebäck became a subsidiary of Ringhals, an NPP company in the Vattenfall group, owned by the State. The Government provides the additional funds needed for single plant operation of unit 2, and for the operation of unit 1 in shutdown mode until 2015.

A small new department (10 persons) created in the new organization became responsible for unit 1, the shut down plant. A strategy for decommissioning unit 1 has been developed on the basis of the following principles:

- (a) Removal of the fuel from the plant as soon as possible,
- (b) Breaking up of all electrical and other connections between the two units to avoid negative interference in either unit,
- (c) No dismantling of unit 1 until unit 2 is shut down,
- (d) No dismantling of unit 1 until the final repository for decommissioning waste is ready.

This strategy is in accordance with the agreement between the Government and Sydkraft and means that no dismantling will start before approximately 2020. The strategy has been approved by the board and has been presented to the regulatory body.

II-7. STATUS OF THE PLANT IN NOVEMBER 2001

The removal of fuel was the first major task contemplated by the decommissioning strategy. Fresh fuel and fuel with low burnup (250 elements) has been transferred from unit 1 to unit 2 and will be used for refuelling unit 2 over the next three years.

When the last fuel element has left Barsebäck the plant will enter a phase defined as 'service operation'. This phase will last until a dismantling project is activated. Based on current knowledge, this will take place in about 2015. Safety requirements during the service operation period will be:

- (a) Unit 1 in a shutdown condition should not be a threat to the safety of unit 2 while unit 2 is in operation,

- (b) There should be no radioactive releases from the unit,
- (c) The physical protection (security) of the unit should be maintained,
- (d) Spare parts from unit 1 can be used for unit 2 but should be replaced if they will be needed for later phases of the decommissioning

During the outage of unit 2 in the summer of 2001, all the equipment in the electrical building of unit 1, including the auxiliary diesel generators, was transferred to unit 2 to complete the physical separation of the power supply to the high pressure auxiliary feedwater system.

II-8. APPROACH OF THE REGULATORY BODY TO THE EARLY TERMINATION OF THE BARSEBÄCK NPP

II-8.1. Legal status of the regulatory body

Sweden's regulatory body is the Nuclear Power Inspectorate (SKI). The Law on Nuclear Activities defines nuclear materials, nuclear waste, nuclear installations and nuclear activities, provides licensing requirements and assigns the full economic and safety responsibility to the licensee for nuclear activities, including safe handling and final disposal of spent fuel and nuclear waste.

A Government Letter of Appropriation contains a statement of SKI mission objectives that provide a clear definition of the requirements on the regulatory body. The Nuclear Power Inspectorate must clearly define the requirements, both with regard to the technical design of plants, and with regard to licensee obligations to achieve high quality in safety related and non-proliferation related activities.

These requirements must be of such a general character as not to have a negative impact on licensee responsibilities or necessitate these responsibilities being taken over by SKI which controls compliance with requirements by supervision of activities.

II-8.2. Financial aspects of decommissioning

The generation reaping the benefits of the Swedish nuclear power programme should take full technical and financial responsibility for the safe management and final disposal of the spent fuel and nuclear waste generated. The NPP owners shall submit annual estimates of all future costs for management and final disposal of spent fuel and nuclear waste, including decommissioning. The cost estimates are to be reviewed by SKI as a basis for a

government decision on a fee per nuclear kilowatt-hour produced, to be paid into interest bearing funds managed by the government.

II-8.3. Early concerns of the regulatory body

The regulatory body had the following concerns during the initial phase of the early termination of operation of Barsebäck:

- (a) Management of safety and safety culture at the plant,
- (b) Staffing and competence in relation to the actual situation and to future tasks and demands,
- (c) Motivation of the staff,
- (d) Confidence on the part of the regulatory body that the top management team of the plant could be trusted and relied upon.

To make sure that these concerns were addressed, SKI needed to follow and evaluate how the plant developed overall strategies for ensuring safe operation of both units and confirm that the plant had sufficient competent staff for safety related duties. Furthermore, as long as there is nuclear fuel at the plant, SKI will follow the evaluation of the plant's safety culture and verify that the plant is ensuring operation, maintenance and inspection activities to a satisfactory level.

II-8.4. Actions taken by SKI in the initial phase

The regulatory body visited Barsebäck more frequently, inspected the plant more intensively and focused inspections on interviews. SKI developed a special trending process on event reports from Barsebäck to reveal precursors that could indicate safety concerns. The regulatory body established a special working group, bearing in mind the long term perspective of the closure of the plant.

