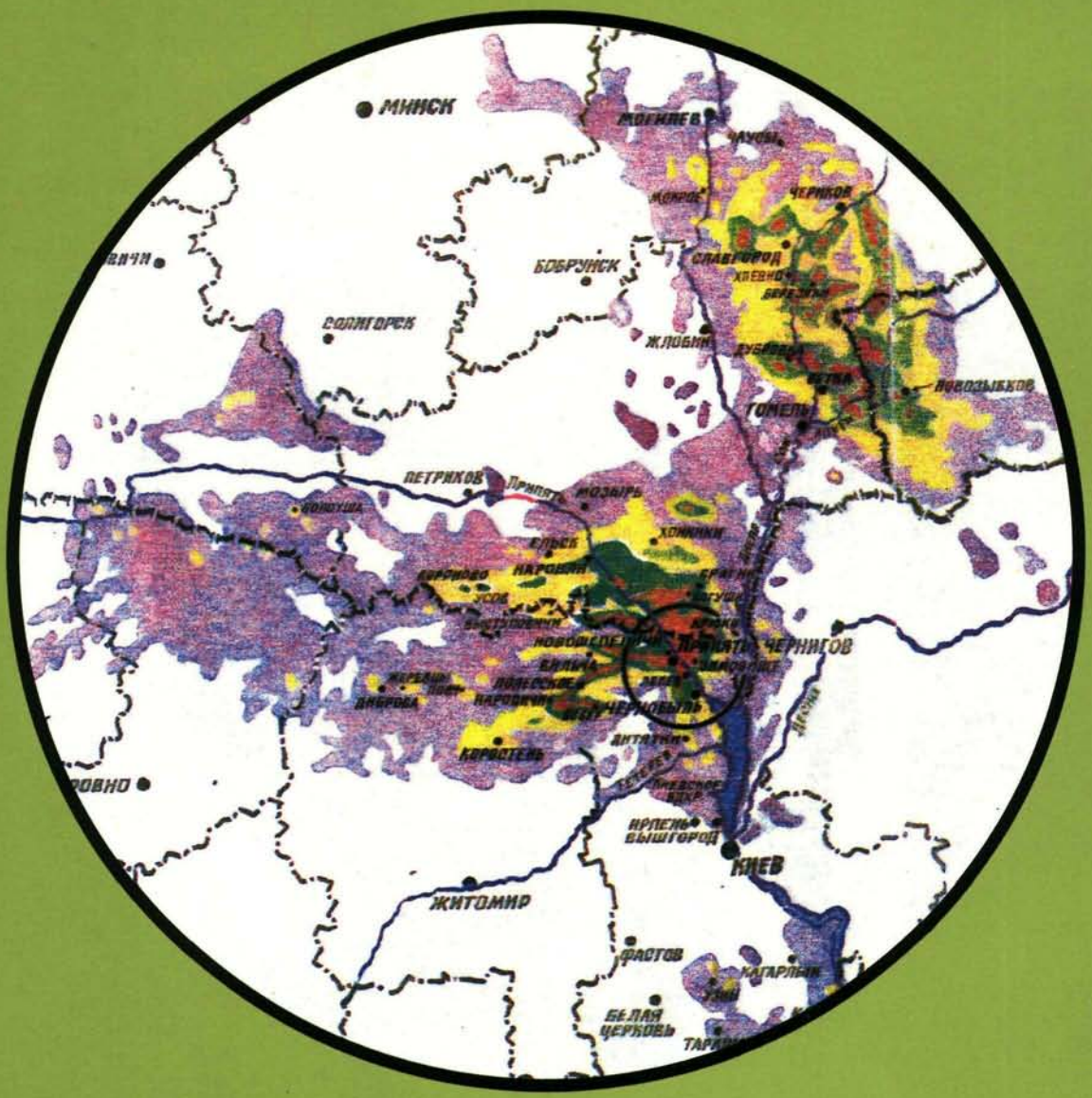
THE INTERNATIONAL CHERNOBYL PROJECT

PROCEEDINGS OF AN INTERNATIONAL CONFERENCE



ASSESSMENT OF RADIOLOGICAL CONSEQUENCES AND EVALUATION OF PROTECTIVE MEASURES

THE INTERNATIONAL CHERNOBYL PROJECT

PROCEEDINGS OF AN INTERNATIONAL CONFERENCE

held in Vienna, 21-24 May 1991
for presentation and discussion of the Technical Report

Assessment of Radiological Consequences
and Evaluation of Protective Measures

ISBN 92-0-129391-7
Printed by the IAEA in Vienna

THE INTERNATIONAL CHERNOBYL PROJECT

PROCEEDINGS OF AN INTERNATIONAL CONFERENCE

held in Vienna, 21-24 May 1991
for presentation and discussion of the Technical Report

Assessment of Radiological Consequences
and Evaluation of Protective Measures

Preface

The Technical Report of the International Chernobyl Project was presented to the scientific community and the media at an International Conference in Vienna on 21–24 May 1991 for examination and discussion. The Report, which has now been published, assesses the radiological and health situation in the affected areas and evaluates the protective measures taken. An unedited draft of the Technical Report was made available to participants, together with an Overview summarizing the Project and setting out the International Advisory Committee's Conclusions and Recommendations.

The Conference was designed in such a way that each major task of the Project, corresponding to a section of the Technical Report, was described in presentations by each Task Group Leader and by members of the Group, setting out the methodology, findings, conclusions and recommendations, which were then open for questions and comments. Each session was summarized by a Rapporteur, who also made some concluding remarks. The presentations themselves are not included in these Proceedings since they summarize parts of the Technical Report to which this is a companion volume. Only those scientists who had taken part in the Project made presentations. During the discussion periods some statements were made by representatives of the USSR, BSSR, RSFSR and UkrSSR. The Conference closed with a Panel Discussion on the lessons learned from the results of the International Chernobyl Project.

The discussions were not originally intended for publication. Since, however, they were obviously of considerable interest, it was considered that many important issues could be aired and fine technical points clarified if the complete discussions and statements were to be made available to readers of the Technical Report. These Proceedings cannot therefore stand alone: they are intended to be read in conjunction with the Report.

A daily Press Briefing was held after the formal sessions, during which members of the Task Groups and representatives of the affected Republics answered questions. These meetings are not recorded in the Proceedings.

Editorial Note

This record of the discussions that took place during the Conference to present the results of the International Chernobyl Project was recorded on tape and later transcribed and, where necessary, translated into English. In some cases, the identity of a particular speaker was uncertain and no name could then be ascribed to that contribution. Great care has been taken to avoid misrepresenting any speaker, but individuals have not been asked for approval of the final form of their contributions except when it was necessary to confirm unclear numerical data.

The late decision to publish these very valuable discussions meant that the text had to be salvaged from the tape some time after the Conference, with the inevitable disadvantages of this way of working. A completely unedited transcript would, of course, be unreadable, but the discussions have not been edited as strictly as is normally done for such material.

CONTENTS

THE INTERNATIONAL CHERNOBYL PROJECT

INTERNATIONAL CONFERENCE

ASSESSMENT OF RADIOLOGICAL CONSEQUENCES AND EVALUATION OF PROTECTIVE MEASURES

Vienna, 21–24 May 1991

Chairman: I. Shigematsu
Vice-Chairman: M. Rosen
Scientific Secretary: E. Asculai
Programme Manager: M. Dreicer

PROGRAMME OF THE CONFERENCE

21 May

Director General's opening address

Chairman's opening address

SESSION 1: INTRODUCTION TO THE PROJECT

Introductory address by the Head of the USSR Delegation (V.A. Gubanov)

The International Chernobyl Project (M. Rosen)

Video presentation

The International Programme on the Health Effects of the Chernobyl Accident (IPHECA) of the World Health Organization (P. Waight)

Historical portrayal: chronology of major events (A. Carnino)

SESSION 2: ENVIRONMENTAL CONTAMINATION

Objectives and presentation of the methodological approach used (F. Steinhäusler)

Results of the intercomparison exercise and data management (V. Valkovic)

THE INDEPENDENT SURVEY OF ENVIRONMENTAL CONTAMINATION

Radiological survey of selected settlements in the BSSR, UkrSSR and RSFSR (P. Zombori)

Radionuclides in grass–cow–milk ecosystems (P. Stegnar)

Presentation of the independent verification of the contamination maps (F. Steinhäusler)

Conclusions (F. Steinhäusler)

Plenary discussion

Summary of Rapporteur (B.W. Wachholz)

22 May

SESSION 3: RADIATION EXPOSURE OF THE POPULATION

Objectives and approach (L. Anspaugh)

Presentation of the USSR dose assessment methodologies (L. Anspaugh, A. Bouville)

IAEA independent dose measurements (A. Bouville)

Independent dose assessment and comparisons with reported values (B.G. Bennett)

Conclusions (B.G. Bennett)

Plenary discussion

Summary of Rapporteur (B.W. Wachholz)

SESSION 4: HEALTH IMPACT

Objectives and approach (F.A. Mettler)

INDEPENDENT CLINICAL HEALTH STUDIES

General health situation (H. Royal)

Cardiovascular disorders (H. Royal)

Haematology (A. Kuramoto)

Thyroid (M. Sheppard)

Cancer (K. Mabuchi)

23 May

SESSION 5: HEALTH IMPACT (cont.)

INDEPENDENT CLINICAL HEALTH STUDIES (cont.)

Foetal and genetic anomalies (F.A. Mettler)

Nutrition (R. Parr)

Psychology (T.R. Lee)

Future risks (F.A. Mettler)

Conclusions (F.A. Mettler)

Plenary discussion

Summary of Rapporteur (K. Duncan)

SESSION 6: PROTECTIVE MEASURES

Objectives and approach (P. Hedemann Jensen)

Evaluation of protective measures (P. Hedemann Jensen)

EVALUATION OF RELOCATION

Comparison with international guidance (N. Kelly)

Cost–benefit analysis (J. Lochard)

Decision conferences (S. French)

Summary (N. Kelly)

Conclusions (P. Hedemann Jensen)

Plenary discussion

Summary of Rapporteur (K. Duncan)

24 May

SESSION 7: MANAGEMENT OF CONTAMINATED AGRICULTURAL AREAS

Current situation (A.W. Randell)

Agricultural protective measures (M.J. Crick)

PANEL DISCUSSION: THE LESSONS LEARNED

Director General's closing remarks

Chairman's closing remarks

Director General's Opening Address

I should like to welcome you to this Conference, to which you have been invited in order to examine the Report of the International Chernobyl Project. This Report contains an assessment of the radiological consequences of the accident and an evaluation of the protective measures undertaken.

You have before you an Overview of the Project, which is a concentrate of a much larger report[1] that is also available in final but unedited draft. Both are submitted for your examination.

The International Advisory Committee has adopted the Conclusions and Recommendations of the Project. All the members of this Committee are scientists and experts speaking on their own authority, and they are here to take part in the discussion. I should like to thank them for the tremendous work they have performed and the vast amount of time they have given with no reward except the knowledge that they are participating in a large and honest effort to "sort facts from misconceptions and radiation effects from effects not related to radiation exposure", to quote Professor Shigematsu, who has chaired the Committee and whom I thank particularly.

The Committee's assessment and evaluation which are before you now represent the response to a request directed to the IAEA by the Government of the USSR in October 1989. We expected the task to be difficult and extensive but did not realize how much work it would entail and how long a time it would take. The basis on which we accepted the request were the following:

(1) *We considered it to be the duty of the Agency to assist a Member State if possible. Intergovernmental organizations are set up to be of service to their Member States, and the Agency had already performed a useful service to the world and to the Soviet Union in 1986 by organizing an* ***international*** *inquiry into the technological causes of the Chernobyl accident. The need was now perceived for an* ***international*** *inquiry into the radiological consequences of the accident and an outside assessment of the protective measures undertaken. This would be a natural follow-up.*

(2) *Such an international inquiry called for expertise from disciplines other than those fully covered by the Agency's programme — above all medicine, but including agriculture. It was concluded that while the Agency should provide organization, logistics and secretarial functions, the inquiry should be multidisciplinary, should be undertaken jointly with some other organizations, and should function under a scientific direction separate from the Agency.*

Hence the International Advisory Committee was formed — comprising scientific experts from the USSR and the Republics most affected by the accident. The Committee approved the work plan for the inquiry, monitored the work itself, and carries responsibility for the Report.

(3) *The principles and methods of modern science must govern the inquiry at every stage.*

It is according to these principles that both the Overview and the Technical Report are laid before this assembly of experts.

(4) *The main purpose of the inquiry would be to assist the people and countries affected by the Chernobyl accident by providing independent international expert analysis and assessment and at the same time enabling the world to learn from this radiological disaster.*

International solidarity demands that we all try to alleviate suffering wherever it exists in our shrinking world. Much obviously needed help can be rendered without prior scientific inquiry. It is to be welcomed that many private initiatives have been taken to assist people living in regions affected by the Chernobyl accident and that the United Nations is proceeding with an international assistance project focusing on the economic and social consequences of the disaster. The IAEA warmly supports and endorses this project. However, an effective remedy requires correct diagnosis.

In unpredictable radiological situations such as the post-Chernobyl contamination, advice on appropriate protective measures may vary, even when the facts of the situation have been clarified. This contributes in no small measure to the confusion and anxiety felt by so many people and explains their distrust of experts. I have no other suggestion to make than that you, the scientific experts, must continue your discussion in a worldwide context in order to offer the best advice that can be given on the basis of available data. While these deliberations cannot be the ultimate truth, we know that they will not be influenced by obscurantism or sensationalism, nor governed by any political motives.

Let me conclude by renewing my thanks to each member of the International Advisory Committee, to the hundreds of individuals who participated in one way or another in the Project, to the many governments, institutes and organizations who donated their staff's time, to the government authorities and private companies who donated equipment and supplies, and to the Secretariat

[1] International Chernobyl Project: Technical Report, IAEA, Vienna (1991).

of the Project for all the hard work they did in bringing this Project to its conclusion.

We are grateful, indeed, for the great contribution and assistance of the many government authorities in the USSR and the affected Republics and settlements, and to the many scientists, experts, technical and administrative staff and members of the public who opened their hearts to the visiting experts and described their experiences and their anxieties.

This Project is by no means the end of the road, nor does it answer all the questions raised: for example, about the health of the emergency workers and those involved in the cleanup operations, about the situation of those who have moved out, or about the unprecedented social and economic consequences of the accident.

However, if the Project contributes to the creation of a true picture of the situation and to bringing about effective remedies, it will have served its purpose.

Hans Blix
Director General
International Atomic Energy Agency
Vienna

Chairman's Opening Address

The International Chernobyl Project initiated its Phase I in March 1990 and is now entering its final phase. Our International Advisory Committee was organized for Phase II of the Project in April 1990. The Committee was given the responsibility of formulating the work plan for the Project and monitoring its implementation. The aims of the Project are to examine the assessments that have been made of the radiological and health situation in areas of the USSR affected by the Chernobyl accident and to evaluate measures to protect the population.

Five task groups were organized to conduct this Project, each group consisting of international experts in various fields of radiological sciences. My colleagues from Japan and I, like those from other countries and international organizations, willingly participated for humanitarian reasons in this opportunity to serve the Chernobyl victims, although we had hoped that the lessons learned from the experiences in Hiroshima and Nagasaki would never need to be used in an event such as the Chernobyl accident.

The outline of all data so far obtained by the five task groups will be presented during this meeting and will be open for discussion. We welcome your comments. It is true that there were many difficulties and constraints on the time, manpower and funds available for the assignment, but I can assure you that each team made the greatest possible effort to conduct an independent and scientifically authoritative study.

I am aware that our Report does not mean the end of the International Chernobyl Project but should rather be considered the starting point for further international co-operation. I particularly hope that the Recommendations made in the Report will be implemented with international support. I also wish to emphasize the importance of estimating the radiation dose received by each individual; otherwise, of course, any attempt at a follow-up study of the health effects of radiation would be meaningless. In fact, it may be no exaggeration to say that more than half of all the efforts made in Hiroshima and Nagasaki during the past 45 years to follow up the late health effects of the atomic bomb survivors has been devoted to the dosimetry problem.

Finally, on behalf of the Advisory Committee, I should like to express deep gratitude to all the people in the surveyed areas of the three Soviet Republics who have co-operated in the studies and investigations undertaken by the international task groups. My thanks are also extended to all the Soviet scientists and others who worked so hard together with the Project task groups.

I hope this meeting will be fruitful.

Itsuzo Shigematsu
Director
Radiation Effects Research Foundation
Hiroshima, Japan

Introductory Address by the Head of the USSR Delegation

Today we are witness to an important event — the presentation of the results of a project carried out by a broad spectrum of participants to evaluate the consequences of the Chernobyl disaster for the inhabitants of the affected regions of the BSSR, the UkrSSR and the RSFSR.

From the very first days following the accident, the Soviet Government undertook a large complex of measures aimed at eliminating this powerful focus of radioactive contamination and at protecting the population. Thanks to operations on an enormous scale, the damage and losses suffered as a result of the disaster were significantly curtailed. It was then possible to make the transition from immediate and urgent measures to a series of projects aimed at managing the consequences of the Chernobyl disaster on the basis of reliable scientific principles.

In so doing, it was important to make sure that the extensive and expensive measures being developed and implemented by government organizations were soundly based, and that the methods used were correct and adequate to the task. That was all the more important in view of the high stakes — namely the health and well-being of millions of people. In these circumstances the Government of the USSR considered it essential to avail itself of international experience, to co-ordinate its decisions with scientists and specialists from various international organizations who could evaluate the effectiveness of the measures taken to protect the inhabitants of the affected regions, and to receive recommendations.

Let me express our sincere gratitude to the scientists of the international community who responded to the appeal of the Government of the USSR to lend their expertise.

We are clearly aware of the enormous volume of research that has been performed, of what it cost to ensure its quality, given the time constraints, and of the high professional standards that each project participant applied in performing his or her share of the work.

On behalf of the Government of the USSR, I sincerely thank the members of the International Advisory Committee and personally thank its Chairman, Professor Shigematsu, as well as all the international organizations and participants directly involved in the operations who made possible the successful implementation of such a large scale project.

We appreciate the efforts of the experts to reflect such a vast and diverse quantity of factual information in a benevolent and objective way, and also their evaluation of the views of Soviet scientists and specialists about ways of overcoming the consequences of the Chernobyl disaster. The information acquired through this Project will no doubt be of use not only in our country but will make a meaningful contribution to the new field of disaster science. This assessment of the situation is not a formal act connected with the completion of the Project, but a recognition of the fact that the information derived from worldwide experience is really essential, not only for scientists and decision makers, but also for society as a whole.

To emphasize this, let me cite a number of examples of the way in which the multifaceted work performed by specialists from the international organizations is already being turned to good use in our country and is providing assistance in decision making.

The work carried out with the help of the experts on radiation protection measures (discussed in Session 6 of this Conference) had a marked influence on the development of a concept for making the affected regions inhabitable. It confirmed the idea that it would be expedient to adopt two levels of intervention: a lower level above which protective measures would begin to be applied, and a higher level beyond which rigorous measures such as evacuation of the population would be regarded as essential and indeed obligatory. On the basis of the preliminary information contained in Part F of the Technical Report, on the health impact (Sessions 4 and 5 of this Conference), the USSR Ministry of Health modified and adjusted its statistical accounting system for recording the state of health and morbidity of the population in the affected regions as well as its epidemiological research programmes. The Conclusions and Recommendations of the International Advisory Committee are being used to develop the long term State programme.

Following the conclusion of the Chernobyl Project, I would like, on behalf of the Government of the USSR and the Republics, to invite those who were involved in the project and the members of the International Advisory Committee to come to the USSR when the results of their work are presented to the scientists and specialists of our country, as well as to broad segments of the population in the RSFSR, the UkrSSR and the BSSR. We believe that presentations of this kind are an essential final link or step in the Project, one ultimate goal of which, in addition to providing an impartial evaluation of the situation, is to bring the authority of the world's leading scientists and specialists to bear on the task of instilling confidence in the affected populations, convincing them of the soundness and thoroughness of the measures taken to eliminate the consequences of the accident.

Let me inform you briefly about the present status of the cleanup operations. Five years have passed since the Chernobyl accident, but the grief of Chernobyl is not assuaged. In the course of those five years the damage resulting from the accident and the expenditure required for dealing with its consequences have run to around 25 billion roubles, including the projected costs for this

year. More than 130 000 km^2 have a ^{137}Cs contamination density above 1 Ci/km^2 (37 kBq/m^2).

The disaster gave rise to extremely complex scientific, technical, ecological, social, legal and moral problems. By now a large amount of priority work has been done, including the planned evacuation of people from dangerous regions, agricultural decontamination projects, and — most important of all — medical examination of the population and treatment of those suffering the effects of radiation.

All this work has been part of the joint Union-Republic Programme of Urgent Measures. Under this programme 218 000 residents of contaminated regions are to be relocated in the period 1990–1992, and of these 87 000 had already been relocated or voluntarily left the contaminated zones in 1990. In 1991, approximately four million square metres of living space will have to be constructed, with all the necessary social and domestic infrastructure, and corresponding employment opportunities will have to be provided.

The tasks confronting us today are no less complex than those of five years ago. Our activities are governed by the *Concept for habitability of the regions affected by the Chernobyl accident*. The plan in question was approved this year by the USSR Cabinet.

In accordance with international practice, the main indicator for determining the level of response under this plan is not the degree of territorial contamination by radionuclides, but the effective dose equivalent. The problem confronting us now is that all our operations have to be undertaken in a manner consistent with the circumstances as they have evolved and in keeping with decisions which were made earlier. Therefore, the extent of surface contamination of the land, especially with caesium, also has to be considered in resolving certain matters connected with social benefits and compensation.

Under the 'concept', the following criteria have been established to govern the introduction of protective measures: if the average annual radiation burden beginning in 1991 is more than 0.1 rem (1 mSv) above the natural and technical background level, then protective measures are introduced. If, beginning in 1991, the radiation burden reaches 0.5 rem (5 mSv), then such protective measures as population relocation become mandatory.

As before, population relocation remains one of the most complex problems. In the first few years after the accident people firmly believed, on humanitarian grounds, that one of the most effective protective measures was to evacuate the stricken territories. The key territories in this regard were those with a ^{137}Cs contamination of from 15 to 40 Ci/km^2 (555 $kBq/m^2$to 1.48 MBq/m^2).

In connection with the introduction of the 'concept', every effort has been made to explain to people that resettlement should not be viewed as an end in itself and that it is not the main activity undertaken on behalf of the residents of the affected regions. We are trying to make people understand that resettlement itself is a serious risk factor for human health and is not always necessary. At the same time, however, a person who has resolved to move receives compensation from the State in order to do so. Thus, the programme associated with the 'concept' is oriented towards making decisions about resettlement as serious and responsible as possible, and the intention is to retain the principle that such decisions must be voluntary.

At present a single long-term Union-Republic programme is being worked out to protect the people of the USSR against the effects of the Chernobyl accident. Its primary aim is to care for those on whom the shadow of Chernobyl fell. Above all, this means preventive medicine, medical treatment and convalescence, arranging for the necessities of life in new locations, caring for the young, and preserving our cultural heritage. And, in the final analysis, it also means normalizing social conditions and the psychological climate in the affected regions.

In other words, the efforts of the Government are largely directed towards providing the conditions essential to a normal, full life and reliably protecting the legal rights and interests of the population — special attention being given to children, women and the elderly as well as to those who have been directly involved in the accident cleanup operations.

With these aims in mind, the Supreme Soviet of the USSR passed, on 6 May this year, a law "Concerning the social protection of citizens exposed to the effects of radiation as a result of the accident at the Chernobyl Nuclear Power Plant". Similar laws have been adopted in all the Republics.

This law defines the status of the territories exposed to radioactive contamination, procedures for sustaining normal life and activities in those territories, arrangements for medical assistance and radiation protection for those affected by the accident and for social protection of children and adolescents, and, finally, benefits and compensation for the population.

About four million persons exposed to the effects of radiation as a result of the accident fall under the provisions of this law, including the 600 000 who participated directly in the accident cleanup operations. It also extends to the population of certain areas for reasons other than radiation exposure. Some segments of the population living in areas where the average annual radiation burden was less than 0.1 rem (1 mSv) have also received compensation in various forms for reasons dictated by specific social conditions.

The most difficult problem this law had to deal with was that of ascertaining a causal relationship between illness and disability and the Chernobyl accident, both for participants in the cleanup operations and for the inhabitants of highly contaminated regions. For children and

adolescents the Supreme Soviet decided that compensation should be provided in cases where pathology of the blood-forming organs is diagnosed — specifically, acute leukoses of the thyroid gland (adenomata, cancer) and other malignant tumours.

A source of constant concern is the health of all people who were affected by the Chernobyl misfortune. This being so, the conclusions and recommendations of the international experts are very important for us. We are naturally very gratified that they largely coincide with the conclusions of Soviet scientists. In actual fact, analysis of morbidity among the inhabitants of the contaminated regions has not so far revealed any pattern or features which would enable us to ascribe it beyond doubt to the effects of the radiation factor as such.

At the same time, we note that epidemiological data and clinical observations point to certain unfavourable trends in the state of health of the inhabitants of those regions. The incidence of cardiovascular disease, chronic illnesses of the gastrointestinal tract, lung disease and so on has increased. This may be due to natural changes in the incidence of certain diseases, changes in ecological conditions, disruption of normal patterns of life and diet, or prolonged psycho-emotional tension brought on primarily by the stressful situation before and after evacuation. In the light of this situation and other factors which I shall mention presently, we are inevitably concerned about the state of health of our people. For that reason a prognosis for the future focused exclusively on anticipated insignificant consequences for the health of the inhabitants of the contaminated regions would be less than cautious.

We have no right to quell our concern with an approach such as this, especially as the full effects of radioactive iodine on the thyroid during the first week after the accident — particularly in children — are still not fully known. We must also improve our arrangements for monitoring those who participated directly in the cleanup operations, because many of them received significant doses of radiation.

For these reasons we are directing the health services to carry out further epidemiological studies and to produce a reliable statistical interpretation of the results. And on all these matters we are calling for broad international co-operation: there is vast scope for international research here.

A broad programme is being developed in the USSR with the aim of rendering medical assistance and providing treatment to people who were exposed to the effects of radiation as a result of the accident. A public register has been compiled of those exposed to the effects of radiation which by now contains medical and dose data on 531 000 people.

A special programme called *Children of Chernobyl* is now in operation. It was created to provide effective prophylaxis against the possible negative effects of the accident on children, mothers and pregnant women by raising the standards of medical assistance at all levels. The implementation of this programme will require investments of approximately 900 million roubles over five years.

In the contaminated regions a series of measures is being implemented to bring agricultural production in line with the national standards, which have been made more stringent on three separate occasions during the period of interest. In 1990 the temporary limits for ^{137}Cs contamination of basic agricultural products were 2960 Bq/kg for meat and 370 Bq/kg for milk.

To what extent was our agricultural production contaminated last year? As far as meat is concerned, in all regions the farmers have learned to fatten livestock for slaughter in such a way that the contamination of the meat does not exceed the established limits. Meat containing radioactive caesium in excess of the temporary limits turns up only in connection with the forced slaughter of livestock before the normal fattening process. According to 1990 data, the quantity of such meat did not exceed a few hundredths of a percent.

The caesium concentration in crops, both fruit and vegetables, grown on land with a contamination of up to 40 Ci/km^2 (1.48 MBq/m^2) was hardly in excess of the international standard of 600 Bq/kg.

Of all the basic agricultural products, milk has presented the most serious problems, even though the amounts of milk contaminated in excess of permissible levels have steadily decreased from year to year. In Kiev, Mogilev and Gomel provinces less than 1% of the milk entering the milk processing plants is contaminated. The largest fractions of contaminated milk are found in the Zhitomir and Bryansk provinces, where they amount to 7% of the total volume.

Radiation monitoring is a rigorous three-stage process: agricultural products are checked throughout the growing period, again during processing, and finally as finished products. This year there are plans to create additional public monitoring stations and to develop mobile laboratories. Efforts are being made to improve our system for monitoring radioactive contamination of the environment and to set up information systems and databanks on radiation conditions. In 1990, 121 500 households in the surveillance zone, 5 Ci/km^2 (185 kBq/m^2) and higher, were registered, as well as 217 300 households outside the zone. An airborne gamma survey of 20 provinces was carried out in the RSFSR, the UkrSSR and the BSSR.

To help the population evaluate radiation conditions in their own dwellings, work places and recreational establishments, the Government of the USSR took steps to increase the output of simple, easy-to-use dosimetric and radiological monitoring devices. In 1991 the plan is to provide the public with 700 000 to 750 000 radiation monitoring devices, as compared with only 240 000 in 1990.

In addition to radiation itself and the stressful situations arising from the introduction of restrictive measures and the relocation of residents, there were other factors that had a negative influence on the social and psychological state of people in the contaminated regions, notably inadequate information about radiation conditions and the effects of the accident in their specific region, as well as misconceptions concerning the work being done there. Beginning in 1990 a special information bulletin called *Chernobyl* was published with the aim of providing the public with more information. This publication is sent directly to all affected areas, including organizations at the district level.

However, in spite of the large amount of work that has been done and the great expenses incurred, it has still not been possible to resolve all the problems involved in managing the consequences of the accident. For that we need further efforts on the part of everyone in the country and quite possibly the assistance of the international community.

The Chernobyl tragedy is another reminder that planet Earth is our common home. It glaringly revealed the vulnerability of our civilization in the face of technology. The pain of Chernobyl summons us urgently to find solutions to a problem common to all mankind — the protection of our environment. Chernobyl is one more warning about the terrible force concealed in nuclear energy if it gets out of control.

The bitter lesson of the Chernobyl accident has not been in vain. In the USSR, practical measures of a technical and organizational kind have been taken to increase the reliability and safety of operating reactors. A thorough analysis has been made of all factors governing their safe operation, particular attention being given to the competence and training of operating personnel. At the same time, practical questions concerning the safe operation of all elements and units involved in the nuclear fuel cycle are being resolved, including the decommissioning of power generating units that have reached the end of their useful lifetime.

In the wake of the Chernobyl accident, the problems of using nuclear energy to achieve economic ends have been seriously exacerbated. Not infrequently, people living in the vicinity of operating plants or plants under construction pronounce themselves in favour of shutting them down or halting construction.

As far as the Chernobyl plant is concerned, scientific studies are currently being carried out on Unit 4 with a view to ascertaining the condition of the destroyed reactor and the 'sarcophagus': the specialists have come to the conclusion that the nuclear fuel contained in the sarcophagus is in a profoundly subcritical state, so that no spontaneous chain reaction would be possible. Design studies are being done with the aim of improving the reliability and safety of the cover over Unit 4. It has in fact been decided that a competition should be held to select the most appropriate design either for complete burial or for long term conservation of the destroyed reactor.

Misfortune brings people together; that is human nature. The Chernobyl tragedy tore at the hearts of millions of people on all continents. Many countries reached out a helping hand to us. With deep gratitude the Soviet people accepted any sign of sympathy or support from the international community in their time of need. We want to express our gratitude to all Member States of the United Nations which supported, at the 45th Session of the General Assembly, the resolution concerning international co-operation in mitigating and overcoming the consequences of the Chernobyl accident.

We have noted the growth of international co-operation in overcoming and mitigating the consequences of the accident both in our bilateral relations with various governments and in the sphere of multilateral collaboration under the auspices of the United Nations, the IAEA and other international organizations. The USSR will do everything in its power to ensure that this co-operation is effective and that it spreads and intensifies.

We believe that the unique experience of struggling with the nuclear threat which came to us through this misfortune can and must be used in the interests of mankind, so that a tragedy of this magnitude will never occur again, in the USSR or anywhere else on Earth.

The Chernobyl disaster has shown us again and again how fragile and interdependent is our world, in which all nations and peoples want to live happily, assured of the safety of future generations. All people of goodwill are striving to achieve that noble aim, and the peoples of the USSR extend their full support.

V.A. Gubanov
USSR Council of Ministers
State Committee on the Elimination
of the Consequences of the Accident
at the Chernobyl Nuclear Power Plant
Moscow, USSR

The International Chernobyl Project

M. ROSEN
Division of Nuclear Safety,
International Atomic Energy Agency,
Vienna

A brief portrait of the International Chernobyl Project, describing its origin, goals and working methods, may lead to a fuller understanding of the Project's results as well as its limitations.

INTRODUCTION

In October 1989, the Government of the USSR formally requested the International Atomic Energy Agency to carry out:

> *"... an international experts' assessment of the concept to enable the population to live safely in areas affected by radioactive contamination ... , and an evaluation of the effectiveness of the steps taken ... to safeguard the health of the population."*

The response was a proposal for a multinational team to undertake an assessment of the radiological situation in the three affected Soviet Republics, with the participation of seven international bodies:

The Commission of the European Communities (CEC),
The Food and Agriculture Organization of the United Nations (FAO),
The International Atomic Energy Agency (IAEA),
The International Labour Office (ILO),
The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR),
The World Health Organization (WHO),
The World Meteorological Organization (WMO).

This became the International Chernobyl Project. The Project was formalized at a meeting in Moscow in February 1990 attended by some 25 representatives of the USSR, the BSSR, the UkrSSR and the IAEA.

The work of recommending an approach to implementing the Project was given to a group of ten scientists who, accompanied by two members of the USSR Supreme Soviet, travelled on a fact finding mission through the affected Republics during the last week of March 1990. Their visit enabled them to learn first hand about the requirements of the Project. The group met with officials in Moscow and in the capitals of the Republics and with representatives of scientific organizations, hospitals, clinics and agricultural centres in the affected areas and in the cities of Kiev, Gomel and Moscow.

It was only after the group encountered people in the affected areas that the dimensions of the task became clear. Plans for the Project had been presented to residents of seven settlements in the three Republics, who were invited to share their feelings with the scientific group and ask questions. Anxiety about children's health and about the adequacy of the Government's proposed measures for limiting the radiation exposures during their lifetime dominated the discussions. There was an atmosphere of mistrust directed towards the authorities as well as many members of the scientific and medical communities.

Following the visit of the fact finding group, an International Advisory Committee of scientists from ten countries and seven international organizations was established to direct the Project and be responsible for its findings. Members were called together from well known institutes and universities to represent a spectrum of disciplines, from radiation specialist to medical practitioner and psychologist. The twenty-one member Committee met in Kiev and Minsk from 23 to 27 April 1990 under the chairmanship of Dr. Itsuzo Shigematsu, Director of the Radiation Effects Research Foundation in Hiroshima, Japan.

The Committee agreed upon a detailed work plan. This would be constrained by a compelling need to complete the Project in one year and by the limitations on the resources available. It was clear that the assessment of the Chernobyl accident had already involved extensive efforts and it would not be necessary for the Project to undertake a totally new, comprehensive assessment of the situation. Rather, the task would be to assess the quality and correctness of the existing results and to conduct an independent assessment through field samples, laboratory analyses and internationally recognized calculation techniques. Secondly, to be manageable, the international assessment would have to focus on the four key issues of concern to the population and policy makers:

The true extent of contamination,
The past, current and future radiation exposure of the population,
The actual and potential health effects,
The adequacy of measures being taken to protect the public.

An account of the major historical events of the accident would also be prepared which would provide a

background for fully understanding the complexity of the situation and the interrelated nature of the Project's goals.

GOALS AND SCOPE

The Project deals *exclusively* with the radiological consequences for people living in the affected areas at the time the assessment began in 1990. Thirteen districts in the USSR have been officially identified as having a ground level caesium contamination in excess of 1 Ci/km^2 (37 kBq/m^2). Approximately 25 000 km^2 are defined as affected areas with ground concentration levels of caesium in excess of 5 Ci/km^2 (185 kBq/m^2). Of this total, approximately 58% are located in the BSSR, 32% in the RSFSR and 9% in the UkrSSR. From official USSR reports, this population is approximately 825 000, of which 45% live in the BSSR, 24% in the RSFSR and 31% in the UkrSSR.

It was not the Project's intention to examine the prohibited region, approximately 30 km in radius, round the damaged reactor itself, except to describe the measures taken to contain the accident in the early post-accident phase. As the Project was directed at those currently living in the contaminated areas, the radiological health effects to the more than 100 000 people evacuated from the prohibited zone round the Chernobyl site were considered only for those currently living in the areas under review. Nor did the Project address health effects for the large number of emergency personnel (the 'liquidators') who were brought into the region temporarily for accident management and recovery work. The health of this occupationally exposed population is reportedly being monitored at medical centres throughout the USSR.

WORK PLAN

In co-operation with local authorities, the Project selected a number of settlements in the contaminated areas of concern in order to perform the necessary surveys. Some of the settlements were located in areas of relatively high soil surface contamination while others were located in areas of relatively low soil surface contamination but with the potential for high radiation doses to people through the food chain. These settlements are called 'surveyed contaminated settlements'.

Settlements were also selected outside the contaminated areas to serve as references for comparison. These are called 'surveyed control settlements'. Thirty-five settlements were surveyed but not all of them were used in all the tasks of the Project.

A parallel consideration was the desire of the affected population for practical information about how they could deal with the radiological situation. Project experts concluded that there was a poor understanding in the affected areas of the scientific principles underlying radiation and its effects, as is generally the case throughout the world, and that this was at the root of many of the medical and social problems observed. Therefore, in addition to the main tasks of the Project, several information exchange activities were carried out in order to raise the level of the local scientific community's understanding of the problems involved.

PARTICIPATION

The Project was carried out on a completely voluntary basis by a closely co-operating team of some 200 experts associated with research institutes, universities and other organizations in 25 countries and seven multinational organizations. The time devoted to the Project was volunteered by governments, institutes, companies or the experts themselves. Nearly 50 missions to the USSR were completed between March 1990 and January 1991. The IAEA Laboratory at Seibersdorf, along with 13 laboratories in six countries participating on a voluntary basis, were involved in the collection and analysis of samples. The IAEA Laboratory carried out an intercomparison exercise with participating laboratories from the USSR. Government authorities and commercial companies in five countries donated equipment and supplies, radiation monitors and computing time to back up the work of the Project. Project teams made 2000 measurements of external gamma dose rates at indoor and outdoor locations; over 1000 samples of soil–grass ecosystem and milk were collected; nearly 22 000 inhabitants were monitored for either external or internal exposures; and almost 1500 medical examinations were carried out.

The Project received the full support of the USSR and the Governments of the BSSR, the RSFSR and the UkrSSR. Assistance took various forms, including participation of local scientists in intercomparison exercises; extensive discussion with Project scientists; and assistance in the collection and preparation of field samples and in carrying out medical examinations of the population in the affected areas. Most of the logistic support for the Project was provided by the USSR Ministry of Atomic Power and Industry. There were open and frank conversations with authorities, scientists and, especially, local citizens that greatly helped the international experts' understanding of the situation.

CONSTRAINTS AND LIMITATIONS

The Conclusions and Recommendations of the International Chernobyl Project were approved by the International Advisory Committee at its meeting in Vienna

from 18 to 22 March 1991 and they are based upon the radiological and health assessment carried out by the Project. The technical details of these assessments are to be found in the extensive Technical Report[1], to which reference should be made for detailed information.

The Conclusions and Recommendations are subject to some constraints and limitations in the design of the Project. Ideally, the Project teams would have had sufficient time and resources to examine exhaustively all the information available to them and to verify it independently, as well as to carry out more extensive independent analyses. Such comprehensive efforts were not feasible, nor were they altogether warranted. More limited objectives were seen to be necessary and were adopted. A major effort was therefore directed to assessing the reliability and accuracy of data, techniques and methodologies employed to estimate contamination levels, doses and health effects, and to evaluating radiological protection policies. Sufficient data were also obtained independently to enable the Project teams for each of the four tasks to formulate independent judgements.

A few issues received comparatively little attention, owing primarily to the unavailability of necessary and sufficient data. For example, it was not possible to corroborate the early contamination of land and the exposure of the public due to iodine isotopes. Nor were the early remedial protective actions that were undertaken, such as thyroid blocking by iodine prophylaxis and evacuation, subject to thorough evaluation.

Despite the limitations of time and of financial and human resources, the International Advisory Committee is of the opinion that the Project represents a much needed international humanitarian and scientific response to the needs of the authorities and the people of the USSR who were affected by the Chernobyl accident.

The International Advisory Committee acknowledges the many problems inherent in a study of such breadth. Nonetheless, the work has involved leading and eminent international scientific investigators and medical specialists who endorse its adequacy and its results. It is a significant step in the evaluation of the consequences of the accident.

[1] International Chernobyl Project: Technical Report, IAEA, Vienna (1991).

WHO's International Programme on the Health Effects of the Chernobyl Accident (IPHECA)

P. WAIGHT
World Health Organization,
Geneva

A Memorandum of Understanding between the World Health Organization (WHO) and the Ministry of Health of the USSR was signed on 30 April 1990. It called for the development of a long term international programme to monitor and mitigate the health effects of the Chernobyl accident and for the establishment of an international centre for radiation health issues.

The International Programme on the Health Effects of the Chernobyl Accident (IPHECA) envisages a varied range of activities to provide health care for the exposed populations and strengthen emergency response. These include:

(1) A long term epidemiological study of the health effects in the exposed persons;
(2) Assessment and treatment of possible late somatic and genetic effects;
(3) Diagnosis, treatment and prevention of thyroid disease;
(4) Health implications of the psycho-social effects of the accident;
(5) Establishment and maintenance of radiation health databanks;
(6) A retrospective analysis of the projected dose;
(7) An independent evaluation of levels of contamination and of the control measures introduced.

This is, of course, a very wide ranging programme whose complexity will necessitate development in stages. However, initial steps have been taken to implement the programme through the establishment of the International Centre for Radiation Health Issues (ICRHI). The Soviet authorities are making arrangements for the International Centre to be housed in Obninsk. Regional affiliated centres have also been established in Kiev, Gomel and Bryansk under an agreement between the Ministry of Health of the USSR with those of the BSSR and the UkrSSR. The city of Obninsk, in the Kaluga region of the RSFSR, has a population of 100 000, and is situated about 100 km south of Moscow. It was built during the 1950s and 1960s to house a complex of research institutions. In all, fourteen such institutes are currently located in Obninsk, where there is a study and conference centre with excellent facilities for seminars and meetings of all types.

The nucleus of the proposed International Centre will be provided by the Research Institute of Medical Radiology of the Academy of Medical Sciences of the USSR, which includes the State Registry of more than 500 000 persons exposed as a result of the accident. This Institute is at present composed of two branches, a clinical branch located in the city of Obninsk and a research branch situated a little outside the city. It is planned to amalgamate the clinical departments of pathology, haematology and endocrinology with the epidemiological section (which includes the dose registry) and the radiation cytogenetics department of the research branch, and to use these as the basic units for the new International Centre. At present, the clinical branch includes groups working mainly in nuclear medicine, radiology and ultrasound diagnosis. Efforts are under way to establish a department for dealing with the psycho-social effects of radiation accidents.

Programme support will be provided by other institutions located in Obninsk whose activities would be related to the work of the International Centre. This will include, among others, the Hydrometeorology Institute, which is involved in the mapping of radioactive contamination, and the Agricultural Radiology Institute, which is concerned with the study of transport of radionuclides in the environment and the establishment of transfer factors. An integral part of the epidemiological work of the Centre will be the All-Union Distributed Register of persons exposed as a result of the Chernobyl accident. Information on over 570 000 individuals who have been exposed to radiation from the accident, including those involved in the cleanup work, is on file in the Register and is available. The information has been computerized and includes biographical details, outcomes of medical examinations and estimates of dose. The software has already been designed to manipulate the different cohorts within the Register. Ministries of Public Health of the RSFSR, the UkrSSR and the BSSR provide the major portion of the information.

As an initial step, a Scientific Advisory Committee consisting of nine senior scientists from as many countries met in Hiroshima from 23 to 26 October 1990. This meeting, which was organized in collaboration with the Radiation Effects Research Foundation, which is located there, was also attended by representatives of the IAEA, the CEC, the Japanese Ministry of Health and Welfare, the Ministry of Science and the Technology Agency of Japan, the USSR Ministry of Health and the Radiation Effects Research Foundation. The Committee reviewed the objectives and proposed activities of the International

Programme, including the Centre, and made recommendations concerning its implementation, objectives and priorities.

The Committee felt that the unique character of the mixed internal and external radiation exposure at low dose rates that resulted from the accident was of great international scientific and medical importance. The adoption of a single programme would facilitate the coordination of all Chernobyl-associated health studies. The Committee recommended that the proposed International Programme be implemented according to the priorities which it assigned. It also recommended the establishment of the proposed International Centre (ICRHI) at Obninsk, the task of which would be the coordination and execution of radiation health studies, the provision of information and the organization of international meetings. The Committee also recommended that, owing to logistic and financial constraints, in-patient diagnostic and treatment facilities should not be part of the International Centre but should be furnished on a contractual basis.

In recommending that the International Programme be implemented, the Scientific Advisory Committee identified the following six priorities upon which it should depend:

(1) Epidemiological studies which would include children with thyroid exposure, emergency accident workers and residents who have continued to live in contaminated areas and those who were evacuated soon after the accident.
(2) Dosimetric assessments which should be focused specifically on the study groups in (1) above. (Where direct dosimetric evaluation is not available, other methods of dose estimation will be required.)
(3) Mitigation of psycho-social effects through individual counselling and the provision of full information. (Furthermore, it will be necessary to establish a study of the effectiveness of any mitigation strategies.)
(4) Standardized clinical follow-up studies in support of epidemiological investigations.
(5) Education and training through specialized courses for participating staff; short courses for physicians on the medical aspects of radiation accidents; the basic education programme on radiation effects for the relevant professionals in the community; and provision of general information material.
(6) Efficient database management emphasizing uniformity of data collection and quality assurance and implemented by a computer based network system.

I would like to return to the more current events that have occurred in the development of the programme. As you know, in November 1990 the Director-General of WHO made an appeal to the Member States which have permanent Missions in Geneva for funds to support the International Programme and Centre. Following the generous donation of 20 million US dollars by the Japanese Government, a Task Group was convened in early January 1991 to make recommendations on how these funds could best be spent. This group identified three pilot projects which required implementation as soon as possible:

(1) **A Haematology Project** to review the incidence of haematological disease in those persons living in the zones of strict control, and to establish an allogenic bone marrow transplantation facility in Gomel;
(2) **A Thyroid Project** to assess radiation induced thyroid disease in exposed children;
(3) **An Epidemiological Project** to establish uniform protocols and to develop software to facilitate the manipulation of data for future radiation risk estimates.

A fourth project has since been added, which is a study of the effects of in utero irradiation on children, particularly on the brain.

Following the Task Group Report, the International Programme (IPHECA) and the establishment of the International Centre (ICRHI) were discussed by the Executive Board of WHO, which endorsed further development of the programme and urged Member States to participate actively. The Board emphasized that the programme would have to be implemented by means of voluntary contributions and not through the regular budget. Further consideration of the programme was undertaken by the Forty-Fourth World Health Assembly, which passed a resolution by consensus on 15 May 1991 to proceed with the implementation of the International Programme and the establishment of the International Centre.

Session 2

ENVIRONMENTAL CONTAMINATION

Objectives and presentation of the methodological approach used
F. Steinhäusler (Austria)

Results of the intercomparison exercise and data management
V. Valkovic (IAEA)

INDEPENDENT SURVEY OF ENVIRONMENTAL CONTAMINATION

Radiological survey of selected settlements in BSSR, UkrSSR and RSFSR
P. Zombori (Hungary)

Radionuclides in grass-cow-milk ecosystems
P. Stegnar (Yugoslavia)

Independent verification of the contamination maps
F. Steinhäusler (Austria)

Conclusions
F. Steinhäusler (Austria)

Rapporteur's Report of Session 2
B.W. Wachholz (USA)

DISCUSSION

Yu.S. Tsaturov (USSR): Since the accident, the operational units and scientific institutions under the State Committee on Hydrometeorology and Environmental Monitoring have been collaborating with the various bodies of the Academies of Sciences of the Union Republics, of the Ministry of Health and other ministries and departments in monitoring the atmosphere, soils and surface water in areas contaminated as a result of the Chernobyl accident.

First of all, I wish to say that my organization and all the Soviet colleagues who took part in this work are fully satisfied with the data presented this afternoon. We saw those results in March when, in the first phase, the data prepared by the experts were reviewed. We are happy to note that the suggestions, recommendations and comments made here at the Agency by our colleagues in March are reflected in the Technical Report and in the papers presented here today.

I shall try to reply to the questions which Dr. Steinhäusler has raised in his report on his group's work. These relate, first, to the air contamination data, which unfortunately the independent experts could not obtain. To be brief, I shall cite a few figures to give an idea of the atmospheric contamination within and outside the 30-km zone. In the case of the plutonium isotope which is most critical in inhalation, the concentration was 10^{-18}–10^{-19} Ci/L (3.7×10^{-8} — 3.7×10^{-9} Bq/L) in the 30-km zone around the Chernobyl plant, and in the towns of Pripyat and Chernobyl. These values are lower by two or three orders than those laid down by the radiation safety standards in force in the USSR. Of course, they are somewhat higher than the pre-accident background values, and we attribute this to resuspension of radionuclides into the air. Likewise, in other zones with lower surface contamination levels the content of radionuclides in the atmosphere is lower by several factors of ten than in the near zone and is comparable with the background. The figures for Kiev city are: average monthly concentration of plutonium isotopes 5×10^{-21} to 4×10^{-22} Ci/L (1.9×10^{-10} to 1.5×10^{-11} Bq/L); ^{90}Sr: 2 to 10×10^{-20} Ci/L (7×10^{-10} to 3.7×10^{-9} Bq/L); and ^{137}Cs: 1 to 9×10^{-19} Ci/L (3.7 to 3.3×10^{-8} Bq/L). Such a content of radionuclides in the air layer adjacent to the soil cannot, of course, lead to any appreciable secondary surface contamination due to windborne transfer.

However, available data show that in the contaminated areas adjacent to sites with intensive human activity (such as farmlands under the plough and dirt roads) there is some increase in the radionuclide concentration in the atmosphere. We therefore welcome the recommendations presented today.

As to the question about uncertainty in the analyses of surface, soil, water and air contamination, I understand that this uncertainty is attributed by the independent experts to the preparation of composite maps on the basis of aerial surveys and ground sampling. We estimate this error to be 30–40%. The error in the determination of surface contamination of the soil by caesium isotopes is, of course, much lower, and we agree with the estimate given here by the independent experts.

I should like to comment separately on the question about the overestimate of strontium and plutonium in the Soviet data. From the point of view of a conservative observer, the Soviet officials seem to have been somewhat careful in applying the series of various protective measures on the basis of these overestimates. In other words, there was an element of conservatism here. But from the standpoint of the Chernobyl laws enacted in the Republics and in the USSR as a whole, to which Dr. Gubanov was referring in his introductory statement, we should bear in mind that if the independent experts are going to send these overestimates of strontium and plutonium to the laboratories only confidentially it will be difficult for the official bodies in the USSR at present to prepare data on settlements where the doses should not exceed 0.1 rem/year (1 mSv/year) and to make isodose maps for 0.5 rem/year (5 mSv/year), i.e. in cases where definite decisions are required. Therefore, I request the independent experts, apart from confidentially transmitting the data to the laboratories which made these overestimates, to give the names of these laboratories at least to the Chernobyl committees in the UkrSSR, BSSR and RSFSR. As for the contributions of individual laboratories, the maps which were presented today are based on the data of the State Committee on Hydrometeorology, taking into account the data of our colleagues in the USSR. We now have a detailed official map as of January 1991. I should like to add that all data on environmental contamination resulting from the Chernobyl accident have been summarized and collected in the recently published book *Chernobyl — Radioactive Contamination of the Environment* (in Russian).

F. Steinhäusler (Austria): I should like to express my gratitude to our Soviet colleagues. I shall give you one example of our co-operation. We went into the same village, side by side, they with their instruments, we with ours, and I just want to tell you the result: the ratio of surveying a village, their results devided by ours, was 0.96 $\pm$ 0.05, call it 1, and I think that says it all: there were ten foreigners and I don't know how many Soviet colleagues, and our ratio was 1. Thank you very much for helping us do the work.

I'm afraid I cannot be positive about the request for abandoning confidentiality. I must repeat that right from the start of this intercalibration exercise we promised every participant that only the IAEA Laboratory would know the results, and this confidentiality clause is very important. Perhaps we can work together so that the practical implementation between the Soviet colleagues involved, the committees which have to take decisions and Seibersdorf Laboratory can find a common denominator. That is all I can say at the moment and I hope it is satisfactory.

E.F. Konoplya (BSSR): I should point out that four laboratories of our Institute [*the Institute of Radiobiology of the Academy of Sciences of the BSSR*] — the laboratory of radiometry, the laboratory of aerial radioecology and radiobiology of water systems, the laboratory of monitoring and the laboratory of soil radiochemistry — participated in the international intercalibration. I am pleased to note today that, on the whole, the assessment of the radiation situation in the BSSR agrees with that made by the BSSR scientists. This should form the basis for our future work. It is time now to finish with corroboration of data and proceed to constructive practical collaboration. I hope that this Conference will be the turning point. I need not go into every kind of radiation contamination of the different ecosystems.

I agree with Dr. Steinhäusler's assessment regarding water systems. The only thing I want to add is that what seems to be an overestimate of the contamination of water systems is not actually so. If dynamic studies had been carried out, quite different results would have been obtained in other periods of observation because, in fact, the entire radioactivity is concentrated in the bottom sediments and everything that is in the water is being contaminated continuously. A constant plateau has now been reached.

There are two points which have not been dealt with sufficiently in the Technical Report and in the presentations — the problem of transuranium elements and the problem of their aerial transport. I must say that the problem of plutonium, like that of strontium, is a complex one. It should be noted that plutonium contamination above 0.1 Ci/km^2 (3.7 kBq/m^2) is found outside the prohibited zone and people continue to live in those areas at present. We agree with Dr. Stegnar's data on the migration of caesium and its content in breast milk but we have somewhat different data on migration of caesium in various types of soil. We shall take up this matter when we discuss agricultural problems. It is true that we have a somewhat different understanding of the ratio of ^{239,240}Pu and ^{241}Am, and I must add here that the data which I am going to present are based on direct measurement of plutonium in the different environments

by radiochemical methods followed by alpha spectrometry. *[The speaker showed a slide: a map of the BSSR indicating the sites where the Institute of Radiobiology carries out continuous monitoring of the radiation situation.]* Other institutes and laboratories are also participating in this work in their areas of competence. As for the zones with transuranium elements, the problem is of basic importance for the present situation, for prediction and especially for evaluating the impact on human health and on living organisms. I have said that, first of all, we associate ^{241}Am with ^{241}Pu, which has not yet been mentioned here. ^{241}Pu is also found in our area. It has a short half-life — about 14 years — but it changes into ^{241}Am, which has a half-life of 433 years and is, in addition, highly toxic. It is an alpha emitter. We have made predictions for transuranium elements in the case of individual settlements. For example, at Mosany in 1988 ^{241}Pu amounted to 2300 Bq/km^2 and ^{241}Am to 65 Bq/km^2. By the year 2030 the activity of plutonium will be only 320 Bq/km^2 but that of the more toxic ^{241}Am will increase. The situation in this settlement will not improve at all but may even get worse.

As for aerial transfer, the content of radionuclides in the atmosphere was monitored in different settlements between 1986 and 1990. The content is falling every year, but even in Minsk in 1988 and 1989 it was higher than before the incident.

The concentration of plutonium in the air was studied in different periods of time in different towns of the BSSR (Minsk, Gomel, etc.). In 1990 the plutonium content in the air in Minsk was higher than before the accident. *[The speaker showed a graph depicting changes in the radionuclide content in the air.]* We discuss, in general, a tendency towards a decrease although the fluctuations are substantial. But the picture is not as chaotic as it appears — there is a pattern. If we take the spring months—April and May — we see an increase everywhere. The same happens in the autumn months. These are the months of agricultural activity, which generates dust. The dust is transported by air currents also outside the contaminated zone. We have the same picture at Mogilev, which is situated in the relatively clean zone. If we consider dust suspensions, we shall get the picture I have described.

Finally, there is one more interesting observation. In 1989 there was a forest fire, and at Nedokhojnikij 40 km away the atmospheric content of radionuclides rose by several factors of ten.

F. Steinhäusler: First, I indicated at the beginning what our study could *not* do: it does not lend itself for use as a substitute for long term investigations, such as studying seasonal trends. Second, although we invited our colleagues to provide us with all the information they had, I regret to say that these very interesting data were not supplied, either to our expert teams or to me, so, of course, they could not be taken into consideration.

Finally, I should like to refer to page 17 of the Overview[1], where the Recommendations refer very clearly to the issue as such, as identified by us, recommending that water sampling and air monitoring programmes should be carried out jointly with international colleagues.

V.G. Bar'yakhtar (UkrSSR): Although the main problem associated with the Chernobyl disaster is caesium, I should like to draw attention to one small point concerning strontium contamination, which ought to be reflected in the conclusions. As we all know, on the left bank of the Pripyat an area of about 20–22 km^2 is highly contaminated with strontium — the amount is approximately 10 000 to 12 000 Ci (3.7×10^{14} to 4.4×10^{14} Bq). This strontium poses a great hazard since during floods it can be washed out into the River Dnepr and contaminate the entire Dnepr system situated in the UkrSSR. This spot is of no danger to the BSSR and RSFSR, since the contamination will flow downstream. These 10 000 Ci of strontium may appreciably raise the concentration during the spring floods. While there has been no great rise in the water level (not more than 5%) at any time during the last five years and, fortunately, the Dnepr water has been clean all the time, the danger does exist, as Academicians Paton and Khutsilov and I pointed out as early as 1986.

As always, there are local peculiarities which differ from the overall picture, but it is these peculiarities which can later alter this picture. The strontium on the left bank of the Pripyat is a potential threat to the purity of the water in the Dnepr basin.

F. Steinhäusler: We have tried to address this subject on page 18 of the Overview by indicating that we recommend that the desorption of strontium from sediments in surface water bodies and its impact on agriculture through irrigation practices should be taken into account. That may not do justice to the full problem, as you have illustrated, but we hoped that by highlighting the strontium issue and water ecology we would draw the attention of the regulatory bodies to fund and promote more research in the USSR in that area.

Yu.S. Tsaturov: I should like to say a few words in connection with Academician Bar'yakhtar's comments. A rise in strontium concentration is indeed possible during floods. To elucidate the picture, I will cite data collected this spring. As a result of submersion of more than 30% of the flood-plain of the River Pripyat due to ice blocking in January this year, the maximum concentration amounted to 100–160 pCi/L (3.7–5.9 Bq/L) but remained below the permissible levels in the USSR (in

[1] The International Chernobyl Project: An Overview, Report by an International Advisory Committee, IAEA, Vienna (1991).

this case, 400 pCi/L (14.8 Bq/L)). Predictive evaluations of the possible content of strontium in the Kiev water reservoir show that its concentration may rise to 20–30 pCi/L (0.7–1.1 Bq/L), which is higher than the usual by a factor of 3–5 but is lower than the permissible level by a factor of 10–20. During the submersion of the sector of the flood-plain referred to by Academician Bar'yakhtar, the amount of strontium washed out was altogether about 60 Ci (2.2×10^{12} Bq), i.e. 0.5% of the total quantity present in the flood-plain. We do not estimate the latter at 12 000 Ci (4.4×10^{14} Bq) but only half as much — 6000 Ci (2.2×10^{14} Bq).

Academician Konoplya spoke about the problem of transuranium elements, which was not known to the independent experts or even to the official interdepartmental council on radioactivity measurement in the USSR. It is only today that we learned about these data on transuranium elements for 1986–1987. In particular, I am puzzled by only one thing: why did the Academician say that Mogilev and Gomel were relatively clean and that the concentration in the air at Minsk was an order higher than at Gomel and many times greater than at Mogilev?

T. Terasima (Japan): May I make a general statement regarding the present meeting? On behalf of the Japanese delegation, I greatly appreciate the initiative taken by the IAEA, in co-operation with many international bodies, to assess the radiological situation in the three affected Soviet Republics. I hope that the results of the Project encourage local scientific communities and the people living in the areas affected. I would like to pay tribute to the contribution made by Professor Shigematsu, Chairman of the International Advisory Committee.

I was much impressed by the results reported this afternoon. I am glad to learn that the water resources remained safe and relatively sound. However, I think possible contamination of aquatic biota should be examined and followed up in the future. It may constitute a future research requirement.

F. Steinhäusler: Our measurements indicate that filtered water samples and sediment show very different radionuclide content. The filtered water in summer 1990, with one exception, did not show any measurable amount of radioactivity, whilst the radionuclide levels in some of the sediments, not in all, did show the beginning of elevated radionuclide concentrations. In addition (it is in the Technical Report), fish samples showed some indication that radionuclides in fish are starting to increase in some cases. This is referred to in our Recommendation, on page 17 of the Overview, where we state that the potential for long term contamination of water bodies, possibly leading to contamination of the aquatic food chain, should be investigated. We hope that this Recommendation will create enough interest for the USSR authorities to pick up the subject for future research.

J. Jovanovich (Canada): How do these contaminations of foods and human milk with ^{137}Cs and other artificial radionuclides compare with ^{40}K and the others? Have they been measured? Do you have any comments?

F. Steinhäusler: The contributions from ^{40}K, a natural radionuclide, and those from ^{137}Cs are of a very different order of magnitude, depending on the area we are talking about. If we refer to the high transfer areas then certainly the whole body caesium levels such as in Ovruch start to become significant, but in the low level areas where there is commercially available controlled food, the contribution from ^{40}K is certainly of a non-negligible magnitude as compared to caesium.

Yu.S. Tsaturov: All our measurements are carried out jointly with the BSSR Committee on Hydrometeorology. We collaborate in this matter with the Laboratory for Atmospheric Studies. As for contamination of the atmosphere in the Minsk and Gomel regions, I made no comparison. In fact, the contamination in Minsk is the lowest.

A. Eggleton (UK): We can still see elevated levels of airborne ^{137}Cs in Britain as a result of the Chernobyl accident, and we believe this is due to local resuspension of material that has been deposited on the ground in Britain. The question of resuspension is quite complicated because you have to ask what is the particle size of the resuspended material. There is comparatively little fine particulate, but that is what most air samples measure. If we had an air sample that measured larger particulate sizes, we could expect to see more resuspension, and indeed if we put out a deposition gauge to monitor the resuspension at ground level, and we integrate the deposition on that gauge since the accident, we find that there is now more deposition from resuspended material than there was direct deposition during the passage of the cloud over Britain. That does not mean that there is a continuing release of material from Chernobyl; it is the material on the ground which is being resuspended and deposited very locally, so it is hard to make a definite statement about the resuspension problem. It will be important for some purposes but probably not as a contributor to inhalation dose.

Dr. Valkovic gave details of the intercomparison exercises with radiocaesium and radiostrontium, but he did not mention any intercomparison for plutonium. I think we all know that measuring plutonium is much more difficult than measuring the other two isotopes. I am also aware that this has been the subject of considerable controversy in the USSR, and that there are groups of people who maintain that the official figures are considerably lower than the true values. So I wonder if Dr. Valkovic could tell us what the task force did about this. One final question: what is the scale that these 'hot

spots' represent? Are they areas of 1, 5, 10 or 50 metres diameter?

V. Valkovic (IAEA): We have very little data on plutonium determination from the USSR laboratories and from the laboratories in the network, so we have made no statistical evaluation such as we did for other radionuclides.