The regulatory body requested special safety analyses, including:

- (a) Overall strategies for ensuring safe operation of both units;
- (b) Verification that sufficient competent staff would be available for safety related duties;
- (c) Verification of a good safety culture;
- (d) Consequences for safety, technical as well as organizational, when the plant is being operated with one unit shut down;
- (e) Planned activities for the period of time during which nuclear fuel still remains in the closed unit;

- (f) Security and safeguarding during the phase when nuclear fuel still remains in the closed unit;
- (g) Verification of safe operation when one unit is in operation and one is closed, including consequences and planned changes in operation and in organizational aspects.

The plant was also asked to report on the planned decommissioning activities and on how the nuclear fuel would be handled. In addition, the regulatory body requested monthly reports from Barsebäck and monthly meetings with plant management. The requested monthly reports covered:

- (1) The personnel situation, including the reasons for staff leaving the plant;
- (2) Assessment of staffing and competence;
- (3) Assessment of how the personnel met the changing situation;
- (4) Information, training and actions for keeping up staff motivation;
- (5) Assessment of event trends and the safety of the plant.

Special reports similar to those mentioned above have been requested when the situation changed, for example after governmental decisions. Monthly meetings with plant management were held to discuss the report openly and to hear the views of management and regulatory bodies.

Annex III

EARLY TERMINATION OF OPERATION OF THE TRINO AND CAORSO PLANTS, ITALY

After the Chernobyl accident a public ‘consultation’ (referendum) was held in Italy which resulted in a moratorium on the use of nuclear power as a means of electricity production.

At the end of 1987 the amount of electric power generated by nuclear power in Italy was only about 1500 MW(e), a small percentage of the total electric power generation of about 50 000 MW(e), mainly generated by fossil fuels. Two plants were in operation at that time: Trino, a 270 MW(e) PWR and Caorso, an 860 MW(e) BWR. They are located in northern Italy on the Po river. The other two plants, Latina and Garigliano, had already been closed. All the NPPs are owned and operated by ENEL, the national electricity board, which is a State owned company.

During this moratorium all Italian NPPs were put into a ‘cold shutdown’ condition and long term preservation of systems was carried out (drainage and drying with air in controlled conditions, etc.). Only reversible actions with the aim of saving costs and time reducing checks on ‘out of service’ systems were performed. All these actions were performed on the basis of the current operating licences with formal documents and procedures from the operating handbook, approved by the regulatory body. The nuclear plants maintained the same organizations as during operation, with almost the same number of staff and preserving competences in order to be ready to restart.

III-1. EMPLOYMENT OF RESOURCES DURING THE MORATORIUM

During this period, most of the personnel in the maintenance departments performed plant modifications required to prepare the plants for long term preservation, while those in the technical area and the operations departments were involved in studies and developing procedures for the long term preservation of the two NPPs. The turbine deck operators from the operations department were transferred to nearby conventional ENEL plants for training.

III-2. FINAL CLOSURE OF CAORSO AND TRINO

In July 1990, a final Government decision ordered the closure of the Trino and Caorso NPPs and charged ENEL with initiating activities to bring the plants into a safe condition and to plan for their decommissioning.

It had originally been thought to use the 'SAFESTOR' option for fuel storage since a Government decision on a national repository had not been made. Other uncertainties in the law and regulations about clearance levels for the release of wastes produced from the dismantling of the NPPs and about the need to obtain a decommissioning licence justified delaying the final dismantling of the NPPs.

Once the definitive decision for closure was made, a major reorganization took place with a staff reduction, mainly after the defuelling of the Trino NPP. The Caorso NPP had been defuelled in 1998, mainly due to problems with the local community and trade unions who did not want fuel to be transferred from the vessel to the pools because of concerns that since there was no national repository for spent nuclear fuel the fuel might be stored indefinitely at the plant or NPP site and that this site would end up being selected as the national repository.

III-3. REORGANIZATION OF THE OPERATING ORGANIZATION

The changes to the organization for operating the Trino and Caorso plants primarily covered the following:

- (a) The number of operations department personnel on shift was reduced to the minimum level required by law with irradiated fuel still in the pool (from about 60 persons in 1987 to 24 in November 2001 for the Trino NPP);
- (b) The maintenance department and the chemical and health physics departments were merged with the loss of the section manager;
- (c) In 2001, the health physics personnel were removed from shift duty and assigned to work during business hours on pre-decommissioning activities such as radiological characterization of the plants and waste treatment and characterization;
- (d) The highly professional staff of the technical department were assigned to contribute to the preparation of documents needed for decommissioning.