A.K. Gus'kova (USSR): I consider that the most important and direct data on strontium and plutonium come from persons who died from various causes — for the determination of radionuclides in organs and tissue. Our BSSR colleagues have these data, and made them available to us in the form of analytical information on the situation. These data show that the levels of intake are negligibly low and do not contribute substantially at present to the total dose. But the data in the Technical Report indicate that the specific contribution of these long lived nuclides will increase with time. However, the dose and the total activity decrease, and thus the addition to the dose also remains negligibly small. All this argues in favour of continuing the studies on strontium and plutonium and stresses the need for a more sober and critical assessment of their real hazards, especially in discussing the matter of resettlement, which is so calamitous and distressing for the people concerned.

P.V. Ramzaev (USSR): I fully agree with Professor Gus'kova insofar as ordinary living conditions are concerned. But there is one other thing that we encounter — contamination of the aerial environment as a result of farming activities. Until recently our Institute [*Institute of Radiation Hygiene, Leningrad*], too, was very optimistic about the safety of the aerial environment with regard to the intake of strontium, caesium and plutonium. However, our latest calculations (subject to verification under field conditions) show that in the case of workers constantly inhaling highly contaminated air in ploughed fields, where a considerable amount of dust is raised by the wind, the plutonium in the air — though not of a hazardous level — can be significant in comparison with the level of other radiation components, including even ^{137}Cs, in terms of both external exposure and intake through food. So, according to the preliminary calculations, this plutonium dose to these workers can be fully comparable with the caesium dose. That is why I endorse the International Advisory Committee's view that the problem of resuspension and analysis of the actual intake deserves attention and further study. This point has not been properly verified on people. The matter is now under study at our Institute.

F. Steinhäusler: With regard to the resuspension issue and size distribution, we have carried out cascade impactor measurements, and, I stress again, however limited they were, we did not find any particles below the 3.5 μm range for ^{137}Cs.

We could detect alpha activity, but the levels were extremely low, less than 0.5 mBq/m^3. This led to us to the recommendation that a collaborative programme of air sampling and analysis should be established between the USSR laboratories and the network of international laboratories set up by the IAEA in order to obtain more definite information on the relevance of resuspension and inhalation pathways.

A 'hot spot' is reportedly defined as an area up to 30 m^2 in size which differs in gamma dose rate by more than a factor of 3 from the established mean value for a given settlement. The Soviet authorities have published tables for many settlements which list the statistically characteristic parameters for gamma dose rate, ^{137}Cs and strontium, such as mean, medium, minimum, maximum and number of measurements.

Finally, about the validity of the official plutonium data, I would like to refer to the figure on page 15 in the Overview, which shows that, however limited our plutonium independent assessment is, it does corroborate the official plutonium assessment, so there is very little room for the official plutonium data to be too far off the 'true' value.

N.O. Loshchilov (UkrSSR): I wish to make a few comments to supplement Professor Ramzaev's statement and also on the problem of 'hot spots'. We divide the fallout on the contaminated area into a gaseous component and a fuel component. The fuel component consists of hot fuel particles which mainly contain strontium and plutonium and which with time leach out and go into the soil solution. After leaching out, the strontium becomes accessible to plants. It is fuel particles a few micrometres or less than 1 μm in size which may enter the lungs and, what is worse, are not eliminated. They are, to some extent, dangerous in that they are inhaled during agricultural activities. We carried out experiments during ploughing for almost two months in the BSSR at places where the contamination density was 50 Ci/km^2 (1.85 MBq/m^2). The particles were detected even in sealed cabins, and the specific activity of the air was, and sometimes exceeded, 10^{-13} Ci/m^3 (3.7×10^{-3} Bq/m^3), i.e. above the maximum permissible concentrations. Since nobody is subjected to such a concentration for his whole life or for a whole year, the annual limit of intake for plutonium is not exceeded. Nevertheless, with resuspension into the air, under certain conditions, very high concentrations of alpha-active particles in the air are quite possible.

S. Finzi (CEC): Within the framework of the International Research Centre of Chernobyl (CHECIR), one particular project is now dealing with resuspension, the importance of which has been stressed in this discussion. A certain number of Soviet laboratories will participate in the project and I have here a list consisting of the UkrSSR Institute of Agricultural Radiology, the Emer-

gency Group of the State Committee for Hydrometeorology and the All-Union Institute of Technical Physics and Automation. A certain number of European or CEC laboratories will participate, in particular GSF in Munich, the United Kingdom Atomic Energy Authority, CIEMAT in Spain, and the CEA at Fontenay-aux-Roses.

A.J. González (IAEA): I feel, after hearing so much about resuspension, strontium, plutonium, etc., that we may be in danger of missing the relevant point of the discussion. We are not interested in the environmental contamination per se; this could be very interesting for a research study, for example at the Chernobyl Centre, etc., but the subject of our direct concern is rather the dose to people and the effects of this dose on those people. The main factor governing radiation dose now is contamination by caesium. It is not contamination by strontium; it is not resuspension; it is certainly not 'hot particles'. Perhaps, therefore, we ought to emphasize the fact that we were able to corroborate the more important component of the dose to people, which is the component due to caesium contamination, and that all this discussion we have had on strontium contamination, hot particles, etc., is very helpful for further environmental research but has little influence on the dose people receive.

P.V. Ramzaev: I should like to reply to Dr. González. I was speaking from the standpoint of dose. I do not mean collective dose, which will be small, but individual dose to a very limited number of people, namely tractor operators. Because of this plutonium contamination, their effective dose equivalent can be exactly the same as that due to caesium. In other words, it too does not pose any radiation hazard, a deadly hazard so to say. We are merely emphasizing that this is a fact and ought not to be ignored. What we need to know is dose and not simply concentration.

V.F. Demin (USSR): I would like to comment on plutonium in air. I am responsible for the research carried out in the shelter in Unit 4 at Chernobyl. We are at present drilling into the core and, during this drilling, plutonium sometimes appears in air. I would say that only inside the shelter, in this kind of work, has plutonium in air reached any significant levels, and that is why I am always very sceptical about any data about plutonium in air "somewhere in Minsk", and so on. I think that sometimes people are mixing two issues, the plutonium itself and the alpha-emitters. The content of radon and its daughters, four or five orders of magnitude, even inside the shelter is due to the alpha-emitters more that to plutonium, so I guess that when people speak of alpha-emitters they do not mean plutonium at all.

A. Bauman (Yugoslavia): I believe that our Institute of Medical Research in Zagreb happens to be the only Institute that has been determining ^{90}Sr in human bones since 1964. I have here data of femur and vertebrae for people of various ages, who have died unnatural deaths, not from disease. We started the work in 1986 after Chernobyl and waited until the end of that year to see if there was any difference in the level of ^{90}Sr in human bones. After eight months eating post-Chernobyl food there was no difference, but by the end of 1987 we found large differences in some cases. I can mention only a few cases now, but if anyone is interested we can talk later. For instance, for a group of children ranging from newborn to 10 years old, for 1985 the level of ^{90}Sr in femur was 43 mBq per gram of calcium. In December 1987, it was 110 mBq/g. For vertebrae in 1985 it was 31 mBq and in 1987 it was 64. For the age group of 10–20 years, for 1985 it was 40 mBq/g. In femur for 1987 it was 84 mBq/g. For the range of 20–30 years, for vertebrae it was 40 mBq/g. In 1987 it was 75 mBq/g. The same applies to the age group 30–40. It decreases slowly with age, and for the age group over 50 it remained the same as for the last 10 years.

P. Pellerin (France): I know that in the entire world there are not ten laboratories able to measure plutonium correctly under 1 Bq/kg.

C.R. Huyskens (IRPA): Dr. Steinhäusler, in your overall conclusions you stated that you are confident about the general outcome of the methodology and the quality of the Soviet measurements as compared with those of the international experts. Did you in your discussions with your Soviet colleagues go back in history for the last four or five years in order to get an idea of how much their methods of measurement might have changed in recent years? Is your conclusion on the general quality of the measurements also a retrospective conclusion?

F. Steinhäusler: Our conclusion refers to our visit in 1990, to the data collected in 1990 and the assessment of methodology and equipment as published and officially adopted by 1990. We were unable to re-examine or corroborate historical samples, such as from the very early part of the post-accident phase. So I have to say that our conclusions represent a snapshot of the situation as it presented itself in 1990, including the methodology adopted in 1989 or 1988, but does not include an assessment of historical samples.

Rapporteur's Report of Session 2
(B.W. Wachholz)

I am not sure whether this is the easiest or the most difficult part of the programme today but I am sure that some of you may notice things that I have omitted and others may take issue with the comments I have included. First, allow me to make a few general comments.

It has not been said today, and I think it should be stated, that this was an unprecedented accidental release of radionuclides. It called for policies and decisions that had not been addressed before by other countries or by the international community in an operational sense. The response was an enormous effort involving very many people under what must have been tremendous scientific, economic, political and social pressures. After decisions have been made in such an environment, it is easy to suggest what should have been done differently or what should have been added to what was done. Perhaps those who made these decisions have also had second thoughts by now and if they were to do it again they would do things a little differently. We don't know. However, I think it commendable that the Government of the USSR, having gone through that experience, invited the international community to look over their shoulder to evaluate, to review and to criticize their decisions and actions, to conclude whether such decisions and actions were reasonable and appropriate, and to recommend further courses of action. That in itself is almost unprecedented following an accident of this nature.

The first review presented this afternoon concerned releases resulting in large areas of land contamination, not as a planned release, not under ideal wind conditions with the wind blowing in a single direction, not in terms of setting up and preparing monitoring stations in advance, but exactly the opposite: winds blowing in different directions at different times, resulting in heterogeneous depositions over the several political entities involved. This must have made it extremely difficult to carry out appropriate and comprehensive monitoring activities.

We have heard this afternoon that the objective of the Task Group was to review the environmental monitoring data and the method of assessing environmental contamination. This was done by reviewing the theoretical assumptions and methodologies, by reviewing the databases, experimental procedures, sampling techniques, analytical procedures and instrumentation, and by carrying out an intercomparison exercise. The Task Group also carried out its own independent assessment, involving a large variety of environmental samples: soil, undisturbed soil cores, agricultural areas, playgrounds, air, indoor radon, indoor gamma dose rates, gamma dose profiles along roads, 'hot particles', biomonitors, water of various types, foodstuffs, and so on. This was done within certain constraints that were imposed by reality: a single point in time, a limited number of sites, and a limited number of people. The best that could be done was to try to verify and corroborate what had already been done. The results you have seen and heard: that in general there is very good corroboration, particularly with respect to caesium, with perhaps a less positive correlation for strontium and plutonium. There is a small question mark, primarily due to the limited number of grab samples the team was able to obtain, that water and commercial foods are below the recommended radionuclide contamination values. Moreover, there may be exceptions to this generalization at a local level for homegrown foods and for wild foods. With these general conclusions one could stop and say that corroboration was good, and that could be the end of the evaluation. But the Task Group went beyond these general conclusions and identified areas and subjects that either should be further addressed or should be a subject for research.

Several of these topics have been talked about in the open discussion just ended. This discussion dealt mainly with two areas, air sampling data and monitoring of plutonium and strontium. As I understand it, these air monitoring data were not available to the Task Group at the time it was doing its surveys, but it is interesting and reassuring to see that such data exist and that they are being shared. We heard about air sampling in Pripyat, air sampling in Chernobyl, air sampling following a forest fire, and air sampling in fields ploughed by tractors. One of the several comments made was that airborne 'hot particles' are not a significant risk for the public, and that is probably true. On the other hand, it might be a significant risk for certain selected segments of the public, perhaps critical populations, perhaps the farmers, nor have I heard anything about children playing in areas where there may be contamination and resuspension. I think all this tells us that it is perhaps justifiable to carry out additional studies to determine the degree of hazard resulting from resuspension, whether of plutonium or of beta-emitting particles, because the impression I get is that right now we really do not know. Therefore, consideration should be given to the question of whether 'hot spots' are a hazard and to what extent they are a risk with regard to skin contamination, inhalation and ingestion, including perhaps something as remote as particles being lodged in farmers' eyes. Unfortunately, when the Task Group was making its own measurements in the field, the weather was not cooperative, so these points could not be verified. On the

issue of strontium, we also heard that there is migration down the river, or the potential for migration. Strontium migration may be an area for future study.

One or two other areas are perhaps conspicuous by their absence from the discussion, although I think they were briefly touched on in the presentations. For instance, the area of uncertainty has been mentioned but has not been elaborated upon. Related to that is the question of quality assurance procedures in terms of verification of particular numbers that have been presented. It is certainly desirable, no matter where in the world a laboratory is located, to be able to have confidence in whatever number one receives in the results. While air monitoring with respect to plutonium was mentioned, one area that was conspicuously absent from the discussions is the subject of air monitoring for the radioactive iodines at times soon after the initial accident. It would be very desirable to know what if any data exist in terms of iodine concentrations in air. As we shall hear in the next day or two, and as you know better than I do, the issue of thyroid disease, especially thyroid cancer, is a very prominent one; consequently, the absence of any data or of any reference to data on iodine in air is particularly important. Similarly, there may be other important radionuclides with short half-lives that were released at the time of the accident and which are also no longer available for monitoring. This would seem to be something that needs to be addressed, if for no other reason than to put it to rest.

Finally, I think we all realize that the public health aspects of the tragedy rightfully deserve priority, but that programmes to assess the consequences of the accident, both environmental and human, deserve very careful attention in planning and implementation, so that, as was said earlier today, benefit can be derived both by the affected Republics and by the world at large.

Session 3

RADIATION EXPOSURE OF THE POPULATION

Objectives and approach
L. Anspaugh (USA)

The USSR dose assessment methodologies
L. Anspaugh (USA)
A. Bouville (USA)

IAEA independent dose measurements
A. Bouville (USA)

Independent dose assessment and comparisons with reported values
B.G. Bennett (UNSCEAR)

Conclusions
B.G. Bennett (UNSCEAR)

Rapporteur's Report of Session 3
B.W. Wachholz (USA)

DISCUSSION

E.P. Petryaev (BSSR): I share the concern expressed yesterday and today about the transfer of 'hot particles' in the air and their possible intake into the lungs. For a number of years we have been studying the dispersion of hot particles on the soil surface and in the atmosphere and the content of hot particles in the lungs. I should like to present this material. [*The speaker showed a number of slides, which are not reproduced here.*]

A soil radiograph taken 40 km from Pripyat shows a spot which clearly indicates hot beta particles. A microphotograph shows the isotopic composition of the various particles. Most of them are particles enriched by cerium and plutonium, and there are particles which are made up almost entirely of ^{106}Ru. There are particles (and this is characteristic for particles from the Mogilev province) enriched with caesium. The content of these particles on the surface varies, but attains very high levels, particularly for the near zone where we observed up to 10 particles per cm^2. They are generally found on the surface or in the first 1-cm layer of soil. Naturally, agricultural work and lifting by the wind may lead to intake of these particles into the lungs. So far we have studied autopsy material from the lungs from about 300 people whose deaths were due to various causes. Samples of lung were also obtained after operations. A definite relationship between the content of particles and the concentration of radioactive substances on the surface was found. For the near zone (zone of about 60 km, i.e. the Mogilev province), hot particles were found in the lungs in about 70% of the 300 samples. In a typical radiogram of a sample weighing about 10 grams, the spots indicate what was found directly in the lungs. Therefore, when we are discussing external and internal doses and when we are examining the effect of radioactivity on the organism, it seems that, despite the arbitrary nature of the dose which may be received by the lungs as a result of such heterogeneous distribution of radioactivity in the lungs, this question has to be taken into account and I think that this process may be extremely important. Here I agree with Professor Ramzaev who spoke about this yesterday.

L.R. Anspaugh (USA): After several trips to the USSR, I am absolutely convinced that 'hot particles' do exist. I have certainly seen many radiographs in several of the laboratories I visited.

The really important question is: What do they mean in terms of dose and health effects? Up to now, although I have seen very interesting data on the fact that hot particles are in the soil, on the plants and in some cases in the lungs, the next important questions are: How many of them are there and how much activity is actually in the lung? So if it is possible to convert such data into activity, we would certainly be happy to examine them and revise some of our calculations.

At the present time, unfortunately, we must base our calculations upon models of resuspension which do apply to particles that have been measured throughout the world. Our conclusion in terms of dosimetry is that the hot particles themselves, although they certainly exist, are not a major contributor to the total dose. So we believe that the major component of the dose comes from the external exposure from material deposited on the ground and from caesium that is ingested. Everything else, including the strontium and whatever comes into the body via hot particles, is much less significant. We certainly have not seen any data from our Soviet colleagues that would indicate otherwise. If there are such data we would like to see them, and we do hope there will be some additional special experiments on resuspension so that we can further evaluate this process.

A.J. González (IAEA): Dr. Anspaugh has already addressed this recurrent problem of the radiological significance of 'hot particles'. I have myself addressed the problem in the Academy of Sciences of the BSSR, following an invitation from Dr. Stepanenko when we visited the BSSR. At the risk of repetition, I should say that there is a very clear recommendation from the International Commission on Radiological Protection which basically indicates that a given activity incorporated into a tissue as hot particles carries less risk of cancer induction than the same activity uniformly distributed in such tissue. This is so for very simple reasons: the potential for generation of stochastic effects depends on the number of cells which are target cells. If the activity is uniformly distributed, the number of target cells will be higher, and therefore the risk will also be higher. The photographs showing tissues with necrosis due to hot particles presented here are very impressive but have little relevance to radiation protection. What these photographs indicate is that there are hot particles in the tissues and that necrosis has eventually occurred around them, but the number of cells at risk of becoming cancer cells is lower than if the activity were uniformly distributed, just because the activity is concentrated in a hot particle. I should also like to recall Dr. Anspaugh's own comment that the full contribution of resuspension seems to be very minor. If this small contribution is in the form of hot particles it is even better. The overall risk of carcinogenesis will be lower.

P.V. Ramzaev (USSR): I would like to make some short remarks on the large volume of work carried out by our esteemed scientific colleagues under the auspices of the International Advisory Committee. I think everyone will agree that a tremendous amount of important work has been done. I would like to make three comments.

First, no explanation is given here for the discovery made by the Committee and scientists of the discrepancy between the ^{137}Cs intake and the accumulation which has been postulated very frequently in scientific literature in the last few years. We were faced with this problem 30 years ago in regions of the far north where 30 000 shepherds and reindeer breeders had at that time the same quantity of ^{137}Cs in their bodies as the inhabitants of the Chernobyl region now. There the whole body dose was up to 5 μCi (1.9×10^5 Bq). And we saw there that if one took the intakes based on what they said in terms of what and how much they ate, and if one took the amount of caesium which would be ingested in that case and compared it with the quantity actually found in their bodies, there was a discrepancy of a factor of 2 to 3, and sometimes 5. But it turned out to be a simple matter: if, together with the intake, one took into account the caesium elimination pathway and saw how much was expelled from the organism, one would see that the amount of caesium actually excreted under normal conditions by no means corresponded to the intake.

In evaluating the intakes, we do not make corrections for cooking or for inaccuracies in estimating intake, and in the long run these inaccuracies accumulate and become significant. There have been conjectures that the caesium is absorbed less in these regions than elsewhere, and even the supposition that only a fifth is absorbed. But it turned out that this was not the case. If you take the ratio of ^{137}Cs excreted in urine and faeces, you will see that in fact at least 80% of the caesium is expelled with urine. Moreover, for the accumulation one took the longest period for excretion from the organism. In people leading active lives it is shorter; the caesium is expelled quicker. This brings me to the second conclusion regarding the discrepancy between intake and accumulation of caesium in the body.

My second remark is that everywhere in the Report the half-time of ^{137}Cs in the environment is given as 14 or 7 years. The actual process of the removal of caesium from the first stage (this is evident from milk and meat) has been taking one to two years for the last five years, and not fourteen or seven years. We realize that in future this excretion will slow down, but this correction should have been made in the dose calculations.

Finally, the reiterated statement in the reports and papers that data were not provided seems very strange. There is a whole series of allusions to the fact that data on iodine were not provided. I suggest that the Committee should correct this misrepresentation. Either data do not exist, or they were classified as secret, or you did not ask for them. I can tell you (I represent here the RSFSR and our Institute was responsible for these matters on the regions in the RSFSR) that we were not asked for the information which you say was not presented. In particular, none of us was asked for data on iodine. They in fact exist. I want to clarify this so that the impression is not given to those present and to the world at large that the USSR did not present something that should have been presented. At least this was not the case in the RSFSR.

L.R. Anspaugh: Dr. Ramzaev, I can make some comments on your three separate points. It is unfortunately true that the lack of correlation between the model predictions and the observed concentrations of caesium was observed throughout Western Europe, following the Chernobyl accident. I think there are several reasons for this. One, as you suggested, is that people do not really eat what we think they do; we have perhaps not taken adequate account of the loss of caesium from food when it is processed, and I think the more important consideration in this case of our own comparison was that this was a comparison, a prediction, based upon the food uptake in the region, without consideration of the food restrictions. So I think the most important aspect is that food restrictions were in fact working quite well.

Your second point was on the environmental half-time of caesium. The 14 year half-time is contained in the official Soviet methodology. Material was presented to us, or was contained in the Soviet methodology, indicating that the real value was something more like 7.5 years, and many Soviet scientists have in fact altered the official methodology to provide what they think is a more realistic estimate, based upon this shorter half-time. The estimates from the independent project are really based upon a more complex consideration which was derived from the global fallout results.

Your final point, on the thyroid iodine data, raises a very complex issue. While we were making our several visits to the USSR, it was a difficult time in the sense that we had neither a common language nor a common culture. It was thus difficult for us to ask properly, at the proper time, for all the data that would be necessary. We certainly did not mean to imply that any data were deliberately kept from us, but only that we did not have the basic measurements that went into the thyroid calculations in the sense of the very raw data of the thyroid measurements. There were hundreds of thousands of them, so we were only adding a very cautionary note that said, since we did not have those direct measurements, we could not perform the calculations ourselves. However, we have reviewed that procedure very carefully, and many papers have been published on it. We have had extensive conversations with Soviet scientists about the methodology, and we certainly believe that it is scientifically sound. Our only comment was that, perhaps only because we did not ask for them directly enough at the time, we did not have the raw data on the actual exposure measurements of the thyroid itself that were made in the USSR.

L.A. Il'in (USSR): I also highly appreciate the tremendous amount of work done by leading international experts working in the field we are discussing here today. At the same time, I would like to make the following comments.

Let us look back and imagine the position of Soviet scientists who were responsible for problems of standardization and the establishment of intervention levels at the time of the accident. If you put yourselves in this position, then you will understand that we didn't have any alternatives and that we were bound to be conservative in the philosophy we adopted for the introduction of the various parameters in the calculations which we made. I wonder how we, and in particular our friends in the USSR, would have looked if the data which you have now presented had been the reverse of what they are. We were deliberately conservative and, as rightly stressed by the experts, we introduced the 90% quantile. I personally, for example, do not agree with the principles adopted by the ICRP when it examines the average individual dose in making similar types of calculations. We took as a basis the principle of the maximum protection of the critical population groups and excluded all possible underestimates in our calculations. Thus, if by taking into account the statements made by the esteemed expert group, you now look again at the data which they present on the lifetime dose, then the safety factor introduced by us into the calculation of the total exposure dose for the incorporation of radionuclides and the effect of external gamma radiation fields is at least a factor of two, or, according to our estimates, two to three for those levels which you saw now. If you introduce a correction for a factor of two they virtually coincide fully with those given by our foreign experts in their independent evaluation.

Secondly, it unfortunately so happened that, in the regions of Polesskoe, which were heavily contaminated, there were very high caesium transfer coefficients associated with the presence of a very large quantity of humus substances in the soils which have the ability to form a complex compound with caesium. In the 1960s, members of our Institute [*the Institute of Biophysics, Moscow*] studied caesium transfer coefficients resulting from global fallout in these very regions. We took the half-time of caesium in the soil to be 14 years, from a sense of prudence, although we assumed that in future this half-time was bound to decrease.

My second point is that, with regard to the data provided by Dr. Bouville on various evaluations of surface caesium concentration, particularly in the town of Bragin, one has to be able to admit one's mistakes. The data were obtained by other organizations by means of annual refinements. In our Institute, under our programme 'SDACHA', we combined all the data obtained from these regions and included them in the processing. Therefore, the density contrasts to which Dr. Bouville drew our attention are up to about five, but we gave our foreign colleagues the information (we used material from 1989) after we had received the final information from the official sources of the Meteorological Committee. Incidentally, we gave all the information which we

have in the Institute, including the information on problems of exposure of the thyroid gland.

Finally, I would like to take this opportunity to mention the problems met with in making retrospective evaluations of thyroid dose commitments. These problems are extremely complicated and it was impossible to solve them even during the first days after the accident. I remember that the measurements on our colleagues in the UkrSSR — former members of our Institute from Leningrad — were made by experts, and there were 100 000 or more of these measurements. But, in addition to this work, the local radiological and civil defence services involved were, unfortunately, largely incapable of carrying out such measurements. This was no fault of the scientists, but rather the fault of our system. Therefore, our Institute in particular has been working on reviewing the dose commitments, because when the work was being done in 1986 in Chernobyl we did not have data on the density of iodine fallout and we still do not have them. Nor do we have them yet for atmospheric iodine concentration. Therefore, the only thing to do is to establish an evaluation model retrospectively and to use adequate calculation methods. We are engaged on this at present.

I have just one small request, which comes, it is true, rather late, and concerns the fact that in the Report prepared by the Committee there is one discrepancy which I personally find very worrying. In the section on dose evaluation, it is stated that one of the problems was to evaluate the short lived radiation component in the first days of the accident. Dr. Bouville referred to this in his statement and he said that, according to your evaluations, the contribution of short lived radionuclides to the total annual exposure dose did not exceed 10%. This conclusion is important to us for the simple reason that a number of people in the USSR, including people who claim to be scientists, are attempting to undermine the reliability of our dose commitment evaluations by maintaining that we did not take these doses into account and that they are therefore a determining factor in possible future pathology. Of course I am not referring to doses to the thyroid gland. Therefore, in the answers to Dr. Bouville's questions, I would like it to be stated more clearly, particularly since scientific representatives of our Republics are also here today, what the opinion of the expert group is on the contribution to the annual exposure dose for 1986, as well as for 1986 to 1990, of short lived nuclides for intake by inhalation, for the dose from the cloud and for the dose from the surface to populations which resided during the initial period in the contaminated areas. I am naturally not asking you for a precise answer, but I would be very interested in what you would estimate the order of this contribution to be: is it 5%, 40% or 70%?

B.G. Bennett (UNSCEAR): I could answer the last question rather specifically. Measurement experience in many countries of Europe took account of these short lived emitters. From available data, UNSCEAR has estimated the total transfer factor to be 105 μSv per kBq/m^2 of caesium, with the dose due to the short lived emitters of 6 μSv per kBq/m^2 (15 units outdoors $\times$ the shielding/occupancy factor of 0.4), so that is approximately 6% of the total dose. This is in countries further away from the accident site. Near Chernobyl, I would expect the short lived emitters to be somewhat more important, but on the whole the external exposures from caesium become dominant in the longer term. The only other point Professor Il'in made that we could comment on is that we certainly recognize the overestimation the Soviet scientists intended to introduce in their doses, and this was substantiated by our results. It is common practice; it is something all scientists would do to make sure that they do not underestimate the doses. This is important in order to provide adequate radiological protection for the population. The problem in doing this, however, is that then you might take excessively stringent protective measures and your estimates of health effects would be exaggerated, so this must all be kept in perspective. You must estimate doses as realistically as possible in order to make the most reasonable judgements about relocation, evacuation and estimated health effects that might eventually occur as a result of these exposures.

L. Anspaugh: I think Professor Il'in is quite right in saying that if the order of the doses were reversed, the headlines would be very different from what they are now. And I would like to draw attention to page 26 of the Overview, where we recommend that probabilistic dose assessment models be developed, so that it would not be necessary to make only a conservative dose prediction. The most realistic estimates could then be made and it would be possible to look at the distribution of dose in terms of percentiles. It would also be possible to explicitly address the question of the uncertainty in the dose assessment.

K.I. Gordeev (USSR): During work on the management of the consequences of the Chernobyl accident, I participated directly in the work of the group of Soviet scientists concerned with the development of methodologies for calculating and evaluating internal and external exposure doses and with evaluating the effectiveness of the protection measures which were carried out to reduce the effect of radiation on the population living in the radioactively contaminated areas. I would first like to thank the esteemed foreign colleagues, and in particular Dr. Anspaugh, Dr. Bouville and Dr. Bennett, for the work they have done in examining in detail all aspects of our activities. Listening to their reports, I can now be satisfied that they fully understood our difficulties and our needs.

I would like to offer some clarification about the contribution made by short lived nuclides, gamma emitters,

in the formation of the external gamma radiation dose. In this case, we simply have direct experimental data. It is well known that at a distance of up to 50 km round the Chernobyl nuclear power plant, dosimeters set up before the accident were positioned everywhere. Thus, when the release from the fourth unit occurred, these dosimeters were in the field and the integral dose was recorded by each dosimeter, of which there were 50. When the release had ceased, these dosimeters were removed and the dose formed from the fallout products was calculated. Naturally, there is a difference between the integral dose registered by the dosimeter and the dose which was caused by the fallout products — it is that dose which formed the cloud and that dose which it is stated was not taken into account. I should point out that this dose at all distances from 5 to 50 km did not exceed 20% of the annual dose for the area.

With regard to the dose calculated for a longer period of time, naturally the contribution of this dose declines sharply. Moreover, it was introduced with a safety factor into the calculation methodology, and I should point out that our colleagues have somewhat underestimated the contribution of short lived nuclides. They simply attributed this to a certain overestimate on our part of the external radiation dose for the first four years with respect to the doses which were obtained by independent experts. This is because we took into account ^{131}I, ^{144}Ce and other nuclides which here I did not see as short lived gamma emitters. I should point out that the transfer coefficient from the fallout density to the gamma dose rate used by us was 0.18 to 0.26 whereas the experts took a coefficient of 0.1. This explains our slight overestimate of the short lived gamma radiation component and a certain underevaluation on the part of the experts. In general, of course, what we wanted was confirmed by the experts. It was impossible to predict and calculate the measures without having some kind of minimum safety margin. I think that the safety margin we selected indicates that we foresaw the development of events very accurately.

L. Anspaugh: I think that if we made this kind of comparison anywhere in the world the results would probably come out about the same. I also think that differences in calculations and parameters can easily lead to a difference of a factor of two or three, and we consider this to be good agreement, particularly in the light of your very deliberate cautionary moves to make sure that the doses were not underestimated. I think our bottom line conclusions must not be lost, and we should not spend too much time looking at the minor differences; we were certainly very satisfied with the overall results and thought the agreement was very good.

S.T. Belyaev (USSR): I have one semi-question, semi-suggestion. Your main results are presented as a dose assessment for the first four years. It would be very useful to have annual dose estimates, say for 1990, because this is the best understood quantity for the whole population; it is certainly the basic quantity for future projections.

T. Matsuzaki (Japan): The Overview says that doses were overestimated by a factor of two to three. Could you comment on the thyroid dose? Might there be a possibility of over- or underestimation?

A. Bouville (USA): This is a very difficult question to answer since Dr. Bennett and I do not have much information about the thyroid doses. We know they were calculated but we do not have the raw data. However, Dr. Bennett showed with his indirect estimation that we have the right order of magnitude. This estimation is very uncertain; I personally feel that we know the right order of magnitude of the thyroid doses, but it is very difficult for us to say whether they are under- or overestimated because of the high degree of uncertainty. That is a task for independent assessment.

Rapporteur's Report of Session 3
(B.W. Wachholz)

We have heard a great deal about dose reconstruction and dose assessment this morning. I should like to start by trying to put these results into some sort of context.

Yesterday we heard about environmental monitoring, corroboration of monitoring results, laboratory intercomparisons and sampling as well as some concern about future needs regarding 'hot particles', resuspension, migration, quality assurance and uncertainties. All this information will ultimately be a major database for exposure and dose estimates. Why do we want dose estimates? I can think of several reasons and I would like to mention two or three. First, in order to provide a basis for the IAEA's response to the request from the USSR, there is a need to determine the exposures and doses to persons residing in particular locations, with particular life-styles, under certain conditions, i.e. the controlled areas. It is also necessary to estimate anticipated exposures and doses to people who were to relocate elsewhere. This is probably the primary reason for attempting to undertake the assessment of exposure and dose

estimates. However, there are other reasons why one would wish to estimate exposure or dose. One is able to identify those individuals, subgroups or populations which might need or wish to be more closely monitored and followed for possible future health effects on the basis of their past or anticipated exposures. Finally, if there are to be reasonable, rigorous epidemiological studies in the future, there must be individual doses that can be calculated and assessed, perhaps even doses to specific organs such as the thyroid, bone marrow, and so on.

It is clear that since these reasons focus increasingly on the individual, there is an increasing commensurate need for individual, and therefore more difficult, dose estimates. The dose and consequent risk of living in a certain area can often be approximated by using average values and coefficients, but by the time we get to the other end of the spectrum with large scale epidemiological studies, every effort must be made to estimate individual doses. This point was emphasized yesterday by our distinguished Chairman in referring to the extensive efforts that have been made to address dosimetry studies in Japan. It is difficult to overestimate the importance of dosimetry and dose reconstruction.

Let us review briefly what we have heard this morning. (If anyone here is not familiar with the processes involved in dose reconstruction, I suggest reading the first three paragraphs of the Introduction to Part E of the Technical Report.) We heard this morning a review of dose methodologies carried out in the USSR, including both external and internal dosimetry. These dose reconstruction methodologies were based upon data obtained from both direct measurements (e.g. whole body counts for caesium and thyroid measurements from iodine) and indirect measurements (e.g. dosimeter readings, exposure rate measurements, ground deposition values of caesium and strontium). Some of these were not always as clear as one might wish, but there were obviously sufficient bases for reviewing and assessing them.

Specific dose assessments in seven settlements were carried out by the Task Group, whose methodologies were based upon both measurements and modelling, and included both external and internal exposures. The results of these independent assessments were compared with similar assessments made by Soviet scientists for the seven settlements. Considerable time was spent comparing the two assessments, and we have heard several times that there were factors of approximately two to three difference between them (i.e. the Task Group dose assessments were usually lower than the Soviet assessments by a factor of two to three). I would like to re-emphasize what Dr. Anspaugh mentioned earlier: considering all the uncertainties and all the parameters that must go into these calculations, I think the comparison is very close. I doubt that it would be much closer even if carried out under more desirable circumstances. I can say that in the USA we are engaged in retrospective thyroid dose calculations due to iodine resulting from the atmospheric nuclear weapons tests at the Nevada test site; we are going back nearly 40 years in some of these calculations, and it is not an easy thing to do. I think we can all appreciate the complexities and the difficulties that have been encountered, and I think it is reassuring that the two independent approaches should result generally in comparable findings.

The issue of 'hot particles' was raised again and there seem to be differing opinions about their relative importance. I think all this points to is the need for further studies to identify how prevalent such particles are, what they are made of, and whether or not they are biologically significant. The issue of caesium transfer in soil was touched on and responded to. The issue of data availability was raised, and I am sure that the Task Group would welcome any additional data that perhaps, being unfamiliar with the language and circumstances, they did not ask for in an appropriate manner and or at an appropriate time. I am sure that they would welcome any additional information that anyone can give them. The issue of short lived isotopes was raised and was addressed by various people, some more precisely than others. Finally, one or two questions were asked about ICRP methodologies and philosophies, but I don't think this is the time to go into that subject.

I shall close with one or two observations. First of all, with regard to the reasons I gave as to why one would do dosimetry in the first place, it is clear from the Report and discussions that there is a reasonable basis for estimates of average exposures and doses in terms of community locations and populations. It is also clear that the data currently available are not yet detailed enough to give the individual exposures that would ultimately be necessary for longer term epidemiological studies. The issue of uncertainty was raised again, with its companion, quality assurance, but I don't think we need discuss them any longer. Nevertheless, continued dose reconstruction efforts are anticipated, and reference has been made to studies commencing in July of this year as well as some forthcoming meetings, so I have no doubt that we shall be hearing more about dose reconstruction of exposed populations in the USSR.

Session 4

HEALTH IMPACT

Objectives and approach
F.A. Mettler (USA)

INDEPENDENT CLINICAL HEALTH STUDIES

General health situation
Cardiovascular disorders
H.D. Royal (USA)

Haematology
A. Kuramoto (Japan)

DISCUSSION

L.A. Buldakov (USSR): I would like to ask about the range in the ten year old age group. Does this mean exactly ten years, or is it 10–12 or 10–14 years? I would also like to ask about the range in other age groups.

F.A. Mettler: For practical purposes it is exactly two years, exactly five years, exactly ten years, exactly forty years. It is not a range; every one of those children and people was born in that year. In some cases we actually have it down to three months of that year (e.g. January, February, March of 1985), but they are not age ranges, they are specific slices in that year, and they are exactly that age.

Question from a Japanese participant: Did you also examine the mitotic connected anomalies quantitatively? This was a very useful examination, for example, for the victims of the Oak Ridge criticality accident many years after exposure.

F.A. Mettler: We did not examine that. You have to remember that, in many cases, we were hundreds of kilometres from an airport. You will also see later that we had some difficulties in doing cytogenetics because of the time it took to get to the laboratories where this analysis had to be done. For immune studies we restricted ourselves to fairly routine things that could be done in the field, and I think that helps us to understand Dr. Kuramoto's remark that there are very sophisticated immunological tests, but these require laser cell sorters and very competent people with superb access to supplies. These tests might be very interesting to do in the future, but we just could not do them on this trip. That is why we have to say that we cannot rule out subtle immunological abnormalities, but there are no huge abnormalities.

INDEPENDENT CLINICAL HEALTH STUDIES (cont.)

Thyroid
M.C. Sheppard (UK)

Cancer
K. Mabuchi (Japan)

DISCUSSION

A.K. Gus'kova (USSR): Are you acquainted with the Osechenskij and Ivanov data for the BSSR? This material has been published and it fully confirms your view that there was only an increased frequency of chronic lympholeukosis and a general but slight tendency for the disease rate to rise even before the accident. Our BSSR colleagues have these data and they could provide you with a copy.

F.A. Mettler (USA): Perhaps I should answer the question. Yes, we actually saw some data like that, but I think the conclusion of our expert epidemiologists was that the tumour registry system was not good enough for firm conclusions to be made. We did see a lot of data in the BSSR and UkrSSR and we looked at everything as a whole. On one hand, there is no evidence to suggest an increase; on the other hand, one might ask whether there could be an increase that was not detected by the system. We think that is possible. We don't know the answer.

A.J. González (IAEA): I presume that your health effect numbers from the Hiroshima and Nagasaki data correspond to doses which are about two orders of magnitude higher than the doses that the dosimetry group has given for the Chernobyl general population living in contaminated areas. To obtain the same statistical power, if the Chernobyl doses are two orders of magnitude lower than in Japan, the number of people in the sample would have to be four orders of magnitude higher, and obviously we do not have so many people in the contaminated areas. In addition, we have all the demographic problems that you have indicated relative to studying Chernobyl: problems with the registries, lack of data, old data, etc. Given these constraints, do you believe that there is really a chance of any late effects being detectable in the future by any epidemiological study? I am not suggesting that we should not undertake epidemiological studies, but it is convenient to put them into a realistic perspective.

K. Mabuchi: That is the point; I think we should. There are many problems, but none of them is insoluble. I think we can solve them.

F.A. Mettler: There may be subgroups of children where thyroid cancers are very easy to see, so the answer to Dr. González' question is, yes, it is possible to design studies where you can clearly see differences between control and specific exposed populations.

Session 5

HEALTH IMPACT (cont.)

INDEPENDENT CLINICAL HEALTH STUDIES (cont.)

Foetal and genetic anomalies
F. Mettler (USA)

DISCUSSION

J. Nauman (Poland): I am concerned about the conclusion you reached that there are no visible results of radiation in your study. I should like to ask, isn't it true that you have no real control group with which to compare your malformation rate? Isn't it true that genetic changes should be expected only ten, twenty or thirty years later, as you said, and isn't it true that your cytogenetic study showed that the background and the number are not sufficient for any conclusion to be made? I am a little concerned, therefore, about whether your conclusion that you do not see any effects of radiation is correct. You cannot arrive at any conclusions at all because of timing, numbers, etc.

F.A. Mettler: I agree. The data are not statistically powerful enough, for cytogenetics particularly. I said at the beginning that we were going to raise some questions and not solve them all. I think this is one of the areas where we were able to review only Soviet data and more work is needed. We are not prepared to say that this study is powerful enough to indicate that there was no difference relative to cytogenetic effects.

J. Nauman: If you did not find any changes related to the radiation, you cannot in fact make any conclusions at this moment.

F.A. Mettler: Are we talking about malformations now?

J. Nauman: I am talking about malformations, about genetic changes, and about the cytogenetic study. In fact, for malformations you had no control group from previous USSR studies from 1987 which would show any difference because, as you said, there are no data.

F.A. Mettler: For malformation rates in some areas there are previous data, and they are not significantly different.

J. Nauman: Yes, but you told us that intelligence quotient and the head size are most important and that you did not have data on them.

F.A. Mettler: That's right. I agree with you completely that intelligence quotient is interesting and that there are no background data.

J. Nauman: Do you agree that there is no reason to arrive at any conclusions concerning long term genetic changes on the basis of the time elements of this study?

F.A. Mettler: Absolutely.

J. Nauman: Thank you.

F.A. Mettler: I think you will know the answer to recessive genetic changes seven generations from now. A little later I will show you at least the future risk estimates that have been proposed by the ICRP on the basis of all the other studies.

T. Terasima (Japan): I have listened to Dr. Mettler's report with great interest, and I believe cytogenetic studies are extremely important in assessing radiation exposure. Scoring of chromosome aberrations depends entirely on age; it increases with age. The value is somehow affected by cytotoxic drugs and by medical radiographs, so in evaluating the chromosome data, the personal history of a medical X ray must be taken into account. As the scope of the present study is very limited, I hope that our Soviet colleagues will carry on with a similar line of cytogenetic studies. Although it is tedious, I think it would be rewarding.

A.J. González (IAEA): I feel that Dr. Nauman's intervention could leave us in a state of uncertainty on the genetic impact of the accident, and this is something with which I personally do not agree. It is not true to say that we cannot draw any conclusions about hereditary effects. We know a lot about genetic effects already. We know that in all the epidemiological studies we have done (with only one exception, which we can discuss separately) there is no statistical evidence of hereditary effects. We know that the hereditary effects we are looking for have a very low probability of occurrence and a tremendously high background rate. According to UNSCEAR figures, the probability of incurring a hereditary effect of any sort is nearly 1. Over that high

background we are looking for hereditary effects in areas where very low doses have been incurred (as our dosimetry group has confirmed) and where the expectation of the effects occurring and being detected is therefore very small. Thus, it is not surprising that the studies did not find anything. To decide that because of such a statistical constraint the conclusion of this study has zero value is an exaggeration. This is a confirmatory study; it is not an epidemiological study in itself.

Y. Nishiwaki (IRPA): Some of my colleagues in Japan are collecting samples of teeth from the dentists in Gomel and, by measuring the electron spin resonance (ESR)[1] of the enamel, they can measure the possible total radiation dose received by an individual. By this means it is possible to estimate the total dose received in the past. The Technical Report, however, only tells us the dose four years after the accident. One of my former students, who is involved in this study, remarked that if the total recorded dose is low, we do not know what proportion of the dose is due to medical or dental X rays and natural radiation and how much (if any) is due to Chernobyl fallout. If, of course, the total recorded dose is high, then the proportion due to causes other than Chernobyl fallout can be considered negligible.

[1] According to ESR dosimetry, most people received insignificant doses but there is still a small percentage of people with significant high doses. The reason is unknown, but it is assumed that some of the children who played at the 'hot spots' while unattended by parents might have received a higher dose. *(Added by Y.N.)*

INDEPENDENT CLINICAL HEALTH STUDIES (cont.)

Nutrition
R.M. Parr (IAEA)

DISCUSSION

Question from a participant: Dr. Parr, can you tell me how many of the 76 persons who participated in the iodine study were children, women, pregnant women and men? Obviously, the iodine intake is different for each of these categories.

R.M. Parr: The intake data were for adults only, and I think there was approximately an equal number of men and women.

From the same participant: I think the International Council for the Control of Iodine Deficiency Disorders, the European Thyroid Association and the European Community advise the iodine intake for children to be over 50 μg and for pregnant women to be over 200 μg. The recommended intake of 120 μg mentioned in your presentation is only an average. I was concerned about the iodine intake when Dr. Sheppard showed us the data yesterday. I asked him later whether the data came from men or women, because thyroid goitre occurs much more often in women than in men.

R.M. Parr: You are quite correct. The recommended requirements are different for men, women and children. To save time, I only presented the data for adults, but if follow-up studies are conducted, we would certainly recommend that they focus upon the population groups most at risk, which would include women and children.

F.A. Mettler (USA): We collected enough data to be analysed for probably the next five years. We intend to go back and look at certain things, for example dividing out the sexes, and particularly to look at thyroid volume versus thyroid stimulating hormone (TSH). I don't think anyone has ever done this kind of thing before.

We also said that there were nodules. We would like to know how many people have a single nodule, how many have multiple nodules, what is the average size, and so forth. We shall probably investigate this later, but we have not had time to do it yet.

Question from a (Russian-speaking) participant: Could you tell me why the experts did not check the vitamin balance? A lot of Soviet research in the contaminated area, and I am talking particularly about the first few years after the accident, revealed clear evidence of vitamin deficiencies owing to the limitations placed on the consumption of vegetables, fruit, etc. Have you any data on this important diet component, and why are you not studying it?

R.M. Parr: I think you have touched upon an important point. Certainly vitamins are of interest, but owing to lack of resources, we did not include the analysis of vitamins in our study. However, I should like to make the point that the anthropology data showed values fully consistent with expected growth rates for children and, therefore, just on the basis of these data, one would conclude that vitamin deficiencies, if present at all, are not seriously affecting growth and are therefore not seriously affecting health.

F.A. Mettler: There is also a little more information to be obtained from the haematology. I think you saw the red cell-size distribution curves: typically they tended to be on the low side, which, if anything, would suggest iron deficiencies. If there had been significant vitamin B_{12} deficiency there should have been *large* red cells instead of small ones. So again, from the haematology data, vitamin deficiency did not seem to be a major problem.

INDEPENDENT CLINICAL HEALTH STUDIES (cont.)

Psychological disorders
T.R. Lee (UK)

DISCUSSION

Question from a (Russian-speaking) participant: You said that evacuation and stress are causing a reduction of life expectancy by a factor of two in middle-aged people who had to be evacuated. Could you please repeat that and confirm that I have understood you correctly, since this is an extremely important problem, and could you tell us where this is stated and who proved it? Could you give a more concrete answer to this question? You said that life expectancy decreases by a factor of two in adults and middle-aged people when they are evacuated, or that they lose their joy in life. Can you state more clearly where these data can be consulted and who produced them, and confirm that I didn't misunderstand you?

T.R. Lee: Such a question is not answered simply. The consequences of relocation depend upon the length of time people have been expecting it, their preparedness, whether they go to favourable or unfavourable circumstances, whether the relocation is voluntary or involuntary, and so on. However, the sheer disruption can take its toll in the case of elderly people. These conclusions are drawn from a large body of literature which has recently been summarized in a review paper which, quite coincidentally, is referenced in the Technical Report under the name of Lee.

J. Nauman (Poland): Did you ever ask people living in the control settlements whether they believed they were living in a non-contaminated area? That might have an effect on the stress and so forth.

F.A. Mettler (USA): Yes, actually.

J. Nauman: How many responses were there?

F.A. Mettler: It was very interesting, because most of the control villages we went to had not, of course, been overrun by physicians before, so we were an unusual sight, and when we arrived some of the villagers began to be afraid that their village must in fact be contaminated, and that was why we had come to look at them. We said we thought the village was quite clean but that we would still like to look at the villagers. While we were making the physical examinations we asked the villagers whether they wanted to be relocated, and we found that 20% of the people in the control villages said they did. Our doctors were instructed to ask why. About 10% of the people said they wanted to move because it was obvious that their village was contaminated but that the authorities (whether from Moscow or the Republic) had not yet arrived to tell them. They knew it would take a long time to inform all the villages. About an equal number knew the village was quite clean but wanted to move because they were afraid of another accident, with the wind blowing their way next time.

S.T. Belyaev (USSR): If a group of people are not significantly contaminated but live in an area officially designated as contaminated, what, in your opinion, would be the psychological effect on those people?

T.R. Lee: My leader and I agree that we do not have a view on that because it is not part of our remit and it is a major political problem that can only be sorted out by our colleagues in the USSR. It will be discussed later today, I understand.

A. Eggleton (UK): I think we all know that financial compensation is being paid to some of the population in the more contaminated areas, and I would like to ask whether the psychological effect of this was studied by the Task Group and, if so, with what result?

T.R. Lee: No, I am sorry to say that was not studied, so we do not know the effect. I think that some of the major political and policy decisions affecting Chernobyl were made before the Task Group got to work.

F.A. Mettler: Let me just add that it was clear to us in some of the contaminated villages we visited that the amount of the financial compensation had been changing for some time and that the scheme itself seemed to be changing. But the arrangements may have been different in the different places we visited so I don't think it is an easy matter to get to the bottom of.

A.F. Tsyb (USSR): I would like to ask whether you have studied possible interrelations between psychological and medical factors and how the constant stress, which has lasted several years now, is affecting the state of health of the public.

T.R. Lee: We have not been able to study it. It ought to be studied in the future and the expectation is that prolonged stress and uncertainty of the kind experienced by the population could well have some longer term consequences. These, I suppose, would most likely take the form of gastric disorders, depression, alcoholism, and so on. But the future looks fairly bleak unless the problem is tackled decisively, so that people know whether they are going or staying.

Future risks
Conclusions
F.A. Mettler (USA)

Statement by A.K. Gus'kova,
Institute of Biophysics, Moscow

Statement by V.G. Bar'yakhtar,
Vice-President of the UkrSSR Academy of Sciences, Kiev

Statement by K.K. Dushutin,
Director of the Chernobyl Scientific Centre, Pripyat Scientific Production Unit, Chernobyl

Statement by E.F. Konoplya,
Director of the Institute of Radiobiology, BSSR Academy of Sciences, Minsk

Statement by the Chairman of the BSSR Committee
on the Consequences of the Chernobyl Accident

Statement by N.D. Tron'ko,
Director of the Kiev Institute of Endocrinology, Kiev

Rapporteur's Report of Sessions 4 and 5
K. Duncan (UK)

Statement by A.K. Gus'kova, Institute of Biophysics, Moscow

First of all I would like to point out that the research methodology used by the international experts was unusual and no research of this type has been carried out in the USSR. As a rule, our own colleagues have either investigated specific populated areas as a whole, or organized children's collectives, or else other specific groups of people from one professional group have been selected for study. Therefore no comparison of these data is possible. I agree entirely with Dr. Mettler that many of the inconsistent findings came from Soviet studies which were poorly organized from an epidemiological point of view. Where scientific standards were maintained, the information we obtained was similar to the International Project on the whole.

We can provide some additional information for certain groups of children. For instance, 2000 pregnant women were studied in the UkrSSR during 1986. The state of health of the mothers, main health indices, and even special tests on the newborn babies were all normal. It is interesting to note that pregnancy problems were particularly numerous in 1987 when migration processes were more intense, both in the mothers and, to a lesser extent, in the children, though all of the values lie within the boundaries of statistical significance. A lot of Soviet data confirms that there was a drop in the birth rate in 1987. I would point out that a similar process of demographic changes occurred, for example, in Japanese cities affected by the nuclear explosions, though there it was significantly more extended.

The birth rate in our study groups returned practically to its original level by 1988–1989. Psychometric tests were performed on certain children in a somewhat adapted form. In the BSSR, child development corresponded to the age related norms in the control group and no divergences were found. It is interesting to note, for example, as far as the establishment of rhythmic electrical activity in the cerebral cortex is concerned, not only was there no sign of retardation but rather two thirds of the children exhibited signs of accelerated formation of brain activity. I would also like to pass on a little information about reconstruction of doses using other methods. Each has its own limitations. Glycoprotein mutations can only be used for people with specific types of zygote and not for everyone. At high doses we are

obtaining satisfactory results using this method. We are working in collaboration with a laboratory in the United States of America. However, even with these people, we did, for example, for our most serious patient who received a high dose, get a very idiosyncratic ESR signal from the teeth. His signal could have led to an erroneous dose evaluation.

Chromosome aberrations in lymphocytes are, I think, only an effective evaluation tool when one is trying to locate people with extremely high doses, as was done by Dr. Mettler, or to label a group which differs significantly from the control group where there is some doubt concerning the radiation effects from which they may be suffering. There would not be much point, I think, in performing such tests on thousands of people at these dose levels. In our experience, elimination of aberrations over these periods of time, even where doses are high, is such that it would be very difficult to identify the dose received in 1986 with any confidence.

The psychological damage is clearly the most important factor, as Professor Lee has said. What is the best way of alleviating this? I do feel that it is very important to realize that this factor is due not so much to a conviction that danger exists or does not exist, but rather to an uncertainty, a lack of constructive plans for the future. Here, as a doctor, I feel that we must work on location with individuals and small groups and try to help them find a sensible perspective on the risks and a point to their lives for the immediate future, thus relieving the uncertainty. Mass measures aimed at thousands of people are of no use here. This problem must be solved in specific terms in each region, each Republic, each village, and with specific groups of people, if we wish to provide real help. Educational programmes should also be clearly differentiated. Our experience has shown that a high level of knowledge can, of course, be of help in finding a solution, but at the same time it is very difficult to correct instantly, so to speak, the internal pathology picture in this way. Many things have already been fixed, reinforced by the press and by political events.

The major faults in our work which the Technical Report reveals are indeed only to be expected. We have had little to do with statistics and have been but ill acquainted with this type of statistical indices; therefore, it was something of a surprise for many doctors to find out how many people had this or that illness. As far as I can see, we have not identified all the problems yet, even at this basic level. Therefore, these five years can only serve as a background indication, which must be matched to international diagnostic standards to provide us with a basis for further investigation.

With regard to methodological standards and age group specific controls, it must be said that our country is indeed very large and that even inside the country we may find that the indices vary a great deal from place to place. I once worked on a large programme comparing the state of health of reactor operators from the six Republics and, when we had selected our control groups, we found that the differences between the control groups from the six Republics were greater than the differences between irradiated personnel and the control groups. Therefore, the selection of an adequate, dynamic and unbiased control group is extremely important.

I feel sure we are going to need help with equipment. This is a big problem even for those collectives who are dealing with the highest risk group — the people who are already ill. I would like to take this opportunity of expressing our gratitude to our Japanese colleagues, in particular, who have helped provide my clinic with the equipment we need for people suffering from radiation sickness. This group is a very small one, and you will realize how great our problems are if we then begin to study potentially healthy people. It is even more difficult to study healthy people than sick people. For this we need more techniques, more equipment, more statistical apparatus. I therefore entirely agree that, though the health services must keep an eye on everyone, the scientists must draw their conclusions on the basis of selected groups of carefully chosen people who are at the greatest risk; the work should be goal oriented and it should be well organized along the same lines as the international experts' work.

In conclusion, I would request that the methodological experience which this group obtained during its work be summarized in a special monograph on the methods they used in order to find out as quickly as possible the fate of people who had been exposed to some specific factor. It is not so much the findings that are important as the methodology itself which was used to identify needs, the main reference sources, goal oriented selection, and representative sampling of an enormous group of people. It seems to me that it is worth summarizing this experience as it would be useful in any similar situation.

Once again, I would like to express my deep gratitude to our colleagues for all their comments and for the tactful way they made them. This is a great and important lesson for us. And of course — and this is the most important thing — we are happy to find out that the people we have been so worried about have not suffered any notable damage over these first five years, and that the doses are lower than we could have supposed.

Statement by V.G. Bar'yakhtar, Vice-President of the UkrSSR Academy of Sciences, Kiev

The statement I am about to make was prepared jointly by myself and the Head of the Medical Radiology Division of the UkrSSR Ministry of Health.

We are extremely grateful for the enormous amount of work that has been done and I feel sure we shall derive great benefit from it. Many points have been clarified, but I feel equally sure that a lot of serious problems remain. We must remember that the Technical Report, when it is published, will be an independent document and the conclusions in it must be very carefully thought through.

Everyone here knows that two large groups were selected for observation, and Dr. Mettler has already stressed that the health of cleanup staff and evacuees is also of great concern to us, particularly in the UkrSSR, of course; but our colleagues who took part in the mission are also not indifferent to this matter.

I would like to tell you about some data we have gathered in the UkrSSR on the 'cleanup staff', the people who during 1986–1987 did a lot of work in the immediate vicinity of the reactor. These data are the results of observations carried out by scientists in approximately 30 institutes of the UkrSSR Academy of Sciences and Ministry of Health.

There are 129 000 cleanup staff living in the UkrSSR. What problems do we have here? We only have precise data on received doses for 56 000 of these people, i.e. about half. These doses range from 100 mSv to 200 mSv. Special cases suffering from acute radiation sickness were excluded from the cleanup staff category; this group amounts to 187 people in the UkrSSR, and just over 1000 people who received radiation burns during the operation. In 1986, the people in this category were aged 25–40.

One conclusion which we can already draw is that we should of course have been drafting people aged 35–40 and older and not people aged 20–25. We can say this now and I can even explain why. These people are exhibiting a number of effects.

First of all, there is distinct impairment of the immune system. Groups of approximately 500 people were selected and subjected to special medical examination. This work was carried out by the Institute of Biochemistry of the UkrSSR Academy of Sciences, the Institute of Oncology and Radiology of the Academy of Sciences and the Scientific Research Institute of Otolaryngology, the Institute of Urology, the Khar'kov Medical Institute, and the Khar'kov Institute of Medical Radiology. Impairment of the immune system was found among approximately 80% of the cleanup staff examined. As I am by training a physicist and only started to investigate these problems from the radiological point of view in 1986, I shall not go into any further detail as regards the effect on killer and phagocytic cells since I am afraid of getting lost.

Secondly, the number of cases of thrombosis showed a clear tendency to rise. Here the trend is as follows: if on average we have 14 cases per 100 000 people in the UkrSSR, this figure has risen sharply between 1989 and the beginning of 1991. Up to 1989 we had only 13 or 14 cases among cleanup staff. As of 1991 we have 20, and to date there are about 10. Correspondingly, the death rate has risen.

Thirdly, and this is one of the main reasons why we now see clearly that young people should never have been used, sexual disturbances have been found among a third of the cleanup staff. As a matter of interest, according to the medical records approximately every third member of the cleanup staff has an illness of this kind.

There is definite impairment of the hearing function related to impairment of the adaptational and compensatory characteristics of this system and of the vestibulary system. This work was all carried out in the Kiev Ear, Nose and Throat Research Institute and the Kiev Scientific Research Institute of Urology. Approximately 500 people were examined and approximately 40% have this type of problem. Qualitative and quantitative changes in the blood have been found among cleanup staff — leucocytosis with a shift of the blood count to the left. Approximately 1100 people were examined and abnormalities were found in 24%. I could also talk about such simple matters as the fact that there has been a rise in all types of pathology, but that would be trivial.

I would now like to speak briefly about the state of health of the public. I shall be discussing some data on the more highly contaminated regions, i.e. the Polesskoe district. This area was mentioned in the Report but there they were only talking about the Polesskoe district proper, whereas my data for the Polesskoe district also includes the Narodichi district. People living in these districts, as we have already heard from the reports on contamination and doses, received doses of approximately 20–50 mSv. In individual villages — and this seems to have been fairly reliably proved — higher doses did occur, i.e. 120, 150 and in some cases even as high as 200 mSv. This is true of villages such as Yasen, Shevchenkovo, and Vilyuj. We can find the same trends here as among the cleanup staff, only of course less pronounced. Here I shall be referring to data produced by the All-Union Scientific Centre of Radiation Medicine and the Kiev Institute of Paediatrics. They examined children in these districts who were also suffering from impairment of the immune system, although the state of their immune systems does seem to be improving and returning to normal of late.

The Kiev Scientific Research Institute of Paediatrics, Midwifery and Gynaecology, together with the Dnepropetrovsk Medical Institute and the Vinnitsa Institute, carefully monitored the state of health of pregnant women. Significant changes were found as of 1989, some even in 1988. Cases of prenatal toxicosis increased by a factor of 1.5, cases of anaemia by a factor of approximately 1.5, uterine bleeding by a factor of 1.5 and in some villages by a factor of 3. Premature births increased in number by a factor of 1.5 to 3. I do understand that, when the International Advisory Committee was at work — and I had the honour of being one of its members — these data were still in an unprocessed and unchecked state since they are for 1990, but I would like the Committee to know about them.

I would now like to raise once again the question of children, and it is with regret that I must point out that we have definite evidence of chromosome aberrations in children. All this means, I think, that we should be a little more cautious about our conclusions. I refer in particular to the page of our final document where it is stated: "Current health effects (i.e. for 1991) — Reported adverse health affects attributed to radiation have not been substantiated either by those local studies which were adequately performed or by the studies under the Project." This statement seems to me to be too optimistic. I would like to see a more cautious formulation here since, in its present form, it is unacceptable.

I would once again like to express my thanks for the help the International Advisory Committee gave to the whole Union and in particular to the UkrSSR. I have no doubt that it is needed. I would like to ask you, Mr. Chairman, to request Dr. Rosen, as the representative of the IAEA, to put together a joint research programme for the next five years, particularly since, according to all the data, this will be the time when early serious consequences should begin to manifest themselves.

Statement by K.K. Dushutin, Director of the Chernobyl Scientific Centre, Pripyat Scientific Production Unit, Chernobyl

I would like to quote the Recommendation on page 35 of the Overview on potential delayed health effects, that concentration on prospective cohort studies of selected high risk populations should be endorsed. We have data from a comprehensive, clinical, medical and biological research programme on the state of health of 5000 cleanup staff who have been working in the 30 km zone around the Chernobyl plant since 1986 and are still doing so. We have found that the effect of the harmful factors in the 30 km zone is complex. Apart from the radiation effects, other biogenic factors, i.e. chemical, physiological and psychogenic, have a significant influence on the metabolism.

The most significant health changes have been found in the immune system. These usually set in significantly earlier than clinical disease symptoms, and therefore the research workers concerned feel that the universality of the autoimmune reaction provides us with a means of identifying people who are on the borders of health pathology, i.e. risk groups. The most sensitive point among the group of cleanup staff who were examined was the haemopoietic system. Ultrastructural and metabolic changes in the haemopoietic systems cause an impaired resistance and an increased risk of onco-haematological diseases. Biological research at a molecular level has revealed early effects of low doses of ionizing radiation. Here, the model which most fully reflects the state of the biological membranes in the metabolism as a whole is the surface cell membrane of erythrocytes. The various factors present in the 30 km zone round the Chernobyl plant induce changes in the microelement composition of organs, tissues, cells and their enzymes, increase the rate at which cobalt, copper and zinc are eliminated from the metabolism, and sharply reduce the content of the latter in key enzymatic systems. The stressing and overstressing of the adaptational mechanisms of the metabolism can increase the occurrence of psychic disturbances, illnesses of the nervous system, psychosomatic, neuroendocrine and autoimmune diseases which affect working capacity and life expectancy.

In our opinion, the data we have obtained show that in future the research workers should concentrate on three risk groups: children who have received high doses to the thyroid gland, evacuees from the town of Pripyat, and cleanup staff. If no changes are detected in the state of health of members of these risk groups the public can be reassured. However, the conclusions presented here today in the report of the International Chernobyl Project concerning the state of health of the public will not, we feel, allay fears since, unfortunately, the project did not evaluate the risk groups, not even children who have received doses to the thyroid gland, but rather evaluated the whole population in specific populated areas.