III-4. REHIRING OF PERSONNEL MADE REDUNDANT BY THE REORGANIZATION

Since all the NPPs are owned and operated by ENEL, which also has other conventional plants and operates in other business areas such as research laboratories, training schools and distribution structures, every effort was made to employ displaced personnel within the company. Examples of this process were:

- (a) Transfer requests to neighbouring conventional plants were allowed. This was easier for employees of the operations and maintenance departments. For example, three thermoelectric plants were in operation near Caorso and a new conventional plant had been constructed near Trino. Many operations department employees affected by the reorganization found new jobs in these plants.
- (b) A plan for retired staff was established.
- (c) Some staff utilized their skills in activities different from the routine management of the NPP that could be performed by workers with their past experience (either in the NPPs or in other areas within ENEL). In this way a greater number of plant employees than that strictly required for routine NPP activities could be justified.

III-5. NEW WORK FOR STAFF REMAINING WITH THE PLANTS

Other activities carried out by Trino and Caorso staff included:

- (a) Chemistry and health physics department personnel were directed to provide support to conventional plants in radiation protection surveillance of their radioactive source containing instruments such as smoke detectors, instruments for measuring dust in the air for environmental surveillance around conventional plants, and instruments for gas chromatography placed in chemical laboratories.
- (b) A calibration centre for radiological instruments was established in the Caorso NPP. This centre became one of several calibration services in Italy where all radiometric instruments of the four Italian NPPs are now calibrated. The centre has now been expanded to provide calibration services to external customers.
- (c) Whole body counter checks were done for local universities or other firms.
- (d) Plant radiological characterization was done in order to plan properly for the dismantling of systems.

- (e) Operations department staff provided technical advice abroad. Staff from Caorso and Trino were present at the startup of the Laguna Verde NPP in Mexico, which is a BWR similar to the Caorso NPP.
- (f) Operations staff assisted technical staff in the planning of decommissioning activities.

III-6. OTHER ENEL INITIATIVES TO FOSTER EMPLOYMENT OF PLANT WORKERS

The need to develop and co-ordinate employment opportunities for workers was understood and a programme was developed for this purpose. The strategy was to be flexible, creative and to focus outside the nuclear plants (but still in ENEL) as well as inside the NPPs. The trade unions agreed to this strategy. Many employment opportunities existed in the areas around the NPPs because of the many non-nuclear plants operated by ENEL.

Personnel remaining at the plants had to change their mentality. Workers had to face the new reality that what they had constructed and managed until a few days previously was now to be dismantled and decommissioned.

The areas focused on by management included the following:

- (a) Employee morale: Steps were taken to ensure that early closure did not result in loss of staff and corporate memory.
- (b) New mentality: The focus was put on dismantling and providing incentives to complete work and not perpetuate jobs.
- (c) Creation of mixed working groups: Teams were created using both experienced and new workers for training for the dismantling of the sites.
- (d) Establishment of new positions: Chemistry, health physics, maintenance and operation department personnel were given new tasks and positions. Staff used skills learned during operation.
- (e) Design activities: Employees were used to evaluate systems and components for the dismantling of all non-essential items, and work began on plant modification.
- (f) Dismantling: With the aim of reducing costs, reducing risks posed by hazardous materials and training workers in decommissioning, the balance of plant dismantling began (Trino NPP). The work included sales of spare parts and fresh fuel, defuelling and waste treatment.

It must be noted that many of these activities had to be within the scope of the current operating licence of the NPP, mainly managed as plant modifications in accordance with current operating procedures and under the

supervision of the regulatory body. In fact, a proper decommissioning licence has not been issued yet.

The approach to the decommissioning strategy was changed. The SAFESTOR option originally chosen was abandoned in favour of immediate dismantling, i.e. rather than deferred dismantling after many years of waiting following the installation of safety systems, it was decided to undertake dismantling in one phase. This new decommissioning strategy was spelled out in guidelines from the Ministry of Industry issued in December 1999 (promulgated in May 2001 as a Ministry of Industry decree) that provided for:

- (1) A complete dismantling of the four Italian NPPs before the end of 2020;
- (2) A national repository for irradiated fuel and radioactive wastes to be operational at the beginning of 2009 (the repository site is to be selected before the end of 2005);
- (3) Wastes from past operation of NPPs to be treated and/or conditioned before the end of 2010;
- (4) The spent fuel cycle to be completed (storage of fuel assemblies in dry dual purpose casks temporarily stored in NPP sites pending transfer to a national repository; only a small fraction of the fuel to be sent for reprocessing in accordance with a prior contract).

This change in strategy has caused delays because the licensees need to prepare documents to apply for a decommissioning licence.

III-7. ESTABLISHMENT OF A NEW COMPANY

In March 1999 a new corporate structure was established for ENEL. The new company, SOGIN (Corporation for the Management of Nuclear Facilities), will manage and plan decommissioning strategies for all four plants and the completion of the spent fuel cycle and will create employment by developing new business. In November 2000 SOGIN was transferred to the Treasury Ministry, while ENEL is following a privatization path. These efforts have been funded by transfers from ENEL and by contributions from charges to utility customers.

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