I would like to present some information concerning the Chernobyl Scientific Centre. The research which is being carried out in the Centre at present covers five areas: development and testing of new technologies for decontamination of materials, buildings, equipment and management of radioactive waste; radiation monitoring in the 30 km zone; study of the medical and biological consequences of the accident including the effects on cleanup staff; study of the radiological aspects and development of new technologies to enable contaminated territories to be used for agricultural production; and study of the general radioecological features of the Chernobyl accident. Acceptable working conditions have been established, and laboratory equipment and living conditions are also satisfactory. Five projects have been announced for Chernobyl and are being reviewed by the government organizations: two projects with the Republic of Korea, one project with Japan, one with Switzerland, and one with Finland. In addition, six projects have been prepared in collaboration with the Commission of the European Communities. The forthcoming research into the consequences of the accident, which is being planned as part of the International Project could, we feel, actively involve the Chernobyl Scientific Centre.

Statement by E.F. Konoplya, Director of the Institute of Radiobiology, BSSR Academy of Sciences, Minsk

The problem we are discussing today is a very complex one. It is of vital importance both at this present moment and for the future. In this context, I would like to say first of all that I agree with the position and proposals of Dr. Bar'yakhtar and of Dr. Dushutin, whose data are mainly on the cleanup staff. We have data on the BSSR population. I should add that we have a unique opportunity here to evaluate the influence of the accident on the health of the population, most particularly since we were performing systematic research in the Narovlya district even before the accident, using the programmes and methodologies of the World Health Organization, so this is a good opportunity to evaluate what happened in 1986. I agree with the comments made by Dr. Bar'yakhtar to the effect that discussions as to whether there is an increase in illness in the contaminated regions have become trivial and secondary for us. This is a stage we have already passed, and most people admit that there has been a rise. We have sufficient statistics in the Ministry of Health's data processing system and the Ministries of the three affected Republics; indeed, even the Deputy Health Minister of the USSR himself confirmed this in the Committee of the Supreme Soviet of the USSR in 1989.

At present we are discussing the mechanisms and causes of this increased rate of illness in contaminated regions. Generally speaking, I think we should certainly not rule out the radiation factor, and I would endorse the proposal made by Dr. Dushutin that we must assume that various harmful factors are having a complex effect on the metabolism, and an unexpected one. Since the data on the immune system and genetic factors in the Technical Report were not complete, I would like to report some research which should be of interest. *[The speaker showed a number of slides, which are not reproduced here.]* We have done some basic work on the endocrine system and I must say that the changes we have found in the endocrine, the immune and other systems occur in phases, and therefore the data which the experts produced and which indicated that there was no change in the T-4 content may be entirely valid; we also have not found any changes.

Changes in the immune system have been seen in an experiment which we started in 1986, and since this is a scientific conference I think it is acceptable to report an experiment on animals which have spent six months or a year in contaminated districts — i.e. in Cherikov and Slavgorod. When the animals had been in Cherikov for six months there was no evidence of changes in immunity in the blood, but there were already changes in the immunogenetic organs. After a year, we could already detect changes in the immunity indices in the blood. The same is true in Slavgorod.

And now for the population. We tried to divide the population into various groups according to the subsequent exposure dose prognosis: people living in areas where the predicted dose is 10 rem and 30 rem maximum. The control group was the Minsk district. The research was performed in the Krasnopol'sk district of the Mogilev region. We have not only already found changes in the immune system, but these changes have caused a reduction in the number of lymphocytes, and there are changes in complements and immunoglobulins, etc. However, we are detecting differences which are dependent on the predicted dose. With respect to the immune system I would draw three main conclusions: first, immunity against infection is reduced, and second, autoimmune processes increase. Here we are talking about the Minsk region (control group) and the Raulyatsk region. There is an increase in antigens in the functions of the thyroid gland and the liver, i.e. autoimmune processes increase. Third, there is a reduction in immunity against tumours, as we found last year in particular and the year before, and this is worrying. Here, the control group was Minsk, Krasnopol'e and Narovlya. Immunity against tumours is impaired. And now the genetic changes. The data come from an investigation carried out during 1986 and 1987. The research has been followed up in subsequent years. In all the populated areas where we carried out research the number of chromosome aberrations is on the increase, and specifically those types of changes which are characteristic of radiation induced effects. Alongside our study of chromosome aberrations, we evaluated the functioning of the genetic apparatus of the cell which synthesizes DNA and protein and we have quite a lot of material on this. What does this tell us? It tells us that at present there is already instability of genome, and currently we have the capacity to carry out monitoring in order to identify high risk groups. Our laboratory at the Institute has signed an agreement with the IAEA laboratory at Seibersdorf and we shall be carrying out joint research on evaluation of the immune system and monitoring.

Statement by the Chairman of the BSSR Committee on the Consequences of the Chernobyl Accident

It is very important to us that people who help to shape public opinion, particularly teachers, who spend most of their time with children, and general practitioners, believe in the International Advisory Committee's report and believe that it reflects the reality of the situation. However, certain statements in the Russian translation we have been given will undermine confidence in what we have been told today. What do I mean by this?

Disturbances in thyroid gland function — this question is at the top of the list for most of the people who have been affected in the BSSR — are concentrated in one area where such problems are endemic. In one town with 100 000 inhabitants, scientists from the Leningrad Paedological Institute who have set up an organization jointly with the Swedes examined 10 000 children aged 12–14. According to their data, 20–30% of these children have thyroid gland problems, and this is a high figure. They do not blame this on radiation effects. People from the 30 km zone were evacuated to this town in 1986. There are about 300 children there. Ninety per cent of the children in this category have thyroid gland problems. It is stated in the report that nodules in the thyroid gland were found only very rarely among children. I would like this excluded from the revised text.

And another thing, with regard to neoplasms. Fourteen cases of cancer of the thyroid gland have been officially registered in the Gomel region in 1990. I understand that many people realize that local doctors can make mistakes and can classify illnesses incorrectly, but this particular fact has been checked at the Scientific Research Institute in Minsk and confirmed by Moscow. Up until 1985 only one such case had been registered. And yet here we have a statement to the effect that there is only hearsay evidence of such tumours. This undermines confidence in the International Project and in the people who, I have no doubt, performed their work in good faith. I would therefore ask that these sections be amended in consultation with the Soviet delegation to take account of the information that we have, before they are released to the public and the press.

Statement by N.D. Tron'ko, Director of the Kiev Institute of Endocrinology, Kiev

Our Institute started to study the dynamics of thyroid gland function and structure on 12–15 May 1986, i.e. two weeks after the accident at the Chernobyl nuclear power plant, in children who had been hospitalized in the clinic at our Institute and who came from the 30 km zone and regions where very strict monitoring had been enforced. We found that thyroid hormone levels in children who had been exposed to the radiation were no different from the control group. There was an exception, and yesterday, in a report of one of the scientists, it was noted that during the first stage of the investigation increased thyroxine levels had been found in a small group of children. This situation normalized itself after 6–8 months.

Another problem which is causing us some concern, and the representatives from the BSSR have just been talking about this, is the problem of cancer of the thyroid gland. The clinic in our Institute is a specialized institution and most children suspected of having cancer of the thyroid gland are sent to it. For instance, in 1990, 20 cases were operated on for cancer of the thyroid gland. For the sake of comparison, in previous years — 1985, 1986, 1987, 1988 — one or two cases were operated on. All the cancer cases which were operated on were verified. These cases of thyroid gland cancer were classified carefully according to sex, age and dwelling place. Total dose levels to the thyroid gland from ^{131}I and other short lived radioisotopes, iodine radioisotopes, were produced by Professor Likhtarev from the All-Union Centre of Radiation Medicine in Kiev for both internal and external exposure. The material removed during the operations was subjected to a morpho-histological examination. Of course, the question presents itself: in theory, there should be no additional cases of cancer of the thyroid gland by this point. The experience of Hiroshima and Nagasaki has shown us that the latent period is ten years; on the Marshall Islands, the first case of cancer of the thyroid gland was detected eight years later, and according to certain data from the reference sources even that is rather soon. It is possible that this sudden outbreak of cancers of the thyroid gland is a result of the better medical care of children in comparison with the period before the accident.

I would like to look at this problem from another point of view, however. If we consider the insalubrious ecological situation, a possible combination of the action of iodine radionuclides and internal exposure, and the fact that many districts, including the Chernikov district, have endemic goitre, all these factors could reduce the latent period to some extent. This should definitely not be excluded. Since we have over 8000 children in the UkrSSR who have received high absorbed doses to the thyroid gland, I do not share the optimistic view that the first radiation induced thyroid gland cancers will appear only after ten years.

DISCUSSION

C. Dotres (Cuba): The William Soler Children's Hospital, Havana, has been treating 4265 children from two to eighteen years old in a programme of medical care of children from the areas affected by the Chernobyl accident. Several of our observations were similar to the results we heard yesterday afternoon and this morning.

The children fall into four main groups: 3% with oncohaematological conditions (70 of these had various kinds of leukemia, two of which required bone marrow transplantation); 17% requiring hospital admission; 60% needing only ambulatory care; and 20% with general health problems. From the radiation dosimetric point of view, the estimate of equivalent dose for external irradiation, measurement of ^{137}Cs activity, and determination of the equivalent effective dose integrated over 70 years of life, have shown that the children from Chernobyl treated in Cuba fall into the category of low dose cases. The biological indicators of radiation injuries employed in the radiobiological studies of the case did not show any significant influence of the factors present in the children. It was obvious that among the 4265 children treated in Cuba there were some whose condition was not related to exposure to ionizing radiation, while other children require a long term follow-up to assess the correlation between their clinical conditions and the results of the dosimetric and radiobiological studies.

J. Nauman (Poland): I think it would be safer if we added something to the very important statement that no health disorders could be attributed to radiation exposure. I would like to add something to the effect that disorders related to the stochastic effects of radiation should not be expected to be seen before 1995.

Comment from a Japanese participant: Dr. Mettler mentioned future studies. I should like to comment on the methodology of clinical and laboratory examinations. According to our experience in Hiroshima and Nagasaki, examination methodology has changed considerably during the last 30 years, so it may be important to record the conversion date when one technique is replaced by another. Hiroshima and Nagasaki reports revealed recently an increase in parathyroid hyperfunction, so may I suggest screening the serum calcium level to detect this in the future?

P.V. Ramzaev (USSR): I wish to bring two facts to your attention and thus add a little Republican "fat to the fire" of our discussions. I have health data from the RSFSR for these regions. Cases of cancer in contaminated districts started immediately in 1986 in the RSFSR. Before that point, the figure was negligible and yet in 1986 there was immediately a 15% rise in cancers, and the level has remained there. What does this tell us? Clearly there was an immediate effect. We immediately sent a lot of doctors there and started to check this. The second fact is an unpleasant one: the number of congenital malformations has risen by a factor of 5; 140 cases have been reported. We are now looking into this. However, I wouldn't go so far as to say that this is definitely caused by the radiation. Why? Because in one region, the Krasnogorsk region, which was the most contaminated, and in the Bryansk region, there were significantly less cases than in the Novozybkov district which is not contaminated. That is one point. Secondly, it turns out that the local health services in one district are very careful about recording every case and in another region they don't pay much attention to it. I make this point because it shows that we have to organize our research seriously and carefully. We have even had some cases of hypothyroid disease; this is increasing, but I would refrain from making any definitive comments on this yet. I therefore support the proposal put forward by the representatives of the UkrSSR and BSSR — and the Committee is also in agreement with this — that we should start serious and large scale work.

Comment from a participant: Many details have been put forward about the possibility of thyroid cancer, and this is certainly a very important subject. But let me, as a physician, remind you that cancer of the thyroid is certainly the most curable of cancers, and nobody has to die of it if it is properly treated. It is very important to develop follow-up treatment.

F.A. Mettler (USA): The Chairman has asked me to reply. I think we all agree that there are population groups (such as emergency accident workers and evacuated persons) which may have health effects that have not been covered by this International Project and which ought to be examined. That is clear. It is also clear, and I think we all agree, that we are not likely to have found stochastic effects at this time, and we need to look for them in the future. Much of the data just presented by our Soviet colleagues as slides were shown faster than I could assimilate them and, as I have not seen most of the data before, I cannot comment. Data that have been verified since the International Project was completed are 20 cases of thyroid cancer. These have been confirmed by the pathologists at my Institute, at my request. It is possible for the latent period for thyroid tumours to be 5–10 years; certainly there are some tumours following extremely high doses where you can drop the latent period back a bit. I don't think we know the answer about the thyroid cancer because the baseline data and detection methodology are not clear. It is also possible that techniques have changed from thyroid palpation to thyroid ultrasound and that detection methodologies are different. I am not sure I shall know the real answer for another five or ten years, but I agree that it is worth studying.

Rapporteur's Report of Sessions 4 and 5
(K. Duncan)

For two days we have considered various aspects of measurements, and several speakers felt it necessary to point out that dosimetry was not an art form in itself but has an important relationship to what happens in the human dimension. For the last two sessions we have been talking about the human dimension, and I think some of the tenseness of some of the recent discussion symbolizes that transition from what you might call pure objective science to something which has a very considerable subjective element in it. The public has from time to time an almost mystical belief in doctors. This varies in time and place but it puts an enormous burden on my profession. Some people are convinced that presenting a possibly damaged body to a physician is in itself a constructive act. This has moved on to a situation where some of us feel that the whole business of screening needs to be looked at much more intellectually and much more strictly scientifically, a point which was eloquently put by Dr. Gus'kova in her statement.

One extremely interesting suggestion, which Dr. Mettler has summed up three times so I do not need to do so again, was that the details of the very strict methodology employed ought to be carefully recorded. It was worth spending time yesterday to talk about such details as making sure that the glassware all came from one particular batch, that the reagent came from one particular batch, and so on, in very great detail. There is a very real danger of what you might call in other terms 'snatch samples' for epidemiology. It has to be very, very rigorous.

I think Dr. Mettler was right when he said yesterday that this has been an unprecedented review. I am not aware of anything on this scale that has ever been done before. He was also at great pains to point out that you had to have a marriage, if that is the right word, between biological propositions and statistics. It is no good just going fishing in a pond and seeing what fish come out; you must have a very systematic review. I do not intend to go through all the parts of the presentations — that would take too long — but I'll just highlight one or two points.

Dr. Royal pointed out, and it was mentioned again in the discussion afterwards, that there is a danger that if you look carefully enough you always find something, and if you look more carefully you find even more. That is a lesson which has to be related to the strictness of the design and execution of these studies. Dr. Kuramoto pointed out that one of the by-products of this type of study was that sometimes — often — it was possible to pick up individual problems and help individual cases. But, you know, although it is a rather unpopular topic, we ought to make it quite clear that there is a cost involved in all this. It is not good enough to say: "Yes, I did this huge study, and I found one man who had one leg shorter than the other." You have to be able to show that there is a real benefit from any studies undertaken.

We also heard about the Cuban findings, but, without more details about the population studied, and without studying the published findings, I cannot usefully comment. Then, in yesterday's discussion, Dr. González emphasized the importance of ensuring that any study undertaken is of sufficient statistical power, i.e. high enough doses and enough people. The importance of this was pointed out again when the Conclusions and Recommendations were discussed. I wonder if I would be stepping outside my present limited role if I make a plea for this to be foremost in people's minds when they are talking about epidemiology. One problem we have encountered in many countries is that small studies with no real prospect of success have been pursued. These, of course, produce ambiguous results but have been quoted all over the world, depending on how anyone wishes to interpret them.

At the opening of the Conference we heard about the World Health Organization's developments at Obninsk and it seems to me that these have a vitally important coordinating role. This calls for a lot of scientific humility. It is quite natural for a scientist to want to guard his or her own data and to want the fame of publishing in his or her name, but it is wrong if this leads to a lot of small, fragmented studies when a bit of planning, which I think is being offered, could lead to a really effective, large scale study. We do need it. I am quite sure that much of the doubt and ambiguity running through all the discussions of the last two days are related to this kind of scientific uncertainty.

Today we heard from Dr. Mettler about the difficulties of reporting and definition when talking in terms of abortions, malformations and all the various confounding factors. Dr. Parr then told us about the nutritional aspects, and about some of the non-radiation factors, the possibility of lead as a confounding factor, and so on. Then we came to Professor Lee's paper. One thing is certain, that this accident has had profound psychological consequences; that is beyond debate. But I think it would be wrong to treat that fact on its own, because the whole problem of radiological protection has profound psychological overtones. This is merely an extreme example of the phenomenon.

It is customary for doctors and scientists, when they are faced with the unpleasant publicity which this field often attracts, to turn round and savage the nearest media person, whoever it may be. It is not entirely fair to blame journalists, broadcasters and people of that sort

because they have been given a pseudo-authority by pseudo-scientists in very many cases; this was made quite clear in some of yesterday's discussion.

There is a great burden of responsibility on scientists to speak only in scientific terms. Not reputation, not fame, not money, but only honesty matters. As to the future, Dr. Gus'kova, in her statement, talked about the need for further education, and we have all been agreeing with her. Perhaps because of her medical background, which I share, I was much impressed by her emphasis of the fact that you can have great campaigns, you can have educational programmes, you can publish as much as you like, but in the last analysis it is one person talking to another and getting the trust of that other person. This places a heavy burden on the medical profession who, rightly or wrongly, is trusted to do that well. Therefore the first responsibility (who guards the guards?) is to make sure that the medical profession is trained well enough to take on that heavy task successfully. I have been struck by the humanity and scientific humility of the people making presentations here today and yesterday. There has been no attempt to overstate what this Project has achieved.

We have seen that ridiculous word 'radiophobia' consigned to the wastepaper basket, or whatever is used in a modern office, and we shall go on later to talk about costs and benefits, whichever is relevant. It seems to me, and I make no apology for repeating what several people have said, that there are three conclusions I would like to leave you with:

(1) The best must be done for those affected, whether in the mind or in the body. (It is far more difficult to evaluate what is the best than always to listen to the loudest voice. There are many things to consider in deciding what is best for the individual or the group.)
(2) There are lessons to be learned in order to ensure, not that no accident will ever happen again, but that we learn from our mistakes as we have done through the long years of history.
(3) The huge task of education and information goes ahead, nationally and internationally, dispassionately, without faction, without rancour and with as many facts as the scientists and the doctors can provide for its implementation.

Session 6

PROTECTIVE MEASURES

Objectives and approach
Evaluation of protective measures
P. Hedemann Jensen (Denmark)

EVALUATION OF RELOCATION

Comparison with international guidance
N. Kelly (CEC)

Cost-benefit analysis
J. Lochard (France)

Decision conferences
G.S. French (UK)

Summary
N. Kelly (CEC)

Conclusions
P. Hedemann Jensen

Rapporteur's Report of Session 6
K. Duncan (UK)

DISCUSSION

S.T. Belyaev (USSR): While Task Group 5 was working, a Committee in the USSR was formulating a new concept of living conditions for the people in these territories.[1] We are grateful for the influence of the Task Group on discussions which helped us to prepare this concept. It has now been accepted officially, but in some sense also rejected officially. I would like to describe the main features of this concept for safe living. Ideally, it is purely radiological protection policy and it is very simple if no other factor exists. But the Chernobyl situation, which we have been studying for four and a half years, is very different. First of all, there were inadequate decisions on countermeasures and incomplete information. All this produces a post-accident syndrome, with negative health effects. It all goes round, one factor influencing another. This was the situation. So what would be the approach to introducing this concept for living? First of all, how many people are we looking for? Then, let us say, the two levels we have been hearing about: 'no action' and relocation limit.

If we think about it, the number of people is very sensitive to this 'level', because a little push moves you from say 800 to 4 million and so the question suddenly arises: what population group are we dealing with? This is the first problem, how to choose this 'no action' level. We certainly need it, and we always tend to push this level lower and lower and include more and more people somehow connected with Chernobyl. That is the first problem. Now, how to proceed? First of all, when we introduced the countermeasures, we reduced the doses in each place and somehow pushed the line to this point. That is a good policy. Without any relocation, we just make the total dose lower and lower. Now we have quite a different position. We have not only dose, but we have sociopsychological effects of different kinds. These include the excitement, the stress, of people living in different territories. There is a spectrum of excitation,

[1] "Concept for habitability of the regions affected by the Chernobyl accident."

and experts here have already mentioned this stage of excitation or stress. It does not depend very much on dose.

Sometimes the people living in a certain area become excited at more or less the same degree and even higher. Now, what kind of countermeasures should we introduce? Of course, the ideal policy would be just to push for some settlement, or group of people living in these conditions, at a certain dose and with a certain excitement. This would be the ideal. How can we achieve it? Suppose we decide on relocation of population. Well, it may go from large dose to great excitement. It should be understood that it may be more dangerous to health to be in one place than in another. How do we start to undertake the kind of countermeasure suggested? First, we have already decided to take into account the annual programme of all relocation below 40 Ci/km^2 (1.5 MBq/m^2) and even below this.

Our first statement is that no more mandatory relocation is needed! Our first premises, the radiological, nonradiological, and sociopsychological factors and, of course, the negative health effects of relocation, are considered. The first and main principle is that no additional mandatory relocation is needed. We understand that some countermeasures, which somehow mean restriction of life-style, of agricultural production, and so on, produce some excitement (stress, anxiety), so some countermeasure should already be agreed. We have one very good countermeasure: just to improve agriculture. These are the main principles and criteria. First, we introduce a 'no action' level, which we take as 1 mSv per year (about 5 Ci/km^2 or 185 kBq/m^2). The total number of people living in this territory would be a little less than one million. Then we introduce, not the relocation level, but the control level, which I would like to explain. Suppose we eliminate some countermeasures and some restrictions; then perhaps there is less social anxiety but a little higher dose (but how far can we go in this direction?) and then we introduce this control level. Control level means that the dose should be not more than 5 mSv per year. That is the essence of this concept and it has been approved. The concept was a compromise with almost all of the scientific community and most government institutions, but it was approved by the Committee of the Supreme Soviet and was admitted as a basis for the law. In this law, the level of 5 mSv per year is now considered to be the level for mandatory relocation.

It is my own opinion of course, that if I myself am living in a certain place and do not want to move, then mandatory relocation is just a violation of human rights. That is my opinion.

L.A. Buldakov (USSR): Mankind has fallen into the trap which mankind itself had set. Experts know that, among the various harmful factors, the radiation factor is perhaps the least harmful. But this is not known to the public at large, who do not want to reconcile themselves to the fact that for 50 years they have been fed falsehoods. They hold on to their firm belief that any radiation which is slightly higher than the background is fatal. It is very difficult to make them change their minds. Therefore, when we developed the 'safe living concept' and concluded that such a level would be a lifetime dose of 350 mSv, it was not a random value. This value was based on world experience in radiology, which shows that, in the case of short term irradiation, doses below 1000 mSv produce no noticeable effects. We made a correction for the particular sensitivity of children, by a factor of about three, divided these figures and obtained the value of 350 mSv. From the standpoint of radiology and not from that of radiation protection alone, we understood that the effects could appear in the case of very long exposure over a lifetime and therefore decided on the new term 'lifetime dose' — 350 mSv. However, this value raised a storm in our country. We were accused of being inhuman simply because the concept that the action of radiation had no threshold had been ignored. Unfortunately, we had taken a step beyond what was customary with us, i.e. we had decided on some threshold (350 mSv), meaning that the risk was much smaller than the benefit. In our country human life and health are regarded as the most valued treasures, and nobody will let you calculate in terms of money when it is a question of human health. Thus, having accused us of inhumanity, all the other opponents of this concept began to lower the dose, and therefore Boris Yeltsin and Neale Kelly are both right in taking us to task for choosing too low a dose for decision making. But the situation was such that it was impossible to take a really meaningful dose, for example 1000 mSv. We are grateful to Task Group 5 for its criticism of those who adopted 350 mSv. However, it must be made clear that this value was adopted on the basis of radiobiological parameters, considering the possible risk, although we realize that it is negligibly small and cannot always be determined.

One other thing I should like to add. Here today there were references to the state of health — that there are actual data confirming that such levels of radiation did not affect the genetic or carcinogenic structures. At low radiation doses the mechanism of action is quite different; this was reported in Paris at Professor Duboire's conference. But it is very difficult for us to prove this, to prove what nobody wants to believe. If the Technical Report and the Overview had very clearly given such values or such conditions, I am sure it would have been a great help to our people.

V.F. Demin (USSR): I have some comments on that part of the report of Task Group 5 which deals with the analysis of the effectiveness of the countermeasures, and I speak as a person who was involved in the USSR in the preparation of similar and other scientific data used in

taking decisions on protective measures. It has already been pointed out here that not only the radiological but also the non-radiological risk factors must be taken into account. This point is very important. When we include other risk factors, the scope of optimum decision making becomes wider and the possibilities are greater but, at the same time, the task becomes more complex because of the multiplicity of factors and the need to prepare much more additional data. Task Group 5 has already referred to the paucity of their data. This reflected the actual state of affairs in the USSR at that time. It was not the case, as has been noted by one of the other groups, that they had approached the wrong organization. But it should be clear that these data are of exceptional practical significance. The price of such accurate data is measured, in the best case, in thousands of millions of roubles and, in the worst case, in tens of thousands of millions of roubles.

To demonstrate what is essential, I should like to refer to data obtained recently. The collection of data on the effectiveness of the various countermeasures is continuing; unfortunately the work is proceeding slowly in spite of its great importance. As for the effectiveness of some countermeasures — this does not apply to all factors — we have used here the well known assumed relationship between man-rem and man-days lost. Here are some extremely generalized, simplified ideas about the data which have now appeared. I want to refer to two items which are highly relevant to what has been discussed here: agricultural measures and measures related to improvement of medical care. These measures, especially the agricultural ones, are highly specific; specific to the region and specific to the characteristics of development of the USSR national economy. They are highly effective. If we had been able to formulate a correct strategy, the effectiveness of these countermeasures would have enabled us to improve our decision making strategy substantially and to reduce to some extent the total costs mentioned. The data available to Task Group 5 were very limited and sometimes I thought they were below some threshold of significance. In evaluating the results achieved by this Task Group, I must say that they handled and utilized most brilliantly the small amount of data at their disposal, made the maximum number of recommendations and, above all, they demonstrated what the risk analysis technique currently available to the international community was capable of. There is still a lot of work to be done before this technique can yield results of practical importance.

Two numbers are given [*in a slide which cannot be reproduced here*]) in the estimate of economic losses: 20–25 and 30–40. The former was obtained from some models based on some concept of optimality. The latter value is the result of an attempt to assess those trends which, if they persist, would lead to such values. It must be emphasized that this is not the arithmetic sum of all costs and detriments but values adjusted for 1986. The arithmetic sum may be much higher. People who know economics will understand that this is how it should be done. The cost of ineffectiveness may be reckoned in thousands of millions and even tens of thousands of millions of roubles.

J. Jovanovich (Canada): I have been most impressed with this Conference and with all the conclusions, and I would like to add something concerning cost and benefit. We understand what cost is and we understand benefit as a benefit to the health of a population. Whenever I, as a nuclear physicist, come to a gathering like this, we always talk about the nuclear physics, about the radiation; we never talk about the air pollution. Just two weeks ago, at an international conference in Anaheim, it was reported that air pollution in American cities has accounted for an estimated 60 000 deaths a year, making it among the nation's top killers. This is not a crackpot report and it is nothing new. I have already heard it from the Office of Technology Assessments of the Congress of the USA nine years ago where, using linearity hypothesis, familiar to us, they have been estimating 51 000 deaths per year. Now, if I have 10 billion dollars or 10 billion roubles and want to improve the health of the population, I have to decide whether to spend that money on relocating people because of the 100 mSv or on cleaning up smoke stacks. We should not forget that we live in a real world, and that there are other technologies more dangerous to the health of populations than nuclear power, including the Chernobyl accident.

A.J. González (IAEA): I have just a moment ago received an unofficial translation of an article from Izvestia of the day before yesterday which I believe is very relevant to today's discussion. It states that on that same day a new Soviet law was published, which would establish the following limits for the relocation of people living in areas affected by radiation. It seems that (a) obligatory relocation with full compensation for loss of property should be considered when the average dose exceeds 5 mSv; (b) the population in areas with doses exceeding 1 mSv could stay on or be relocated upon request, also with full compensation for property loss; and (c) people in areas with less than 1 mSv per year would have special status and be entitled to some bonuses and compensation without relocation.

I ask myself what the consequences of this law would be if the USSR authorities decided, for instance, to control radon exposure in dwelling houses, following a similar policy. The average global dose for radon assessed by UNSCEAR is in the order of 1 mSv and I can imagine that in the cold climate of northern USSR, with airtight houses, the levels can be higher than that. I do not want to enter into the internal politics of the USSR, but I am very concerned about the implications of this law for radiation protection, and I should like to hear the comments of Task Group 5 on this point.

P. Hedemann Jensen (Denmark): I would like to make two comments. The first concerns Dr. Belyaev's statement that "this is a violation of human rights". The statement speaks for itself. Regarding the work done by Task Group 5, we have not evaluated this two-tier system because when we ended our study the work was still in progress. However, our conclusions are very firm. We say that there can be no justification on radiological protection grounds for the adoption of a more restrictive policy if consideration is limited to the cost and risk reduction alone. This should be strongly resisted. Secondly, if this new criterion that we have not evaluated is more restrictive, then it could not be justified. But as we have not evaluated it, we cannot be very firm about it at the moment. If it turns out to be more restrictive, then our conclusion is clear: it could not be justified.

Y. Nishiwaki (IRPA): In making a cost–benefit analysis, if all the factors involved are precisely known there would be no problem. But often, as in the case of radiation protection and nuclear safety, many factors are uncertain. In this case it is a problem of decision making in a 'fuzzy environment'. Risk estimated by the expert may be considered to be objective risk, but risk perceived by the general public is subjective risk based on subjective evaluation. If a subjective evaluation is made, it very often does not follow conventional binary logic. When subjective evaluation appears it would be more appropriate to use Łukasiewicz multivalued logic or 'fuzzy logic'. Let us take a simple example. To the expert, anywhere in the world, a dollar is a dollar. In the case of the general public, a dollar perceived by a very poor person is quite different from a dollar perceived by a billionaire. In just the same way, risk estimated by the expert is a totally different concept from risk perceived by the general public, although the same word is used. We must take this difference into account and we must make a greater effort to carry out scientific studies on the structure of psychological effects in order to solve this problem.

Comment by a participant: There are many countries where a large proportion of the population receives much higher doses than 5 mSv per annum from radon and its daughters. Governments and populations affected by this radon irradiation do not bother about the situation. So we should rather compare the variability of situations in the world, the natural variations of doses, and so on, and not look at only one problem. We are living in a complex world and we should take care that people who are relocated are not relocated to regions where they receive more irradiation through radon.

P. Pellerin (France): I would like to support Dr. Nishiwaki's comment. Chernobyl is a very big disaster. It was triggered by the explosion of the reactor, but radioactivity has not very much to do with the present situation. We must recognize that this is perhaps one of the biggest disasters in the history of humanity because the consequences will last a very long time, but perhaps a major error to be avoided is to attribute this disaster to radioactivity. Radioactivity has played its role, but we should perhaps consider now all the socio-economic consequences which cannot be solved by means of technology only.

Question by a participant [*referring to the previous session*]: There were a large number of interrupted pregnancies in Europe because of fear of Chernobyl. Did the Task Group ask any questions about interrupted pregnancies among the population of Chernobyl?

F.A. Mettler (USA): We did not ask specifically how many medical abortions are being done in connection with Chernobyl. As I indicated this morning, there were about five times more abortions than live births, but we did not go into the reasons.

Comment from a (Russian-speaking) participant: I should like to support the experts' and the Committee's views on how and where the modest resources of our country can be spent more effectively and also where these could be invested much more effectively on radiation work. I will give only one example. Our estimates show that in the USSR the average dose from all sources of radiation is 420 mrem (4.2 mSv) per annum. Of this, 1.9 mSv is due to the natural background and 1.2 mSv to medical practices. If we consider that the harm from the doses referred to here amounts to purely stochastic, probabilistic effects since the individual doses in this case are immaterial, we have to take collective doses. Thus the collective dose in the USSR for 70 years, the period over which collective doses are calculated at present, is 8400 million rem. The collective dose from Chernobyl in the USSR territory is 20–30 million man·rem. This means that, from the standpoint of collective dose and harmful consequences, about which we are concerned, there are still in our country 300 Chernobyls to which nobody there pays any attention.

Comment from a (Russian-speaking) participant: For lack of time I cannot comment on Dr. González' communication. As for the protective measures and the measures involving compulsory relocation at a level of 1 mSv, it seems there is some error or inaccuracy in the translation. We are willing to have these things clarified individually and to help in sorting them out. It is a very complicated matter.

Rapporteurs's Report of Session 6
(K. Duncan)

I thought before the meeting started that the report of this working group might well be one of the most interesting because it brought together so many human aspects and added them to the technical aspects, so this is a very different chapter from its predecessors. It goes closer and more overtly to the frontier between science (including medicine in this case) and politics, economics and social science, if I may use that term in front of this audience. The apparent contradiction in the conclusions is explained on page 42 of the Overview and was made extremely clear by Dr. Hedemann Jensen in his introduction, so I need not go into it again.

I should like to make one or two points before I deal with the various speakers. Here is one that came out of the intervention right at the end. There are all sorts of problems of interpretation, not only the linguistic problem of going from Russian to English, but interpretation of what people mean by particular terms; this was brought out very clearly by Dr. Kelly, and I shall return to it later. I believe that in this field the hardest thing to do is to do nothing. There is a certain parallel with medicine in this. When I was a medical student, many years ago, we were all taught to be very aware of what our teachers called the 'furor therapeuticus'. This can be loosely translated as the desire to do something, whether or not it is in the least useful. In medicine, we often dealt with the problem by using what is called a placebo. A placebo is something that is harmless and usually very cheap; at least we hoped it was harmless. In our present case, the desire to take some specific action has far more serious consequences than anything that faced us in that other sphere. Dr. Hedemann Jensen, in his introduction, pointed out that matters went far beyond radiological protection here, and all these other things had to be taken into account; he emphasized very strongly that the idea that more means better was probably a fallacy. It is a fallacy that is very easy to fall into, because you feel that if you have done something and got some improvement, it is worth doing a little more, and a little more, and a little more. It takes courage to decide that enough is enough, and that enough money has been spent.

The question of relocation was dealt with by Dr. Kelly, and when you think of the number of variables that are brought into that subject, the number of things that have to be considered, I think one can have nothing but sympathy for the people who have to take these difficult decisions and have to take them, as he said, on the hoof, very often without enough clear explanation.

Then we come to Dr. Lochard and the question of cost-benefit. To many listeners this term rings coldly. It is an unhappy choice of words but it was not put over in an inhuman way at all; it was never meant to be inhuman, nor does the whole discipline need to be inhuman, but it does sound so. People say emotionally, and so much emotion comes into this, that you cannot put a monetary value on a human life. In one sense you cannot and in another sense you must, because, people also say you cannot spend too much on health. What absolute nonsense! You could spend the country's whole resources on health and you would be very much worse off at the end. Only the doctors would be very much better off.

Then, I had, at my great age, a culture shock from Dr. French. The sort of medical managers I had as a young man, and the sort of managers I have met in industry, must be rotating at a very high speed in their graves at all these consultations. Now, consultation was always a clear matter when I was a lad. Whoever was senior said: "This is what I propose to do and anyone who disagrees may leave."

I was very impressed with the discussions following the presentations, and quite apart from many quantitative and priority answers they produce, they are very valuable for getting people to be clear in their own minds. What Dr. Kelly said leads to the next question: It's all very well, this sort of decision conference between all the people involved in making these very difficult decisions. I can see that in a well led group such as this one you could get a great deal of combining of minds. What I am not clear about, and what did not emerge from the discussion, was how you take the next step, having cleared all the scientists' minds, all the administrators' minds, all the politicians' minds (if such a thing is possible), how do you go from that stage to communicating back to all the people out there who are gravely concerned? Dr. Kelly took issue with the imposition of terminology, and I mentioned it very briefly at the beginning of this summary. There is clearly a failure of understanding of some of the radiological protection principles, and there is clearly a great need for some of that to be debated, not so much in an open forum but between consenting scientists in private. I think there is a very obvious need to get a lot of that hammered out, not necessarily in the light of the press, and certainly not necessarily in the light of an accident.

This leads to something else. It was quite clear from much of what was said in Dr. Hedemann Jensen's presentation and elsewhere that there had not been, certainly for people in general, enough understanding of what might be happening. And there was clearly a need, which I'm sure we all feel, for much public discussion, not in the heat of an accident but before an accident, with what you might call local liaison committees or whatever the term is, so that the risks are all explained, so that

emergency procedures are understood and can be practised, and so that the emergency procedures do not come out of a clear blue sky, at some terrible time in the morning. People need to know that there has been planning, that something can be done, and that something is being done.

Another point that came out very clearly from Dr. Kelly's presentation, and again in some comments from the floor, was that there is a very real danger of radiation being put in a box, as it were, and regarded outside the context of industrial pollution and the environment in general. Somebody mentioned that nuclear radiation from reactors was regarded separately from radon. That sort of thing contributes very much to the problems of decision makers.

I have said something risky. I said I thought that some of the discussion about some of these technical points has to take place between professional people privately. This is dangerous because one of the difficulties the whole nuclear business is facing is the accusation of secrecy. I think that charge can probably be prevented, after the private discussions, by a full and extensive discussion of the conclusions. But there is no need to publicize all these very complicated things; it just confuses people even more.

In conclusion, I should like to say that it is easy with hindsight to see in every case what should and should not have been done. I think of one of the aphorisms of Hippocrates: experiment perilous, decision difficult. The experiments were perilous here; the decisions that had to be made were difficult. An enormous burden of responsibility had to be carried at very short notice at many levels, and it is very easy to criticize. What is important is to turn events to good account for the future, and that seems to me to have been what we were doing here for the last few days. Let me suggest three additional recommendations that have occurred to me while I have been talking:

(1) Emergency measures must be preplanned and made public, and information to the public must be increased.

(2) A clear understanding of radiation policy and preventive measures must be achieved through the correct use of words. Precise terminology must be agreed in scientific and not polemical debate.

(3) Communication must be greatly increased and improved at all levels.

Session 7

MANAGEMENT OF CONTAMINATED AGRICULTURAL AREAS

Current situation
A.W. Randell (FAO)

Agricultural protective measures
M.J. Crick (IAEA)

DISCUSSION

L.A. Il'in (USSR): I would like to make a few comments. Three years ago in the USSR, our laboratory at the Institute of Biophysics in Moscow, in co-operation with colleagues from other institutes, developed a special method for decontaminating milk using special filters, which was intended for use on private farms. It was based on the compound 'Ferrozin', which Dr. Crick has just shown you, and which was also developed by us for these systems. Together with our colleagues from the UkrSSR and the RSFSR, we have carried out large scale tests of this method on over one-and-a-half thousand individual farms. The high level of effectiveness of this method was confirmed, as the system can deal with five litres of contaminated milk per minute, reducing the caesium concentration in the eluate by an order of magnitude. At the same time, with our colleagues from Sverdlovsk we have developed a compound called 'Befezh'. This compound consists of Prussian Blue associated with carboxymethyl cellulose, which is intended as a feed additive for cattle consuming contaminated produce. The results have been very significant, and I would therefore like to use this example once again to emphasize the urgent need for a joint programme of co-operation. The principles followed by our Norwegian colleagues are similar except that, unlike us, they use boluses, whereas we are using two systems. I must say that the reaction of the population has been very interesting. We have been working in a region in the south of the Gomel province, in the UkrSSR in the Rovensk province, and in the RSFSR in the Bryansk province, and the population showed great interest in the use of these systems, which consist of a rather simple installation. These installations, and particularly the filters, can be easily replaced, and the population obtains milk which is virtually free of contamination. Judging from the present meeting therefore, I think that everyone would benefit greatly if these two programmes could be combined in the future. The main problem, as always, is practical implementation. We need to have a good customer. Our colleagues on the programme have come up against the same problem, but I think this only confirms the fact that independent scientists have reached the same conclusions, and the results have been very positive. The figures shown by Dr. Crick are sufficiently close to those we obtained in the USSR. Just one small obstacle remains: to introduce these methods, on the basis of objective assessment, into the lives of the people living in these areas.

F.P. Kurchenko (USSR): I would like to express my point of view on a number of questions. The data presented here provide rather detailed information on the scale of the measures taken in agro-industrial production to reduce the amount of both internal and external irradiation to the population living in the contaminated areas by reducing the radionuclide content in human foodstuffs and by organizing radiometric monitoring of these foodstuffs. At the same time, a number of comments have been made in the Technical Report and at this Conference, and recommendations have been made to improve the activity of radiological scientific research institutions and agricultural administrative bodies. We are in full agreement with this. It must be admitted that there has been a tendency for the ^{90}Sr content in the soils and in agricultural produce to increase, particularly at low concentrations of radionuclides. We would be very grateful if the IAEA could assist in providing the radiological control services with the necessary sets of standard reagents and apparatus, and could provide the opportunity for a number of Soviet specialists to visit appropriate scientific and practical institutes in Western Europe for training, thus contributing to the undertaking of further planned intercalibration of the apparatus as well as unification and standardization of the analysis methods used. It would be even more effective if the work in a given area could be carried out jointly by Soviet and international specialists.

Specialists in agricultural radiobiology have been very interested to hear of the proposals for the greater use of models to predict the levels of radionuclide content in foodstuffs. I should mention that such prediction models were in fact developed some time ago in the USSR during the cleanup operations following the radiation accident in the Southern Urals, and were used in the organization of a system of measures which, in general, was implemented both in the conditions there and in the early stages of the cleanup operations following the accident at the Chernobyl nuclear power plant. Some aspects of this prediction model were included in the recommendations concerning agricultural production published in 1991. This is the most recent of over 100 recommendations on the management of agricultural production. We were pleased to note the good sense of this recommendation and we shall suggest a wider application of this prediction model to our administrative bodies. At present, the agricultural experts say that crops can be grown in areas with up to 40 Ci/km^2 (1480 kBq/m^2) without significant restrictions, and some crops can also be grown where the level of contamination is up to 80 Ci. (This is to answer the question asked by Dr. Randell.) We feel that land need only be taken out of agricultural production and put under forest when there is a level of over 80 Ci/km^2 (2960 kBq/m^2). In other areas, agricultural activity can be carried out with just a few special recommendations, restrictions and measures to be observed.

We would like to draw your attention to a problem which we may now encounter, which also arises in some aspects of the research carried out by Professor Lee. The USSR Ministry of Health has now suggested stricter standards for animal husbandry and in particular for meat. Five years after the accident the problem of contaminated meat may arise once again. As you are aware, after all of the measures have been implemented, the situation of meat production in the USSR is as follows: in 1986, 5.68% of the meat produced in the contaminated areas was contaminated and in 1990 this figure was 0.01%. When the new standard is introduced the percentage of contaminated meat may be increased substantially because at present the radiation measuring equipment available in the USSR is not capable of reliable measurement of the new levels. The new level is 740 Bq/kg. We have a request to make in this connection. I understand that it is a complicated matter, but we would request that the possibility be considered of providing assistance in the form of Canberra and Selena devices.

We have a problem with milk. In general, we share the views expressed by Dr. Crick but we would like to say that we have been working on this problem, as reported by Academician Il'in, since 1986. And we have studies which show that 'ferrocyanides' and a number of other preparations are effective. The measures which we have implemented have reduced the level of contaminated milk from 30% to less than 2% in 1990. We have participated fully in developing the international programme; we are also making use of the achievements of foreign research workers, and we are now implementing them on a comparative basis with our own studies and results, with the aim of providing contamination-free milk in the private sector as well as in the public sector. But as you know, there are a few organizational problems in obtaining contamination-free milk in the private sector. We are certainly even more actively involved in the implementation of these international programmes in the sector concerning the wider application of caesium binding technologies in both the production and processing of foodstuffs. I would not like to take this opportunity of twisting your words; I would only like to say that in the course of our work we can provide any interested scientists concerned with agricultural problems with any of the necessary material in our possession which was obtained following the visit of experts to the USSR. I have such material with me now.

I would like once again to thank the international experts for their generous assistance to Soviet agricultural specialists.

R.M. Nordin (Malaysia): In his last comment on trade, Dr. Randell mentioned the trade situation with South East Asia, where the people concerned are refusing to accept food exported from the region. Can Dr. Randell tell us what was the previous situation concerning trade between the region and South East Asia and what is the current situation? What other areas are rejecting food from the Republics? Is there any reason why you singled out South East Asia in your statement? You mentioned that you are trying to clear this problem with the Codex Alimentarius. I understand that the Codex Alimentarius has already discussed the matter and may be finalizing the text now in Kuala Lumpur.

A.W. Randell (FAO): South East Asia imports and exports quite a lot of food, and its imports from Europe in general were severely restricted after Chernobyl. South East Asia probably imposes the severest limits on international trade for radionuclide contamination, and we do not quite understand why they are as low as they are. We think the Codex Alimentarius levels are perfectly adequate, and we will be taking this up at the Codex Alimentarius meeting in July this year. We also have a small problem, not quite as severe as with South East Asia, with the West Asian countries, although they are quite willing to accept the Codex Alimentarius limits. In 1986, after a very severe drop in the early months after Chernobyl, trade tended to pick up and in fact increase in Europe as a lot of meat moved up into the Scandinavian countries to replace meat that was lost there. So you can see what free market economy can do for trade in adverse situations.

I think the use of Prussian Blue is developing into the sort of problem faced by farmers all over the world

when they are dealing with different ways to tackle a problem. There are economic advantages to different techniques, depending on the situation. And the economic effectiveness of the different Prussian Blue techniques, in the bolus or the filters, will probably require further study. I am certain that the local populations are going to have a wonderful time deciding which of these techniques they would like to use. This would give the people concerned a say in how they deal with the problem, which would be a good thing in any case. It would also respond to local circumstances and the local economic situation, even at a very micro-level, which is also beneficial. The bolus technique works on meat and not only on milk. Basically, with the bolus, all we are doing is putting the bolus ahead in the production system rather than behind. Speaking of behind, the bolus also works on binding the caesium in the other output of cattle and preventing the caesium from re-entering the environmental system from the dung. The work done by the Ministries of Agriculture of the three Republics has been quite extraordinary, and there is a great deal more to do.

FAO and the IAEA are working together, particularly through the Joint Division here in Vienna, and we shall be working together with people from the three Republics and from other countries on the application of agricultural countermeasures. Two consultants meetings have already taken place and more are planned. We are very impressed by the openness shown by the agricultural people in the affected Republics, and working with them is really a delight. As the situation develops and as changes are made, the problem of providing instruments and techniques for control of contamination in meat will of course have to be tackled by the USSR, perhaps with outside help. FAO has been working with developing countries in setting up training courses for control of radionuclide contamination in food and explaining to people how to apply control. In other words, if you get 10 Bq/kg over the established limit, don't shout panic stations, but react calmly and find out what the situation really is. Perhaps even take another sample and try again.

This is FAO's approach and we shall very likely be publishing it, so it might be that through our co-operative efforts with the IAEA, we can make contact with the USSR. Our biggest difficulty is that we have a constitutional impediment to working directly with the USSR because, unfortunately, the USSR is not a member of FAO. Perhaps that will change one day.

Panel Discussion

The Lessons Learned

M. Rosen (IAEA): The Panel has been called to talk about the lessons learned. I could start by concentrating on one problem that is inherent in any large accident: the difficulty of communication, particularly the difficulty of separating the facts from the plethora of information that becomes available. Certainly a major objective of the International Chernobyl Project was to clarify the current situation and to separate the facts from the myths. The Project concentrated on assessing the health effects of contamination and radiation exposure and assessing the protective measures taken. As you are aware, this was accomplished first by reviewing the existing material for reliability and accuracy, which entailed visits to numerous institutes, hospitals and government agencies, and, second, by independent field work on the part of scientists and physicians.

This Project was the first systematic and methodical study by independent international experts. Most important, its results are documented in the three volumes which have been made available to you for scrutiny. The information obtained by the study led the Project experts to numerous conclusions. Without restating or summarizing these conclusions, let me just mention a few in the medical area, concerning health effects. The Project experts concluded that there were no health disorders that could be attributed directly to radiation exposure. They also noted that the official data did not indicate a marked increase in the incidence of leukaemia or cancer. They did state that there could be a statistically detectable increase in the incidence of thyroid tumours in the future. These few conclusions were the results of the work of a group of 28 physicians, which does not necessarily mean that these results are absolutely correct, but they are the outcome of a systematic and controlled study. Yesterday, however, we were presented with results of Soviet studies which indicated a significant increase in immune system disorders in the BSSR and of current cases of thyroid cancer in the UkrSSR. Unfortunately, this information had not been made available to the Project experts. But the situation does allow us to look ahead, and I would urge individuals and institutes to make their information available to the international community.

I hope that this Project has shown the need for the entire international community to assist the people in the affected areas. We know the Soviet scientific community needs equipment and assistance, and we know that people in the local communities need further medical care and other assistance to ensure that they can live healthy and productive lives. Knowing the facts of the situation will allow us to channel international assistance to the areas where it is most needed and can be best used.

G.O. Gotovchits (UkrSSR): I represent the body [*the UkrSSR Ministry for Protection of the Population from the Consequences of the Chernobyl Accident*] which was entrusted with the responsibility for decision making and for the comprehensiveness and effectiveness of the protective measures to be implemented. I would therefore like to make a few comments on this problem in connection with the report of the International Advisory Committee. We have great respect for the work that has been done, and we value enormously the professionalism of those people who have performed this work, their highly refined methodology, their great technical capacity, and their selflessness. We are extremely grateful to everyone. However, as a practical man, I would like, with your permission, to draw your attention to certain significant features of the realistic evaluation of the situation in connection with the material put before us.

First, the evaluations of environmental contamination seem to agree overall. However, we feel that more attention should be paid to the role played by 'hot spots' in the overall picture, which Dr. Bar'yakhtar particularly mentioned in his statement. The problem of high strontium and radionuclide contamination levels in the water meadows of the Pripyat river is worrying; this river is a main artery of the Dneper basin, the water from which is used by approximately 32 million people in the UkrSSR. In certain circumstances this could have serious negative consequences. There are similar points, other examples, and I think that ignoring them here could lead us to draw unjustifiably liberal conclusions.

Second, with regard to state of health, which Dr. Rosen has just been talking about, and possible changes thereto (I also refer to the statements made by Dr. Bar'yakhtar, Dr. Konoplya, Dr. Tron'ko, Dr. Dushutin and others), this is an extremely significant problem which has not been taken into account in the Report and is therefore not included in the programme of the Conference. Here we are talking about significant numbers of people — cleanup staff, evacuees, and people who are still living in the more highly contaminated areas. The latest data from the scientists and health service specialists in the UkrSSR and BSSR seem to indicate, unfortunately, that there are negative trends (in order to save time I won't quote figures) such as, to cite the main ones: impairment of the immune system; a rise in the number of sexual disturbances; disturbances of the functioning of the hearing and vestibulary systems; qualitative and quantitative changes in the blood count; leucocytosis; a definite increase in diseases of the respiratory organs, the gastrointestinal tract and the cardiovascular system. The

increase in gynaecological problems amongst women is cause for serious concern. Moreover, scientists at the All-Union Scientific Centre of Radiation Medicine have reliably proved that there is an increase in psychogenetic effects, and there are also worrying data, such as those which Dr. Tron'ko was talking about, on cancer of the thyroid gland. The attempts of the experts of the International Project to determine the health effects of the radiation in isolation, so to speak, i.e. not taking into account other environmental contamination factors, including chemical contamination, is also cause for concern. The energy effect was not investigated. Perhaps an approach of this kind may be justified from a purely scientific point of view, but these materials are also valid in applied terms since they will be used to make decisions which will affect the fate of hundreds of thousands of people. Problems of this kind should be reflected more extensively and in greater detail in the research materials.

In the evaluation of protective measures, where mention is made of the extremes (in the opinion of the experts) which were gone to with respect to evacuation of large numbers of the population in areas of the affected Republics, it seems to me that this conclusion does not take into account several extremely significant concomitant factors. These conclusions are, we feel, based only on an evaluation of the contamination level and dose commitments; they take no account of the reduction in the amount of agricultural land available, rescheduling of production activities, reduction in the quality of fodder, the fact that local products and forestry products could not be used, the drop in the employment rate; in short, the disruption and total destruction of the normal way of life and working environment of the population, which meant that people simply could not live there. I must stress that in all these cases this was done in accordance with the declaration concerning habitation of contaminated territories (the laws passed in the country as a whole and in the Republics state that evacuation must be voluntary); only in this way was a final decision taken. We also feel that the potential sources of danger which, alas, still exist cannot be disregarded. Here I am talking about the destroyed Unit 4 of the plant, the so-called sarcophagus, dozens of burial sites for highly radioactive waste in the 30 km zone which, as we know, are being monitored, but about whose fate more fundamental decisions must be taken in the future. All of these sources of risk are not local in character — they are a potential risk not only for the affected Republics but for the whole world. In addition, it would be wrong not to take into account the psychological influence of these factors on the public in surrounding areas.

As a result of these and other problems which have been dealt with in the statements made by my colleagues — though we understand that it was clearly impossible to examine and solve all these problems in the limited time available, and certain topics were not included in the framework of the project — nevertheless, if we consider our responsibility from the point of view of decisions which will need to be taken for the future and possible further developments, I would like to draw two conclusions. First, we should not think of this work as being finished, but rather we feel it should go on until we have found clear and well founded answers to all the problems we have uncovered during these discussions. Second, we feel that some of the basic conclusions which have been drawn concerning the radiological consequences of Chernobyl are too optimistic and could therefore be deleterious not only to the cleanup plan but also to nuclear safety problems in general.

We cannot, unfortunately, agree entirely with the conclusions concerning the overall health effects of the radiation on the population in affected areas as set out in the draft document. The representatives of the BSSR and the UkrSSR have prepared a statement on this matter which will be submitted to the Chairman. We would ask you to look at our opinions, comments and proposals and to make suitable corrections to the final version of the Technical Report.

Comment from a (Russian-speaking) participant:[1] On the whole, I assess positively the work done by the International experts and I think it will help to reassure those people in the USSR who say even now that the measures taken by the Government to protect the health of the population from the effects of radiation were inadequate. I agree with my colleagues from the UkrSSR that the chapters of the Technical Report dealing with environmental contamination, protective measures and radiation exposure of the population basically confirm the vast amount of work done by the Soviet scientists in the first few days and those that followed.

We have been taken to task for overestimating a number of values, but I agree with Academician Il'in that when in May 1986 a decision had to be taken in an hour, those who were to take the decision had no other choice but to go for stricter measures and stricter conditions. Moreover, the health of children in terms of the condition of the thyroid is a very important matter in the BSSR, where the southern part of the endemic areas was affected. There were 500 000 children among those affected by iodine. The studies carried out by our Leningrad colleagues have shown a number of changes in the thyroid among children. I feel that right from the outset our Government should have paid more attention to this problem and the studies should have covered both the cleanup workers (the 'liquidators') and the large group of children affected by iodine in April 1986.

[1] It is regretted that the names of this and the subsequent two speakers were not spoken into the microphone and were therefore not recorded.

The conclusions in the Technical Report chapter on protective measures are also important for the BSSR — 70% of its total affected population live in the 1-5 Ci/km^2 (37-185 kBq/m^2) zone. But, considering the soils, even in the 1-5 Ci/km^2 (37-185 kBq/m^2) zone, people in individual settlements received higher exposure doses than those in the zone studied at Bragin, Veprin and other towns. This was due mainly to the transfer of large amounts of caesium to plants. In particular, the people in these areas obtained cattle feed from large forest tracts. As a result, there was 'contaminated' milk and hence high exposure of a large part of the population. There is another bad feature of the soil in the Polesskoe marshland — for two years the same field yielded clean crops and then in the third year the background increased by two or three orders. This requires further study, and we have sought the co-operation of international organizations in finding a final solution: how to reorient agriculture, what is to be done by the people who have been accustomed over centuries to live on the gifts of the forest but who now find themselves deprived of them.

I want to thank all the participants of the International Project, and I hope that this collaboration with international organizations will continue for the benefit of mankind.

Comment from the Representative of the State Committee on Elimination of the Consequences of the Chernobyl Accident, RSFSR: I wish to thank the international experts for their work. In the RSFSR there are also problems associated with eliminating the consequences of the Chernobyl accident — medical, technical, sociopsychological, economic and many others. These problems can be overcome in the long term only with international collaboration under a comprehensive All-Union programme, with collaboration between the three affected Republics and in collaboration with the international community. We positively assess the documents reporting the work of the experts. This work should continue since many problems remain, including those of the population of the contaminated areas, the 'liquidators' and so on. Moreover, it will serve as the basis for future studies, which need to be continued for many years in order to corroborate the results.

Comment from a (Russian-speaking) participant: The Project has been completed. We consider it to be of international significance, given the participation — more than 200 scientists from 22 countries — and the results of its assessments. These results are not only national; they will be useful for the whole world. What is impressive about this Project is that its results can be analysed by everyone — by an expert who has read the Technical Report, or by a member of a public interest group or an administrator who has read the general Conclusions and Recommendations. The results can also be used in writing public information brochures. It will undoubtedly help people to learn more about Chernobyl and its consequences. Indeed, the results of this Project in many respects assure us that our actions were correct and that adequate measures were taken to ensure protection of the population from radiation. This is one of the most important conclusions, and there is no doubt that the results will be useful now, when a long term programme of activities for the affected areas is being prepared. We again express our gratitude to all those who took part in the Project. However, every new study raises new problems, and these have been mentioned here. We appeal for further international co-operation in the study of the health of the 'liquidators' and in the study of the action of iodine on the thyroid of children. The project is ending but nobody should get the impression that the Chernobyl problem is being closed. The issue is highly complex — a tangle of radiological, social, psychological and stress problems for hundreds of thousands of people. These problems remain, and I should not like to say that they grew out of nothing. The Chernobyl problems are extremely complicated and require further study and more hard work.

F.A. Mettler (USA): Many points have been raised, and I agree that nobody should go away from here thinking this is the end of studying the problems of Chernobyl. We have certainly made it clear that we think there are things worth studying in the future, and that there are populations of significant interest which we have not examined in this Project. Not because they are not important, but because they were not part of the request to us by the Government of the USSR. Certainly the decontamination workers are important; certainly there are high risk subgroups and certainly there are those people who suffered the acute radiation syndrome, and so forth. Our Project was limited to the task that we were given, and we are perfectly willing to agree that there are many other things to do that may in fact be more important. It was difficult for us, in terms of data review, in terms of viewing things and, as I pointed out to you earlier, there were basically two kinds of things we could do: one was to review data for those low prevalence diseases, and the other was to look for internal coherence in that data and for consistency with data we obtained from other sources on the same topic. I was not privileged to get all that BSSR data until about half an hour ago, but I would like to give you some idea about it. I think it shows some of the problems that we had, and you can judge for yourselves.

It is important to look carefully at the data that our BSSR colleague has mentioned to you. He suggests that the data show clear evidence of immune problems (especially in children) that are manifested by increases in all sorts of diseases. Since I have only had this material in my possession for 30 minutes I took the liberty of photocopying nine sequential tables (Nos 106-114), from the document *Main indicators of health*

in Gomel and Mogilev regions, issued by the Scientific Institute of Radiation Medicine of the Ministry of Health of the BSSR, Minsk, in 1991. [*They are reproduced at the end of this Panel Discussion as Tables I–IX.*] These data relate to strict control areas (i.e. highly contaminated) in Gomel and Mogilev regions and cover the years 1976 through 1989. This allows us to look at year-to-year variations, trends before and after the Chernobyl accident, and anomalies in data collection.

Table 106 [*reproduced here as Table I*] shows the incidence of meningitis in children. Incidence of infections is important since any depression of the immune system should result in increases of both viral and bacterial infections. We can see for strict control areas in the Gomel region that the incidence of meningitis in 1988 (2.0) and 1989 (2.1) was in fact *lower* than in any year preceding the accident. In the Mogilev region the highest number of meningitis cases was seen in the years 1982–1985, not after 1986.

Table 107 includes similar data on chickenpox in children. There is a minimally increasing trend but the highest incidence in the Gomel region was in 1983 before the accident. Changes are also reported that span two orders of magnitude from year to year in the same district (for example 28.8 (1982), 313.7 (1983) and 5.6 (1984).

Table 108 relates to measles in children. This table clearly shows a much *lower* incidence of disease since the accident compared to the period 1980–1985.

Tables 109 and 110 (viral hepatitis in adults and children) both show no change since the accident and, in fact, both show that the incidence was higher in 1983 than in any year since the accident.

Tables 111 and 112 relate to respiratory diseases in adults and children respectively. Incidence rates overall are higher since the accident but there has been a constantly rising trend since 1976. Both tables also show interyear and intervillage variation that are difficult to explain. The magnitude of these variations is much more than the increasing trends. For example in Table 111 reported incidence rates vary from about 1000/10 000 (10%) to 47/10 000 (0.47%) within the same district year to year and between villages for the same year.

Table 113 (viral morbidity in adults) shows reported incidence that is highest in 1976 for both contaminated areas Gomel and Mogilev. There was clearly a reporting problem in 1987 with incidence rates dropping from 200–300/10 000 in 1986 to 9/10 000 in 1987 and then back up to 500–600/10 000 in 1988.

Table 114 (viral morbidity in children) again shows immense variation from year to year for given districts. The variation is one to three orders of magnitude. [*The speaker presented several more tables and discussed them.*]

In summary, the data reveals major problems in data collection methodology which have caused statistical noise that is much greater than the claimed radiation effects. These Soviet data should be subjected to a rigid statistical analysis before conclusions are drawn from them.

We tried to perform a scientific study which had control groups and quality control and which hopefully was beyond reproach. We tried to leave a trail as to exactly how we did everything, so if somebody wants to repeat our results they can follow our path exactly. There is no question that our study is limited to the rural population, and this is because we were looking for people in the areas of highest contamination. There is no question that I would certainly look at groups of 'liquidators', that I think they are probably very important, and that they may ultimately show more health effects.

I think nobody is willing to walk away from this meeting and say there will be no radiation induced cancer deaths in the regions we studied; we would not expect them at this point in time. Our study is really limited to a screening examination which would pick up major but not minor health issues. It is important to realize that there are sick people in these regions. When you have a screening examination that picks up 15% of adults we think should see a doctor or who are seeing a doctor at that moment, that is not an insignificant number. And we excluded hypertensives from that group, so we know that there are more who should be in the care of a doctor. We know that if we had made additional types of tests on each person we would have found more disease.

There certainly may be health effects worth studying in the future. Well organized studies with appropriate control groups are needed, together with the best dosimetry that people can get. We have suggested that these activities be co-ordinated through one central group, in this case WHO, so that scientists working in one area will have some idea that another group is working in another area, and they can all use the same methodology. What we do *not* want in the future is an agreement in one Republic to study thyroid one way and an agreement in another to study it in a different way so that we would not be able to compare the results. We must achieve uniformity amongst both Soviet and international investigators if we hope to get useful data.

There are many children in the areas we have discussed. We know there are children in all these areas with leukaemia from various causes, and I think all of them deserve treatment. Not just because we are calling them Chernobyl children or because we say it is due to radiation. I don't care what the cause of the leukaemia is: they all deserve equal treatment.

P. Hedemann Jensen (Denmark): I would like to comment on Dr. Gotovchits' statement that in our evaluation of the protective measures we only took into consideration the radiological, the radiation, the radioactivity factors. That is correct, but it is not the whole story. We tried to separate the variables in the decision

process, and the radiological factor is only one input for decision making. Our conclusions were very clear: we said that the criteria should not be more restricted; they should be strongly resisted unless there are overriding considerations of a social nature. So I think the message is clear, and we know that the driving factors in the decision process have been other than those of purely radiological protection. May I draw your attention to Table 21 in Part G of the Technical Report. We have heard that plans exist to relocate more than 200 000 people. The criterion for relocation, although I understand it has changed now, was 40 Ci/km^2 (1.5 MBq/m^2). The table that I mentioned indicates that about 15 000 people are living in the contaminated areas, above 40 Ci/km^2 (1.5 MBq/m^2). However, 200 000 are to be relocated owing to the social nature of the problem, so I do not completely agree that we only took radioactivity into account. We said clearly that social considerations should be considered.

L.R. Anspaugh (USA): I would like to make a few summarizing comments about the doses. There has been some emphasis on the fact that we concluded that our independent estimates were somewhat lower than the official doses from the USSR and that Task Group 5 has been somewhat critical of the deliberate conservatism in the doses that were calculated with the official methodology. I would like to speak for a moment as a dose assessor in the sense that I know that when you are operating under great pressure it certainly is possible to make a mistake. If you are reconstructing doses that have already occurred, that is not so bad, because you have the opportunity to check your work carefully and make corrections. But if you are projecting doses into the future for real people, the impact of a mistake is much worse, and the result could do serious harm. There are therefore very strong pressures to be conservative, and I think most international models seem to be quite conservative, even though this may not be the original intention.

I should like also to draw attention to the fact that in more recent times Soviet methodology does in fact use actual data, and this is as it should be. It is unfortunate that in our country and in others there are some people who refuse to look at data because they are absolutely convinced that models are better than data. Perhaps we should call this disease 'computergenic distonia', with my apologies to the interpreter. The dose assessment methods used in the USSR are indeed very similar to those in use elsewhere, and they certainly appear to reflect a great deal of experience in modelling as well as with the data required.

Returning to the issue of conservatism, I think, as I mentioned before, that the only solution is to develop good, probabilistic models, so that the full range of variation in results can be examined and used. However, to have developed a probabilistic model is certainly not enough as it is extremely difficult to make sure that such models are accurate. Thus the model validation studies are extremely important and I think these are best done on an organized, international basis. So I return to our recommendation that Soviet scientists participate in such studies. This is particularly true because I think they have access to many data sets that could be used in the validation models and could be developed and used in other countries. Finally, I think that if there were ever to be another accident anywhere near the scale of Chernobyl, we would really need flexible, fully validated models that can be used to project dose very rapidly to the people affected, with the proviso that we can substitute our calculations of atmospheric transport by real data of the simplest nature, which is typically external gamma exposure rate measurements.

To conclude: there is an old saying, that you never know a man until you walk in his footprints, perhaps wearing his shoes. And we certainly looked very hard for those dusty old shoes that had gone down this road, and we tried to put them on and walk where the people had gone before us. That is why we certainly have a great deal of respect for the Soviet dosimetrists.

F. Steinhäusler (Austria): During the last 48 hours I have been confronted in numerous interviews by questions like: "Is Chernobyl only half as bad as we have seen it over the past four years?" and "Is the food really not so bad as we have been told?" and "Does the water not contain any radioactivity?" In other words, did Chernobyl not happen?

When we faced the situation 18 months ago, it looked completely different. We were told: "Don't believe the figures you are given; don't trust the published map," and "It may be all a big cover-up in any case." That was the situation in March 1990. And then one is confronted by people who are worried or frightened, who do not dare to eat and drink what they produce, and this is happening in an area covering tens of thousands of square kilometres and involving hundreds of settlements. And behind you, there are 71 colleagues who are trying to find the truth, who are asking themselves: "Is this map, given to us by our Soviet colleagues, correct? Are the milk and food data correct? Do they know how to measure? Do they know how to analyse? Is it safe for those people to live in that area?" The only way to answer these questions is to go out and measure, to go to the laboratory and find out how they do it, ask them to collaborate with you, give them unknown samples to measure, which is about the hardest test you can give to a scientist. Our Soviet colleagues did this, and then put all the data together. The end result was: yes, the maps are correct. They are not perfect; they could not be perfect. They were made under enormous time pressure and with constraints. I wish I could say that we would have done better, but I don't think we could.

Our Report is not a whitewash, with everything clean and perfect. Anyone who reads the Technical Report or reads the Recommendations and Conclusions does not have to read between the lines. It is stated quite clearly where there are areas that need improvement, whether in analytical quality assurance control, or participation in international intercomparison exercises. But the main conclusion does not change. It is: yes, our Soviet colleagues know what they are doing.

How does this help the people in the settlements who asked us: "Can we eat the food? Can we drink the water?" I don't think it helps them if we state repeatedly, against the facts of measurement, that food is contaminated, soil is poisoned, water cannot be drunk, when the measurements clearly indicate the contrary. In most of the water measurements, for instance, we could not detect any radioactivity. Not because we used unsuitable equipment, but because there isn't any. And I think this has to be stated and spelled out very clearly. We can help these people, not by reviving their fear, but by believing in the measurements our Soviet colleagues made and which have been officially corroborated. This is the only way we can give these people back the trust that they need.

There are indeed problems in the environment which we did not want to cover up, or make less of, such as in the aquatic environment, which has a long term potential for a problem, and we have indicated this. Radioactivity does not disappear overnight; it is in the sediment. We have stated this, we have measured it, and our Soviet colleagues know it. It can show up in fish and in other components of the aquatic environment. We did measure radioactivity in food, but we made it quite clear that commercially available food is under very good control. It is the privately produced food and food collected in forests, against official advice, that is dangerous. Soviet scientists cannot eliminate caesium from mushrooms grown in forests, and neither can anyone else. They can only tell people not to eat mushrooms.

In summary, I would say that the environment does show radioactive contamination. Our Technical Report does not diminish the levels, but it puts them into perspective and on an objective, numerical basis that the outside world can scrutinize and check. That is the only way science can progress; not by rumours and certainly not by frightening people in the affected areas. Finally, I think it is very unfair to a large segment of the scientific community — in this case, our Soviet colleagues and the other 199 members of the team — to suppose that we have been trying to cover up facts or whitewash the situation. We have not. We have been trying very hard to give a true picture, and I think our Soviet colleagues have been trying to do the same.

A. Carnino (IAEA): The work of Task Group 1 was very different from that of the others. The Historical Portrayal contains a great deal of information and was intended to make the rest of the study easier to understand. As a result of the work done by Task Group 1, I should like to recommend that a book be written on the history of the accident up to the present time, containing as much information as possible. I believe this would help to decrease the distrust of the authorities felt by so many people in the affected Republics.

I have found, in the course of interviewing many people, that official communications on radiation protection science are very difficult for the general, non-technical public to understand, even though they have to live with it. It is important that information given to the public is clear, consistent and coherent. Co-operation between the three Republics to this end would perhaps lessen the uncertainties, and thus the stress, experienced by so many people living in the affected areas.

A. Eggleton (UK): I was somewhat disturbed at the Press Conference two days ago to hear a rather equivocal answer to a question on what was going to happen about the presentation of this Technical Report in the USSR in the near future. Early progress reports on this study indicated that there were definite plans to send teams to the USSR to explain the outcome of the study to the general public. What I heard at the Press Conference suggested that those plans were very vague and incomplete, and I think we would all welcome an authoritative statement on the future presentation of this Report to the population of the USSR.

V.A. Gubanov (USSR): I wish to reply to the question about how this material will be presented in our country. As I pointed out on the first day of the Conference, the data will be available to the scientific community at large and to all sections of the public. For this purpose, we are inviting advisers, experts and members of the International Advisory Committee to our country to present these data, conclusions and recommendations. There is agreement in principle; only the dates and durations have to be fixed.

I would like to clarify one basic point connected with relocation. A figure of 218 000 has been given for the population to be relocated, and it is reflected in our programme of urgent measures for 1990–1992. What we mean is that we shall give an opportunity to these people, if they so wish, to move out. We have planned physical and financial resources for this number of persons. This does not mean that they are to be relocated compulsorily.

C.J. Huyskens (IRPA): I should like to make a few short remarks about the dosimetry conclusions. It was said at the beginning of this Conference that attempts at achieving a better dosimetry should be made not just in a general way, but that attempts should also be made to bring individual dosimetry to the best possible state of knowledge, especially for those groups which are to be followed up in the future, such as the 'liquidators'.

General information or average figures on dosimetry should be avoided and not taken as a starting point for correlation with health effects.

You all know from experience that it is tremendously difficult to find any relation between health effects and dosimetry data. The general public is not very well aware of the details and pitfalls of dosimetry. We cannot afford another such accident, not only because of the radiological consequences, but surely also because of the social consequences. We must not only pay great attention in the next few years to research on what we can learn from Chernobyl about the radiological consequences but should give the same attention, the same work force, to the prevention of such accidents in the future.

Comment from a (Russian-speaking) participant: I wish to comment on Dr. Mettler's statement in the Report. It contains negative as well as positive figures. Our speakers have pointed out that the incidence of all diseases has not risen but only that of some cardiovascular diseases. I should like to quote some data. Take, for example, ischaemic heart disease. In the Narovlya district (mentioned by Dr. Konoplya) in 1985 there were 0.23 cases per 1000 persons; in 1989 in the Bragin district there were 9.24; in the Narovlya district 2.41, 7.55; in the Krasnopol'e district 1.55, 5.58. I shall not go into more detail. We have to work over these statistics and find methods. I agree with Dr. Mettler, but we should look not only at the positive but also at the negative figures.

Notes on Tables I–IX

Tables I–IX are transcribed from photocopies of Tables 106–114 from the document *Main indicators of health in Gomel and Mogilev regions* issued by the Scientific Institute of Radiation Medicine of the Ministry of Health of the BSSR, Minsk, in 1991. They are reproduced here in unedited form to illustrate remarks made during the Panel Discussion by Dr. F.A. Mettler. The underlinings have been added by Dr. Mettler.

TABLE I. Meningitis in Children

Таблица 106. Заболеваемость детского населения контролируемых районов Гомельской и Могилевской областей менингококковой инфекцией (на 10 000 детей)

Районы	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Гомельская область														
Брагинский				2,2	1,1	-	1,2	3,6	2,5	2,5	1,5	3,9	3,7	3,7
Буда-Кошелевский				1,7	0,8	2,6	-	1,8	1,8	3,8	2,8	0,9	1,9	2,9
Ветковский				-	3,1	1,0	1,1	1,1	2,8	5,3	5,6	6,3	2,6	5,7
Добрушский				-	2,5	-	1,7	0,9	3,5	1,8	-	-	1,8	0,9
Ельский				-	3,0	1,5	4,5	2,9	2,9	5,8	3,0	-	-	1,6
Кормянский				-	-	1,4	-	-	-	-	-	-	-	-
Лельчицкий				-	-	3,2	1,1	3,3	-	-	2,4	2,4	1,2	1,2
Лоевский				8,3	2,1	4,3	4,2	-	2,1	2,2	2,2	2,3	2,3	4,8
Наровлянский				1,6	-	-	-	3,2	1,6	-	-	2,1	-	-
Хойникский				1,6	3,2	1,7	3,5	7,9	2,7	1,8	3,6	1,2	2,3	1,1
Чечерский				2,6	2,8	8,7	3,0	1,5	1,5	6,2	6,8	9,1	-	-
Октябрьский				-	-	-	-	-	2,1	-	2,1	2,1	-	-
По области				2,2	2,7	2,7	2,8	3,2	3,1	3,7	3,1	3,1	2,0	2,1
Могилевская область														
Быховский	1,4	1,4	2,2	3,7	6,0	4,6	3,2	5,7	4,9	4,9	3,2	3,2	2,4	1,6
Климовичский	-	1,0	1,0	6,2	-	-	-	2,2	1,2	-	1,2	-	1,3	2,6
Костюковичский	-	-	1,9	2,9	1,0	-	-	1,2	-	6,3	4,0	-	4,0	2,6
Краснопольский	1,4	-	-	-	-	3,4	4,8	-	3,4	-	1,8	-	-	2,3
Славгородский	2,3	1,2	1,4	-	1,6	1,6	4,8	1,7	-	7,1	9,1	-	1,9	2,0
Чериковский	1,7	3,5	3,6	-	-	1,89	3,8	-	4,0	2,0	5,9	2,1	14,9	6,2
Горецкий	3,0	-	-	1,6	4,0	5,7	2,5	3,3	7,4	4,1	2,4	0,8	1,6	1,6
Глусский	-	-	-	-	-	-	-	-	2,0	2,1	8,7	4,2	2,1	6,38
По области	1,8	2,1	2,1	2,7	3,3	3,3	3,7	3,9	4,5	4,8	3,7	3,2	3,2	2,7

Примечание: достоверных данных о заболеваемости детского населения Гомельской области менингококковой инфекцией в 1976–1978 гг. нет.

TABLE II. Chickenpox in Children

Таблица 107. Заболеваемость детского населения контролируемых районов Гомельской и Могилевской областей ветряной оспой (на 10 000 детей)

Районы	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Гомельская область														
Брагинский					96,6	67,8	27,4	70,7	158,8	22,8	73,4	76,5	9,3	94,4
Буда-Кошелевский					101,7	57,8	112,9	183,0	77,8	44,3	111,3	217,6	161,9	60,8
Ветковский					113,4	33,0	113,2	152,8	77,2	23,4	39,3	82,3	81,3	40,0
Добрушский					182,7	192,3	279,1	338,6	151,8	282,1	212,7	244,5	264,3	271,2
Ельский					93,9	64,2	129,9	55,9	86,8	53,6	231,3	114,1	138,1	230,7
Кормянский					148,7	71,0	28,8	313,7	5,6	13,9	111,4	-	48,5	270,2
Лельчицкий					81,9	16,1	45,1	56,2	9,2	48,8	4,8	148,8	53,6	34,1
Лоевский					29,8	137,0	23,4	583,7	217,0	252,2	155,6	86,4	193,0	285,7
Наровлянский					193,6	261,7	391,8	98,4	314,5	458,1	332,1	127,7	91,3	406,3
Хойникский					12,1	38,6	249,1	38,1	178,6	109,9	77,7	145,8	54,8	267,8
Чечерский					238,0	88,4	149,3	307,7	223,1	253,1	55,9	369,1	198,2	132,7
Октябрьский					60,8	72,0	40,8	91,7	21,3	67,4	14,9	102,1	206,3	172,3
По области					222,1	210,8	226,1	280,1	213,1	247,9	264,2	215,1	197,8	265,8
Могилевская область														
Быховский	176,7	150,0	209,0	261,7	123,3	323,9	227,8	203,3	322,1	195,1	292,7	(a)	159,8	237,4
Климовичский	222,0	40,6	142,4	108,3	248,4	98,9	59,6	113,3	82,4	34,9	168,3	(a)	56,4	88,3
Костюковичский	136,0	59,3	116,2	86,4	34,7	70,8	120,7	151,9	41,3	219,0	160,0	(a)	135,1	270,1
Краснопольский	42,5	150,7	59,4	201,6	24,1	32,2	372,6	126,7	45,8	128,1	364,8	55,1	348,9	168,2
Славгородский	57,6	43,2	29,2	11,8	147,6	1,6	95,2	67,8	41,4	55,4	125,5	79,2	11,5	40,1
Чериковский	66,1	52,6	47,2	23,6	80,8	88,7	167,9	141,2	272,0	92,1	147,0	(a)	53,1	127,0
Горецкий	82,4	109,5	83,3	128,0	94,4	54,1	77,5	91,7	99,2	82,6	68,0	35,5	112,2	172,1
Глусский	65,7	257,1	120,0	133,9	89,1	269,1	316,7	180,4	46,9	157,5	363,0	285,1	376,6	78,7
По области	193,1	161,3	182,7	212,2	199,3	194,7	282,8	193,6	228,7	204,8	237,8	260,1	202,5	221,6

Примечание: достоверных данных о заболеваемости детского населения Гомельской области ветряной оспой в 1976-1978 гг. нет.

(a): Number illegible on photocopy received.

TABLE III. Measles in Children

Таблица 108. Заболеваемость детского населения контролируемых районов Гомельской и Могилевской областей корью (на 10 000 детей)

Районы	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Гомельская область														
Брагинский				-	112,4	20,7	81,0	19,6	1,3	2,5	43,8	11,8	50,0	-
Буда-Кошелевский				0,8	34,2	6,9	35,3	51,8	13,9	9,4	0,9	9,3	-	-
Ветковский				2,0	14,4	22,3	28,6	-	17,4	2,1	-	10,1	4,0	-
Добрушский				1,6	74,4	4,3	117,4	2,6	9,6	2,7	1,8	0,9	0,9	-
Ельский				-	-	50,7	77,6	82,4	-	47,8	-	-	-	-
Кормянский				-	13,5	52,2	15,1	45,2	-	1,4	-	27,1	4,4	-
Лельчицкий				11,3	33,0	10,8	2,2	6,7	62,1	1,2	-	2,4	1,2	1,2
Лоевский				6,3	76,6	-	68,1	20,4	2,1	89,1	13,3	6,8	34,9	2,4
Наровлянский				4,8	246,8	-	8,2	8,1	-	-	3,6	2,1	2,2	-
Хойникский				-	50,0	30,3	101,3	28,3	37,5	3,6	42,9	36,1	7,1	-
Чечерский				-	188,7	133,3	249,3	4,6	3,1	34,7	15,3	27,3	60,0	-
Октябрьский				-	3,9	6,0	8,2	2,1	100,0	-	-	12,5	-	-
По области				6,2	67,5	24,5	86,2	24,6	19,7	21,7	4,8	10,8	4,4	0,4
Могилевская область														
Быховский	43,2	138,6	26,9	18,0	112,0	4,6	35,7	8,1	-	3,3	-	6,6	1,6	-
Климовичский	44,0	6,9	3,0	248,5	23,7	-	-	-	-	115,7	-	2,5	-	-
Костюковичский	6,3	5,6	92,4	122,3	34,7	12,4	9,2	7,4	11,3	-	-	-	-	-
Краснопольский	-	-	-	193,4	10,3	59,3	4,8	36,7	3,4	14,0	11,1	-	-	-
Славгородский	1,2	22,2	11,1	108,8	3,2	109,7	1,6	-	1,7	12,5	-	-	-	-
Чериковский	1,7	163,2	27,3	18,9	13,5	37,7	67,9	152,9	4,0	7,8	3,9	-	-	-
Горецкий	3,8	30,7	6,3	18,4	158,4	-	12,5	27,5	0,8	66,9	-	-	0,8	-
Глусский	1,5	1,6	140,0	-	10,9	3,6	16,7	5,9	14,3	2,1	-	19,1	-	-
По области	22,8	84,4	64,8	64,7	77,9	13,4	44,1	14,7	26,8	20,6	1,9	3,7	0,7	0,3

Примечание: достоверных данных о заболеваемости детского населения Гомельской области корью в 1976–1978 гг. нет.

TABLE IV. Viral Hepatitis in Adults

Таблица 109. Заболеваемость населения контролируемых районов Гомельской и Могилевской областей вирусным гепатитом А (на 10 000 населения)

Районы	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Гомельская область														
Брагинский	6,4	19,1	14,6	9,9	16,3	76,9	74,2	34,1	14,9	14,6	11,9	7,8	12,0	27,0
Буда-Кошелевский	7,4	32,7	16,0	16,5	28,5	21,3	63,7	51,9	23,7	20,0	16,9	6,9	33,3	64,0
Ветковский	6,5	9,9	17,0	28,7	31,9	13,6	35,2	54,8	32,7	18,6	14,9	9,0	9,7	49,7
Добрушский	13,7	27,9	31,3	14,5	16,3	16,0	59,1	49,3	28,0	28,3	17,9	21,8	22,4	11,8
Ельский	26,9	14,1	12,9	10,6	27,0	55,0	48,4	40,3	25,7	45,3	16,6	20,3	19,8	49,0
Кормянский	19,7	14,9	15,8	40,6	27,2	31,3	80,5	61,6	26,5	28,3	23,7	21,2	9,7	33,1
Лельчицкий	11,0	13,1	5,6	9,9	21,1	15,9	23,6	56,7	31,1	18,6	18,5	29,1	29,5	28,0
Лоевский	24,1	8,6	3,5	9,8	13,1	42,7	46,1	60,1	23,3	18,8	24,9	11,7	13,1	46,8
Наровлянский	7,0	9,2	5,1	11,9	21,2	55,5	91,1	57,0	26,3	28,8	28,6	16,4	14,6	62,1
Хойникский	14,9	26,4	25,6	26,5	12,8	20,8	19,8	38,7	19,1	12,3	9,0	9,1	14,7	27,8
Чечерский	5,7	6,4	11,4	27,0	48,3	43,8	20,1	44,1	32,9	12,3	19,5	28,3	4,0	14,7
Октябрьский	17,6	28,9	5,3	15,2	20,8	5,1	34,0	73,0	38,9	28,2	9,1	21,1	14,9	46,8
По области	12,9	20,0	14,2	17,3	23,9	30,3	43,2	50,5	26,7	21,4	19,7	15,3	19,3	38,2
Могилевская область														
Быховский	11,1	15,7	8,8	16,8	18,5	14,8	15,8	22,8	24,5	27,1	21,2	11,7	11,8	32,0
Климовичский	9,4	21,4	10,0	47,6	25,5	31,8	13,7	54,2	29,4	17,2	9,9	20,1	26,0	27,0
Костюковичский	20,9	18,8	13,1	22,9	22,2	15,0	13,4	21,5	18,8	25,5	28,1	29,9	17,8	23,1
Краснопольский	26,9	23,9	21,7	27,3	23,4	25,3	32,8	11,0	18,7	26,3	11,6	3,4	2,6	61,0
Славгородский	19,9	29,2	9,3	19,5	28,4	27,8	34,4	60,8	17,1	17,3	17,2	8,2	7,6	12,7
Чериковский	12,7	7,1	5,8	13,7	22,2	12,6	14,2	34,4	36,6	9,4	39,1	19,1	5,4	34,1
Горецкий	19,0	8,4	9,4	14,8	29,0	36,3	41,1	35,6	52,6	29,5	15,6	4,8	8,4	51,7
Глусский	5,4	6,6	33,4	13,0	12,7	25,2	24,9	63,2	38,0	11,0	4,4	6,6	12,4	40,4
По области	13,6	15,6	15,2	20,2	22,1	27,8	32,2	43,2	29,7	26,6	20,9	16,0	18,6	40,2

TABLE V. Viral Hepatitis in Children

Таблица 110. Заболеваемость детского населения контролируемых районов Гомельской и Могилевской областей вирусным гепатитом А (на 10 000 детей)

Районы	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Гомельская область														
Брагинский				22,8	40,4	244,8	203,6	97,6	27,5	44,3	23,4	9,8	14,8	66,7
Буда-Кошелевский				40,7	55,6	50,0	198,3	139,3	54,6	34,9	30,2	12,9	100,0	182,3
Ветковский				63,7	77,3	14,9	86,8	122,0	51,1	34,0	39,3	12,7	14,7	170,0
Добрушский				26,6	37,2	25,6	161,7	137,7	61,4	52,7	30,9	48,2	48,2	31,5
Ельский				20,9	51,5	137,3	113,4	91,2	58,8	95,7	35,8	37,5	44,4	86,5
Кормянский				92,6	55,4	68,1	189,0	135,6	49,3	45,8	22,9	24,3	10,2	85,1
Лельчицкий				22,7	68,1	37,6	62,6	167,4	70,1	32,6	44,0	54,8	58,3	63,5
Лоевский				20,8	34,0	132,6	112,8	136,7	40,4	32,6	28,9	9,1	16,3	111,9
Наровлянский				19,0	58,1	185,0	280,3	164,5	41,9	61,3	62,5	29,8	21,7	152,1
Хойникский				69,3	34,7	53,8	56,1	113,3	49,1	31,5	17,9	12,0	51,2	88,5
Чечерский				76,3	138,0	139,1	50,7	126,2	84,6	23,4	42,4	87,3	1,8	41,8
Октябрьский				45,1	56,9	10,0	73,5	181,3	102,1	73,9	17,0	50,0	14,6	119,2
По области				39,7	57,8	75,0	110,5	126,3	60,2	46,3	43,3	34,5	43,9	92,9
Могилевская область														
Быховский	26,0	42,9	21,6	50,4	45,9	39,2	39,7	57,7	52,5	71,5	44,7	26,2	25,4	77,2
Климовичский	20,0	47,5	23,2	126,8	65,6	67,4	23,4	126,8	67,1	39,8	12,2	31,3	60,3	49,4
Костюковичский	50,5	42,6	24,8	55,3	53,7	32,6	23,0	49,4	37,5	55,7	80,0	61,6	39,2	49,4
Краснопольский	58,9	56,5	51,6	70,5	74,1	55,9	77,4	25,0	33,9	50,9	18,5	8,2	4,3	165,9
Славгородский	48,2	49,4	15,3	33,8	54,0	62,9	67,7	167,8	36,2	32,1	30,9	17,0	21,2	36,0
Чериковский	35,6	12,3	7,3	32,1	50,0	32,1	22,6	74,5	106,0	23,5	98,0	29,2	10,6	75,0
Горецкий	64,9	20,5	21,4	41,6	87,2	96,7	109,2	101,7	150,4	71,9	27,9	2,4	17,1	155,7
Глусский	11,9	20,6	125,0	35,7	32,7	67,3	77,8	184,3	93,9	23,4	17,4	12,8	40,4	121,3
По области	34,0	37,3	39,9	52,3	57,1	71,7	81,0	105,4	70,0	61,6	45,4	35,4	45,7	103,3

Примечание: достоверных данных о заболеваемости детского населения Гомельской области вирусным гепатитом А в 1976-1978 гг. нет.

TABLE VI. Respiratory Diseases in Adults

Таблица 111. Заболеваемость населения контролируемых районов Гомельской и Могилевской областей ОРЗ (на 10 000 населения)

Районы	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Гомельская область														
Брагинский	211,1	431,6	363,9	416,4	514,9	639,9	779,9	638,9	735,2	612,8	358,0	522,9	893,4	685,3
Буда-Кошелевский	545,8	348,9	385,2	514,5	438,6	462,0	428,9	363,6	418,6	355,1	543,4	761,4	709,6	899,0
Ветковский	1051,3	1118,4	1247,6	1422,3	1571,4	1369,1	1157,7	973,9	841,7	763,2	555,6	919,1	745,1	529,7
Добрушский	1384,7	1373,5	1048,7	1255,2	971,1	1251,2	1249,5	1035,7	1091,2	1015,1	444,9	694,6	1191,4	1582,2
Ельский	894,9	1330,8	1419,7	1536,0	1628,0	1943,6	1789,0	1991,7	2141,7	1762,3	1785,2	1460,5	2445,4	2153,7
Кормянский	328,3	254,7	292,2	208,0	326,8	553,9	565,1	1071,9	269,1	62,08	60,31	47,4	50,9	428,0
Лельчицкий	598,5	647,2	644,2	737,9	625,3	956,8	757,8	725,9	967,4	807,5	681,5	521,9	797,6	784,6
Лоевский	823,7	842,9	603,5	856,8	1536,9	1350,0	1364,1	1263,9	1519,0	1303,4	126,1	1065,3	1212,1	697,0
Наровлянский	652,17	768,4	708,8	884,9	1070,2	1089,0	972,5	1061,9	1069,4	960,7	891,8	1082,2	1719,3	1367,7
Хойникский	116,0	157,4	83,8	41,5	153,3	141,3	109,4	143,3	490,5	453,51	345,9	607,1	915,5	1088,0
Чечерский	831,8	832,6	991,6	1032,8	758,8	818,9	692,4	776,0	647,0	714,0	765,7	960,8	1050,2	906,2
Октябрьский	1031,8	1140,9	1286,0	1423,3	1376,8	1657,1	1289,6	1288,2	1616,7	2344,6	2203,6	2031,2	2249,5	2143,4
По области	1702,1	1788,5	1722,5	1774,2	1747,9	1781,2	1679,7	1752,4	1860,5	1715,3	1797,6	1740,9	1993,1	2152,4
Могилевская область														
Быховский	1182,6	1331,9	1274,3	1299,7	1176,5	1137,9	1262,8	1128,0	1433,9	1237,7	1242,4	1140,4	1305,1	1425,3
Климовичский	750,4	689,2	819,8	609,2	744,3	793,7	597,5	128,1	153,1	1378,6	1112,0	1024,9	1551,5	1348,8
Костюковичский	668,2	726,6	547,5	778,9	883,9	917,0	819,3	950,6	112,3	928,1	765,4	633,5	721,7	750,4
Краснопольский	392,5	386,5	344,9	346,6	311,9	411,8	410,8	455,7	628,7	503,1	568,8	365,5	736,7	1204,0
Славгородский	296,1	251,2	110,3	1269,5	956,4	862,3	469,9	413,6	416,5	834,9	894,1	652,4	665,3	572,9
Чериковский	609,0	717,9	630,0	630,7	587,1	663,4	831,4	858,4	801,3	787,5	713,0	653,9	686,7	762,6
Горецкий	996,6	1130,8	1045,9	1158,6	1176,3	1135,5	1165,0	1304,5	1463,7	1524,8	1523,2	1381,8	1782,7	(a)
Глусский	717,6	539,5	460,8	769,3	795,6	826,4	621,5	772,2	729,7	750,4	584,5	477,1	741,3	598,6
По области	1569,7	1757,3	1626,4	1775,0	1728,4	1799,3	1630,0	1806,6	1900,4	1792,3	1955,0	1799,1	2176,4	2052,9

(a): Number illegible on photocopy received.

TABLE VII. Respiratory Diseases in Children

Таблица 112. Заболеваемость детского населения контролируемых районов Гомельской и Могилевской областей ОРЗ (на 10 000 детей)

Районы	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Гомельская область														
Брагинский				1815,2	2177,5	2464,4	3182,1	2897,6	3496,3	2860,8	1743,8	2105,9	3453,7	2870,4
Буда-Кошелевский				1082,2	814,5	716,4	1335,3	1269,6	1438,9	967,0	1670,8	2203,7	1801,0	2725,5
Ветковский				2740,2	3169,1	3258,5	2941,8	2512,1	1587,0	1124,5	1136,0	2008,9	1316,0	1378,6
Добрушский				3453,2	3273,6	4494,9	4475,7	3843,0	4191,2	3281,3	1439,1	1884,5	3691,1	5054,1
Ельский				4359,7	3827,3	4880,6	4513,4	4479,4	5350,0	4118,8	4746,3	3695,3	6758,7	5338,7
Кормянский				379,0	808,1	1647,8	1739,7	3347,9	667,6	95,83	71,43	44,29	55,88	950,8
Лельчицкий				1858,8	1441,5	2073,1	2394,5	2085,4	2693,1	2187,2	1878,6	1428,6	2141,7	2341,2
Лоевский				2550,0	4853,2	4523,9	4900,0	3757,1	5014,9	4756,5	4700,0	2959,9	2941,9	1650,0
Наровлянский				2482,5	3482,3	4010,0	3436,1	3541,9	2937,1	3150,0	2137,5	3446,8	6173,9	3629,2
Хойникский				127,6	257,3	169,8	199,1	197,35	787,5	793,7	579,5	1560,2	2567,9	2492,0
Чечерский				2367,1	2121,1	2194,2	1850,7	2053,8	1806,2	1695,3	2106,8	3207,3	3001,8	2147,3
Октябрьский				3931,4	3186,3	3364,0	4400,0	3795,8	4542,6	8315,2	6617,0	5239,6	6114,6	5608,5
По области				4520,4	4376,3	4749,7	4682,8	4723,5	5140,3	4732,1	4655,1	4793,6	5188,5	5395,8
Могилевская область														
Быховский	3191,1	3768,6	3327,6	2978,2	2947,4	2800,0	3750,0	3336,6	4061,5	3567,5	3595,1	4009,0	4412,3	4933,3
Климовичский	1135,0	1006,9	1321,2	1197,9	1436,6	1813,0	1566,0	4070,0	5037,6	4656,6	3467,1	3166,3	4341,0	3742,9
Костюковичский	1105,4	519,4	845,7	1506,8	1604,2	1849,4	1736,8	1718,5	1978,8	1648,1	1648,0	1426,0	1423,0	1413,0
Краснопольский	646,6	581,2	506,3	447,5	450,0	778,0	738,7	771,7	1298,3	1135,1	1120,4	634,7	1455,3	3709,1
Славгородский	760,0	543,2	175,0	369,7	3317,5	2816,1	1253,2	888,1	1034,5	1691,1	2174,5	1722,6	1444,2	1440,0
Чериковский	1342,4	1950,9	1829,1	1879,2	1734,6	2032,1	2711,3	2733,3	2584,0	2582,4	2496,1	2316,7	2163,8	2245,8
Горецкий	2631,3	3294,5	3235,7	3787,2	3236,0	3233,6	2799,2	3528,3	3955,4	4406,6	4960,7	4940,3	5963,4	4366,4
Глусский	1204,5	1250,8	1133,3	1667,9	1640,0	1436,4	959,3	1666,7	1298,0	1483,0	1678,3	1487,2	2261,7	1666,0
По области	3731,7	4358,1	4327,8	4770,3	4871,8	5046,1	4680,7	5129,9	5381,7	2137,3	5633,4	5579,6	6454,4	5805,0

Примечание: достоверных данных о заболеваемости детского населения Гомельской области ОРЗ в 1976–1978 гг. нет.

TABLE VIII. Viral Morbidity in Adults

Таблица 113. Заболеваемость населения контролируемых районов Гомельской и Могилевской областей гриппом (на 10 000 населения)

Районы	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Гомельская область														
Брагинский	124,5	56,8	16,8	7,2	182,8	38,3	98,8	93,4	207,8	131,5	-	18,3	34,3	141,7
Буда-Кошелевский	678,1	88,6	34,0	10,2	136,8	18,4	24,6	27,5	175,7	17,7	100,0	9,4	66,0	87,0
Ветковский	721,5	79,2	36,0	46,7	201,4	207,3	57,4	41,3	77,6	77,6	29,3	-	11,8	56,3
Добрушский	597,8	163,4	56,4	32,9	313,6	393,6	103,1	217,1	480,0	340,8	66,4	31,7	406,8	343,5
Ельский	715,3	261,2	152,0	14,5	539,0	393,9	54,1	53,2	388,0	-	134,0	1,9	181,3	73,2
Кормянский	168,3	119,9	3,4	14,1	89,8	285,9	77,4	-	184,2	7,1	-	-	8,6	9,7
Лельчицкий	330,6	103,4	47,7	12,7	160,2	166,3	27,4	15,6	256,0	63,5	10,0	-	37,8	8,0
Лоевский	342,2	23,2	17,9	27,6	290,1	265,5	81,1	148,8	248,6	174,4	68,7	2,0	29,3	96,1
Наровлянский	945,2	286,8	99,3	53,6	267,1	500,7	101,4	201,8	479,4	80,6	-	-	249,1	0,5
Хойникский	182,8	51,4	8,1	3,0	3,0	91,9	105,8	1,9	76,6	95,8	49,1	8,0	528,6	97,1
Чечерский	248,1	241,1	43,2	3,7	191,1	168,9	65,8	32,9	188,8	30,3	3,3	8,7	140,4	87,2
Октябрьский	442,3	25,9	-	10,0	384,1	193,1	58,0	158,3	597,0	331,3	5,1	-	1037,1	46,3
По области	836,7	305,3	144,5	36,3	519,6	557,3	153,0	370,1	721,3	313,0	328,9	9,1	601,5	417,4
Могилевская область														
Быховский	606,2	216,3	90,4	79,5	34,1	548,5	122,4	41,6	381,2	362,5	71,7	14,2	411,8	354,3
Климовичский	452,8	169,0	0,8	10,0	373,8	179,4	28,4	-	126,2	121,4	22,7	-	135,9	26,0
Костюковичский	294,5	396,7	141,0	105,7	117,1	91,1	53,9	47,1	142,6	182,3	86,1	80,1	228,2	79,2
Краснопольский	47,0	54,1	18,9	2,4	83,3	16,3	17,0	0,4	0,4	82,6	0,5	0,5	29,6	11,0
Славгородский	115,3	162,1	12,6	33,5	214,4	199,0	43,2	70,0	165,0	95,1	169,8	-	143,6	195,6
Чериковский	417,1	107,1	130,8	32,8	87,2	32,6	59,3	2,2	197,3	56,3	45,6	-	1,5	-
Горецкий	242,6	615,6	73,4	28,7	521,8	467,2	29,8	34,1	81,8	170,9	3,3	1,4	190,7	161,9
Глусский	177,3	44,0	50,0	21,5	274,6	235,5	45,6	103,4	285,6	136,4	42,3	-	152,9	97,3
По области	590,2	27,3	154,4	94,4	435,8	607,0	167,4	255,9	516,6	327,6	215,8	8,7	553,0	331,2

TABLE IX. Viral Morbidity in Children

Таблица 114. Заболеваемость детского населения контролируемых районов Гомельской и Могилевской областей гриппом (на 10 000 детей)

Районы	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Гомельская область														
Брагинский				4,3	365,2	45,5	378,6	389,0	688,8	335,4	-	-	129,6	242,6
Буда-Кошелевский				3,4	280,3	26,7	56,0	39,3	625,9	42,5	159,4	0,9	99,0	96,1
Ветковский				127,5	246,4	478,7	206,6	145,1	164,1	21,3	36,0	-	274,7	147,1
Добрушский				6,5	535,5	834,2	211,3	662,3	1205,3	635,7	135,5	27,3	1215,2	693,7
Ельский				7,5	916,7	609,0	104,5	54,4	258,8	-	204,5	-	269,8	41,9
Кормянский				-	74,3	450,7	113,7	-	111,3	4,2	-	-	5,9	17,9
Лельчицкий				17,5	274,5	238,7	98,9	9,0	452,9	175,6	20,2	-	122,6	7,1
Лоевский				10,4	393,6	567,4	53,2	389,8	683,0	545,7	95,6	-	737,2	238,1
Наровлянский				34,9	374,2	1150,0	380,3	491,9	1201,6	48,4	-	-	8,7	2,1
Хойникский				2,4	5,6	250,4	217,5	2,7	168,8	248,7	12,5	-	1151,2	123,0
Чечерский				1,3	212,7	433,3	86,6	92,3	347,7	76,6	3,4	45,5	267,3	129,1
Октябрьский				19,6	552,9	348,0	234,7	572,9	1585,1	956,5	4,3	-	2658,3	74,5
По области				73,7	795,1	1204,7	344,5	875,6	1468,5	719,2	803,9	11,7	1508,1	816,8
Могилевская область														
Быховский	647,3	400,7	248,6	115,0	427,1	1026,2	300,0	130,1	773,0	446,3	252,9	54,1	1382,8	1142,3
Климовичский	682,0	201,0	-	5,2	560,2	233,7	64,9	-	108,2	291,6	84,1	-	57,7	6,5
Костюковичский	339,6	203,7	157,1	151,5	131,6	250,6	112,6	59,3	130,0	15,2	105,3	112,3	370,3	87,0
Краснопольский	31,5	101,5	15,6	6,6	44,8	16,9	66,1	-	1,7	82,5	-	-	53,2	34,1
Славгородский	200,0	264,2	9,7	35,3	538,1	661,3	75,8	86,4	196,6	205,4	149,1	-	298,1	234,0
Чериковский	591,5	94,7	278,2	32,1	176,9	30,2	232,1	9,8	672,0	92,2	131,4	-	-	-
Горецкий	406,1	918,1	92,9	22,4	804,8	745,1	92,5	60,0	143,0	318,2	10,7	0,8	435,0	152,5
Глусский	94,0	87,3	106,7	21,4	256,4	514,6	90,7	211,8	867,4	229,8	43,5	-	393,6	153,2
По области	928,9	526,7	289,3	152,4	647,1	1440,2	532,1	653,2	1296,5	780,4	518,6	16,1	1431,0	752,4

Примечание: достоверных данных о заболеваемости детского населения Гомельской области гриппом в 1976-1978 гг. нет.

Director General's Closing Remarks

I said at the opening of the Conference that if the Chernobyl study and the discussions here will help to clarify the radiological consequences in the three affected Republics the study would have served its purpose. I trust that the determination of those who participated in the study to respect scientific principles in their inquiry has been amply demonstrated in your reading and discussion of the Report, and that the results also have been found to be highly relevant. It has been in line with the scientific principles that we respect in the IAEA to subject this Report to an open, international, scientific discussion among experts, and I know that your discussions in the course of this week have been intense. We welcome that. Only through an open, critical debate in the international scientific community can we achieve a true picture.

I am reminded of a passage in a book by Barbara Tuchman about the Middle Ages, *A distant mirror*, where she writes that the question of the cause of the plague was submitted to the faculty of Paris University. After very long deliberation the faculty officially reported that the plague was due to a particular constellation of the stars. Such obscurities are serious, because if you have a completely wrong diagnosis, you cannot find the right remedy, and it is only by means of rational inquiry that the right remedies will be found. I think the inquiries made by the International Advisory Committee and the critical discussions of these inquiries represent a contribution to such a search for truth.

My impression is that the points that have attracted most criticism were about matters which were not included in the Report. I think you will have perceived that the limitations designed or experienced were certainly not intended to influence the overall picture; they were made for practical reasons. Reference has been made repeatedly to the decontamination workers and to the people who were evacuated. I think there is a clear consensus that it is highly desirable that the present study be supplemented by studies of these groups. There is no question about it. But I think there is a reason why it was decided not to include these groups in the study and not to insist that they should be. There is very great concern in contaminated areas which are inhabited, be it in the UkrSSR, the BSSR or the RSFSR, as to whether people would need to be evacuated and whether they would need to subject themselves to highly restrictive diets. These problems do not arise in the case of those who were sent as decontamination workers or those who were living there but were evacuated; they are now living in areas which are not contaminated and they are not eating contaminated food. That is not to say that they are an uninteresting group, but I think it was understandably agreed that these groups were not to be included at the present stage, and this without any prejudice to the need to study them later. That was the reason why it was deemed acceptable not to study these groups. There is also the practical problem that they are now dispersed over a huge country.

I would like to end by saying that this Project would have been impossible without the contribution of the many individuals, like you, Professor Shigematsu, like the members of the International Advisory Committee, the many Soviet scientists who helped us, the staff in this organization and others, and the many governments that have assisted by donating the time of their scientists or giving equipment. This organization, the IAEA, as one of the participants, has been living at zero growth in real terms in our budget for eight years, and I understand that this Project has cost us about US $500 000 altogether, although the cost of the entire Project is much greater. The work has been completed in a short time, and we are grateful for the intensity with which it has been pursued. I hear that the WHO is planning to undertake a very large project and that they are already practically sure of having at least 20 million dollars at their disposal. We welcome this. We welcome further supplementing studies in the search for the truth in order to find the best remedies to help the people.

Let me thank you all for what you have done in this study and for the discussions that have taken place here during this week. Thank you.

Hans Blix
Director General
International Atomic Energy Agency
Vienna

Chairman's Closing Remarks

I am very happy to be able to close this Conference which has achieved such fruitful results owing to the efforts and co-operation of everyone here. Please allow me to repeat what I said in my opening address. Our report does not mean the end of the Chernobyl Project but should rather be considered the starting point for further international co-operation.

A tragedy such as the Chernobyl accident must never be repeated. We can, however, be proud that so many international experts in a number of disciplines from various countries and organizations have worked together in a friendly and enthusiastic manner towards the same goal: to serve the Chernobyl victims. We are well aware that this goal could not have been attained without great co-operation and support from our Soviet colleagues. It is my sincere hope that this kind of international teamwork for peaceful purposes will be encouraged.

My deepest thanks are due to all those who contributed to this work: members of the International Advisory Committee, consultants, task group leaders and all the experts who participated, the Secretariat of the Project and the many officials of the USSR, the BSSR, the UkrSSR and the RSFSR who gave their time and efforts.

Finally, will you please join me in expressing our thanks to those who worked so hard behind the scenes to prepare and service this meeting: IAEA secretaries, interpreters, engineers and all the others.

Itsuzo Shigematsu
Director
Radiation Effects Research Foundation
Hiroshima
Japan

List of Participants

Abdulla, M.
University of Lund,
P.O. Box 5133,
S-220 05 Lund, Sweden

Abu Bakr, A.
Division of Technical Co-operation Programmes,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Acharya, S.
United States Department of Energy,
1000 Independence Avenue,
Washington, DC 20585, United States of America

Al-Matooq, M.
Permanent Mission of Iraq to the IAEA,
Johannesgasse 26,
A-1010 Vienna, Austria

Alvárez-Miranda, A.
Spanish Atomic Forum,
Boix y Morer 6,
E-28003 Madrid, Spain

Anderer, J.
Division of Nuclear Safety,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Andrasi, A.
Central Research Institute for Physics,
Hungarian Academy of Sciences,
P.O. Box 49,
H-1525 Budapest, Hungary

Anspaugh, L.R.
Lawrence Livermore National Laboratory,
P.O. Box 5507/L-453,
Livermore, CA 94550, United States of America

Anstee, M.J.
United Nations,
Wagramerstrasse 5, P.O. Box 500,
A-1400 Vienna, Austria

Aoki, Y.
University of Tokyo,
7-3-1 Hongo, Bunkyo-ku,
Tokyo 113, Japan

Asculai, E.
(Scientific Secretary)
Division of Nuclear Safety,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Barabanova, A.
Division of Nuclear Safety,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Bar'yakhtar, V.G.
Academy of Sciences of the UkrSSR,
Kiev, UkrSSR

Bauerstam, U.
National Institute of Radiation Protection,
P.O. Box 60204,
S-104 01 Stockholm, Sweden

Bauman, A.
Institute for Medical Research and Occupational Health,
University of Zagreb,
P.O. Box 291,
YU-41000 Zagreb, Yugoslavia

Beets, C.
Permanent Mission of Belgium to the IAEA,
Operngasse 20b,
A-1040 Vienna, Austria

Belyaev, S.T.
I.V. Kurchatov Institute of Atomic Energy of the Ministry of Atomic Power and Industry of the USSR,
123182 Moscow, USSR

Benini, A.
Division of Nuclear Safety,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Bennett, B.G.
United Nations Scientific Committee on the Effects of Atomic Radiation,
Wagramerstrasse 5, P.O. Box 500,
A-1400 Vienna, Austria

Bennett, L.
Division of Nuclear Power,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Beránek, J.
Czechoslovak Atomic Energy Commission,
Prague, Czechoslovakia

Bianco, A.
Ente Nazionale per l'Energia Elettrica,
Viale Regina Margherita 125,
I-00198 Rome, Italy

Binner, W.
Österreichisches Forschungszentrum Seibersdorf GmbH,
A-2444 Seibersdorf, Austria

Birol, E.
Permanent Mission of Turkey to the IAEA,
Zieglergasse 5,
A-1070 Vienna, Austria

Bobyleva, O.A.
Department of Radiation Hygiene of the
Ministry of Health of the UkrSSR,
Kiev, UkrSSR

Boeri, G.
Direzione per la Sicurezza Nucleare e Protezione Sanitaria,
Comitato Nazionale per la Ricerca e per lo Sviluppo
dell'Energia Nucleare e delle Energie Alternative,
Via Brancati 48,
I-00148 Rome, Italy

Borodastov, G.V.
Working Group of the Ministry of Atomic Power
and Industry of the USSR on Implementation of
the International Chernobyl Project,
Staromonetny 26,
Moscow, USSR

Borovikov, V.
Permanent Mission of the BSSR to the IAEA,
Erzherzog Karl-Strasse 182,
A-1220 Vienna, Austria

Borrás, C.
Pan American Health Organization,
525, 23rd Street NW,
Washington, DC 20037, United States of America

Bouville, A.
National Cancer Institute,
c/o Environmental Measurements Laboratory,
376 Hudson Street,
New York, NY 10014, United States of America

Bridi, D.
Agency's Laboratory,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Brubaker, T.
RAD Elec. Inc.,
9000 Brieryie Road,
Richmond, VA 23229, United States of America

Buchtela, K.
Atominstitut der Österreichischen Universitäten,
Schüttelstrasse 115,
A-1020 Vienna, Austria

Buldakov, L.A.
Institute of Biophysics of the Ministry of Health
of the USSR,
123182 Moscow, USSR

Burkart, K.
Kernforschungszentrum/FTU,
P.O. Box 3640,
D-W 7500 Karlsruhe 1, Germany

Burkart, W.
Institut für Strahlenhygiene,
Ingolstädter Landstrasse 1,
D-W 8042 Neuherberg/Munich, Germany

Burmester, K.
Bundesamt für Strahlenschutz,
Sessenerstrasse 80,
Salzgitter, Germany

Bush, W.R.
Division of Nuclear Safety,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Bussurin, Yu.N.
Ministry of Atomic Power and Industry of the USSR,
11910 Moscow, USSR

Carnino, A.
Division of Nuclear Safety,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Chang, J-O.
Division of Nuclear Safety,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Chelyukanov, V.V.
State Committee for Hydrometeorology of the USSR,
Moscow, USSR

Christensen, G.C.
Institutt for Energiteknikk,
P.O. Box 40,
N-2007 Kjeller, Norway

Congdon, M.
Division of Nuclear Safety,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Cooper, E.L.
Agency's Laboratory,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Coppée, G.H.
International Labour Organisation,
4, route des Morillons,
CH-1211 Geneva 22, Switzerland

Cortes-Toro, E.
Division of Life Sciences,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Coulon, R.
Institut de protection et de sûreté nucléaire,
Commissariat à l'énergie atomique,
B.P. 6,
F-92265 Fontenay-aux-Roses Cedex, France

Crick, M.J.
Division of Nuclear Safety,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Danesi, P.R.
Agency's Laboratory,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Dargie, J.
Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Dekner, R.
Agency's Laboratory,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Delves, D.
Division of Nuclear Safety,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Demin, V.F.
I.V. Kurchatov Institute of Atomic Energy of the Ministry of Atomic Power and Industry of the USSR,
123182 Moscow, USSR

Dircks, W.
Department of Administration,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Djuric, G.
Yugoslav Radiological Protection Association,
Slobodana Penezica 35,
YU-11000 Belgrade, Yugoslavia

Dones, R.
Division of Nuclear Safety,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Dong, Bainian
Permanent Mission of China to the IAEA,
Steinfeldgasse 1,
A-1190 Vienna, Austria

Dotres, C.
Ministerio de Salud Pública (MINSAP),
7924 Calle Vento, Alta Habana,
Havana, Cuba

Dreicer, M.
(Programme Manager)
Division of Nuclear Safety,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Dubinchuk, V.
Division of Physical and Chemical Sciences,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Duke, B.
Economic Commission for Europe,
Palais des Nations,
CH-1211 Geneva 10, Switzerland

Duncan, K.
(Formerly: National Radiological Protection Board)
Westfield, Steeple Aston,
Oxfordshire OX5 3SD, United Kingdom

Dushutin, K.K.
Pripyat Scientific Production Group,
Chernobyl, UkrSSR

Eberhard, C.
Office of Nuclear Technology and Safeguards,
United States Department of State,
Washington, DC 20520, United States of America

Edvardson, K.
National Institute of Radiation Protection,
P.O. Box 60204,
S-104 01 Stockholm, Sweden

Efremenkov, V.M.
State Committee of the BSSR on Rectification of the Consequences of the Chernobyl Accident,
House of the Government,
220010 Minsk, BSSR

Eggleton, A.
AEA Technology,
Building 551, Harwell, Didcot,
Oxfordshire OX11 0RA, United Kingdom

Erwin, R.A.
Division of Nuclear Safety,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Esmaili, A.
Permanent Mission of the Islamic Republic of Iran to the IAEA,
Jaurèsgasse 9,
A-1030 Vienna, Austria

Esteve, J.
International Agency for Research on Cancer,
150, Cours Albert Thomas,
F-69372 Lyon Cedex 08, France

Fairobent, L.
United States Department of Energy,
M/S EH1, 1000 Independence Avenue,
Washington, DC 20585, United States of America

Fazarinć, A.
University Institute for Public Health and Social Care,
Trubarjeva 2,
YU-61000 Ljubljana, Yugoslavia

Finzi, S.
Nuclear Safety Research,
Commission of the European Communities,
Rue de la Loi 200,
B-1049 Brussels, Belgium

Flakus, F-N.
Division of Nuclear Safety,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Franzen, F.
Division of Nuclear Safety,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

French, G.S.
School of Computer Studies,
University of Leeds,
Leeds, W. Yorkshire LS2 9JT, United Kingdom

Fritelli, L.
Direzione per la Sicurezza Nucleare e Protezione Sanitaria,
Comitato Nazionale per la Ricerca e per lo Sviluppo dell'Energia Nucleare e delle Energie Alternative,
Via Brancati 48,
I-00148 Rome, Italy

Fröhlich, F.
Agency's Laboratory,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Fry, F.A.
National Radiological Protection Board,
Chilton, Didcot,
Oxfordshire OX11 0RQ, United Kingdom

Gadola, A.
Ente Nazionale per l'Energia Elettrica,
Viale Regina Margherita 137,
I-00198 Rome, Italy

Gaensbacher, J.
Agency's Laboratory,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

García, O.
Centro de Protección e Higiene de las Radiaciones (CPHR),
Calle 20, No. 4110e/18A y 47,
Playa La Habana, Havana, Cuba

Gentner, N.E.
Atomic Energy of Canada Ltd,
Chalk River Laboratories,
Chalk River, Ontario, Canada K8H 2W8

Gil, E.
Consejo de Seguridad Nuclear,
Justo Dorado 11,
E-28040 Madrid, Spain

Gillon, L.
Centre d'étude de l'énergie nucléaire,
Boeretang 200,
B-2400 Mol, Belgium

Gittus, J.
British Nuclear Forum,
22 Buckingham Gate,
London SW1, United Kingdom

González, A.J.
Division of Nuclear Safety,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Gordeev, K.I.
Institute of Biophysics of the Ministry of Health of the USSR,
123182 Moscow, USSR

Goto, S.
Chubu Electric Power Co.,
73 Brook Street,
London W1Y 1YE, United Kingdom

Gotovchits, G.A.
State Committee of the Council of Ministers of the UkrSSR on Protection of the Population from the Consequences of the Accident at the Chernobyl Nuclear Power Plant,
Kiev, UkrSSR

Govaerts, P.
Centre d'étude de l'énergie nucléaire,
Boeretang 200,
B-2400 Mol, Belgium

Gregorič, M.
Rep. Adm. for Nuclear Safety of Slovenia,
Kardeljeva Ploščad 24,
YU-61113 Ljubljana, Yugoslavia

Grey, J.A.
Australian Nuclear Science and Technology Organization,
Lucas Heights Research Laboratories,
Private Mail Bag 1,
Menai, NSW 2234, Australia

Grodzinskij, D.M.
Institute of Botanics of the Academy of Sciences of the UkrSSR,
Vladimirskaya 54,
252000 Kiev, UkrSSR

Gubanov, V.A.
State Committee of the USSR Council of Ministers on the Rectification of the Consequences of the Accident at the Chernobyl Nuclear Power Plant,
Gorkij Street 33,
Moscow, USSR

Gus'kova, A.K.
Institute of Biophysics of the Ministry of Health of the USSR,
123182 Moscow, USSR

Gustafsson, M.
Swedish State Power Board,
Vattenfall, PUSR/2,
S-162 87 Vällingby, Sweden

Gutiérrez, J.
Instituto de Protección Radiológica y Medio Ambiente de CIEMAT,
Avenida Complutense 22,
E-28040 Madrid, Spain

Gwynne, M.
United Nations Environment Programme,
IAEA Office, United Nations,
Room B426, Palais des Nations,
CH-1211 Geneva 10, Switzerland

Hamada, R.
Permanent Mission of Tunisia to the IAEA,
Ghegastrasse 3,
A-1030 Vienna, Austria

Hance, R.J.
Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Hara, H.
Chubu Electric Power Co.,
73 Brook Street,
London W1Y 1YE, United Kingdom

Hashimi, J.A.
Permanent Mission of Pakistan to the IAEA,
Hofzeile 13,
A-1190 Vienna, Austria

Hedemann Jensen, P.
Department of Health Physics,
Risø National Laboratory,
P.O. Box 49,
DK-4000 Roskilde, Denmark

Hefner, A.
Österreichisches Forschungszentrum Seibersdorf GmbH,
A-2444 Seibersdorf, Austria

Heinzelmann, M.
Forschungszentrum Jülich GmbH,
P.O. Box 1913,
D-W 5170 Jülich, Germany

Henrich, E.
Bundesanstalt für Lebensmitteluntersuchung und Forschung,
Abt. Strahlenschutz,
Berggasse 11,
A-1090 Vienna, Austria

Hide, K.
Division of Nuclear Safety,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Hill, J.
British Nuclear Forum,
22 Buckingham Gate,
London SW1, United Kingdom

Hille, P.
Institut für Radiumforschung und Kernphysik,
Universität Wien,
A-1090 Vienna, Austria

Ho, N.
Permanent Mission of the Republic of Korea to the IAEA,
Praterstrasse 31,
A-1020 Vienna, Austria

Hochmann, R.
Agency's Laboratory,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Hoe, S.
Civil Protection Agency,
16 Datavej, Birkerød,
DK-2100 Copenhagen, Denmark

Hofkirchner, P.
United Nations,
Wagramerstrasse 5, P.O. Box 500,
A-1400 Vienna, Austria

Hogg, G.R.
Permanent Mission of Australia to the IAEA,
Mattiellistrasse 2-4,
A-1040 Vienna, Austria

Hosoda, Y.
Radiation Effects Association,
Institute of Radiation Epidemiology,
1-9-8 Uchikanda 1, Chiyoda-ku,
Tokyo 101, Japan

Hu, Zunsu
China Institute for Radiation Protection,
P.O. Box 120,
Taiyuan, 030006 Shanxi, China

Huyskens, C.J.
International Radiation Protection Association,
Eindhoven University of Technology,
P.O. Box 662,
NL-5600 MB Eindhoven, Netherlands

Ignatenko, E.I.
Ministry of Atomic Power and Industry of the USSR,
11910 Moscow, USSR

Ilari, O.
Nuclear Energy Agency of the Organisation for Economic Co-operation and Development,
38, boulevard Suchet,
F-75016 Paris, France

Il'in, L.A.
Institute of Biophysics of the Ministry of Health of the USSR,
123182 Moscow, USSR

Iljas, J.
Permanent Mission of Indonesia to the IAEA,
Gustav Tschermak-Gasse 5-7,
A-1180 Vienna, Austria

Irlweck, K.
Institute of Inorganic Chemistry,
University of Vienna,
Währingerstrasse 42,
A-1090 Vienna, Austria

Itakura, S.
Atomic Energy Bureau, STA,
Policy Division,
2-2-1 Kasumigaseki 2, Chiyoda-ku,
Tokyo 100, Japan

Ivanov, S.I.
Ministry of Health of the USSR,
Moscow, USSR

Ivanov, V.K.
Institute of Medical Radiology of the Academy of Medical Sciences of the USSR,
Korolev 4,
Kaluga Region, Obninsk, USSR

Iwasaki, T.
National Institute of Radiological Sciences,
Anagawa 4-9-1, Chiba 260, Japan

Jarvis, F.
International Confederation of Free Trade Unions,
Rue Montagne aux Herbes Potagères 37-41,
B-1000 Brussels, Belgium

Jovanovich, J.
Department of Physics,
University of Manitoba,
Winnipeg, Manitoba, Canada R3T 2N2

Jurina, V.
Ministry of Health of the Slovak Republic,
Bratislava, Czechoslovakia

Kabanov, L.
Division of Nuclear Safety,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Kaltenecker, H.
United Nations Educational, Scientific and Cultural Organization,
7, place de Fontenoy,
F-75007 Paris, France

Katz, M.
Permanent Mission of the United States of America to the IAEA,
Obersteinergasse 11/1,
A-1190 Vienna, Austria

Kayser, P.
Ministère de la Santé,
Rue Fr. Faber 6,
L-1135 Luxembourg

Kelly, N.G.
Directorate General for Science, Research and Development,
Commission of the European Communities,
Rue de la Loi 200,
B-1049 Brussels, Belgium

Kenik, I.A.
Council of Ministers of the BSSR,
Lenin Square,
220600 Minsk, BSSR

Kenneke, A.
Office of Governmental and Public Affairs,
US Nuclear Regulatory Commission,
Mailstop 385,
Washington, DC 20555, United States of America

Kerekes, A.
Frédéric Joliot-Curie National Research Institute for Radiobiology and Radiohygiene,
P.O. Box 101,
Budapest, Hungary

Khashaba, A.K.
Permanent Mission of Saudi Arabia to the IAEA,
Formanekgasse 38,
A-1190 Vienna, Austria

Kienzl, K.
Federal Environmental Agency,
Ministry of Environment, Youth and Family,
Spittelauer Lände 5,
A-1090 Vienna, Austria

Kimura, T.
Permanent Mission of Japan to the IAEA,
Prinz Eugen-Strasse 8–10,
A-1040 Vienna, Austria

Kirchmann, R.
International Union of Radioecologists,
Maison des associations internationales,
University of Liège,
Oupeye, Belgium

Kislyak, S.
University of Foreign Affairs,
Smolenskaya Semnaya,
Moscow, USSR

Köhler, H.
Division of Nuclear Fuel Cycle,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Kolb, H.
Forum für Atomfragen,
Hohe Warte 38,
A-1190 Vienna, Austria

Kolechov, I.I.
Permanent Mission of the USSR to the IAEA,
Erzherzog Karl-Strasse 182,
A-1220 Vienna, Austria

Komarov, E.N.
Leningrad Scientific Research Institute of Radiation of the Ministry of Health of the USSR,
189646 Leningrad, USSR

Konoplya, E.F.
Institute of Radiology of the Academy of Sciences of the BSSR,
Minsk, BSSR

Korun, M.
Institut Jozef Stefan,
Jamova 39,
YU-61111 Ljubljana, Yugoslavia

Kostenko, Yu.V.
Permanent Mission of the UkrSSR to the IAEA,
Erzherzog Karl-Strasse 182,
A-1200 Vienna, Austria

Kromp, W.
Institute of Solid State Physics,
University of Vienna,
Strudlhofgasse 4,
A-1090 Vienna, Austria

Krüger, W.
Bundesamt für Strahlenschutz,
Dienststelle Berlin,
Waldowallee 117,
D-O 1157 Berlin, Germany

Kudryashov, A.S.
Permanent Mission of the USSR to the IAEA,
Erzherzog Karl-Strasse 182,
A-1220 Vienna, Austria

Kuhar, B.
Zavod R Sloventje Za Varstvo,
Bohoričeva 22a,
Ljubljana, Yugoslavia

Kumar-Frauendorfer, E.
Austrian Foreign Ministry/University of Vienna,
Minoritenplatz 3,
Dr. Karl Lueger-Ring 1,
A-1010 Vienna, Austria

Kunz, R.
Permanent Mission of Switzerland to the IAEA,
Wagramerstrasse 14,
A-1220 Vienna, Austria

Kuramoto, A.
Research Institute for Nuclear Medicine and Biology,
Hiroshima University Hospital,
Kasumi 1-2-3, Minami-ku,
Hiroshima 734, Japan

Kurchenko, F.P.
Council of Ministers of the USSR,
State Commission for Foodstuffs and Supplies,
Moscow, USSR

Kuroda, M.
Joint Inspection Unit,
United Nations, Palais des Nations,
CH-1211 Geneva, Switzerland

Lacanale, L.
Permanent Mission of the Philippines to the IAEA,
Nedergasse 34,
A-1190 Vienna, Austria

Laitano, R.F.
Centro Ricerche Energia Casaccia,
Ente Nazionale per l'Energia Elettrica,
P.O. Box 2400,
Rome, Italy

Landa, E.R.
United States Geological Survey,
World Meteorological Organization,
431 National Center,
Reston, VA 22092, United States of America

Lauridsen, B.
Risø National Laboratory,
P.O. Box 49,
DK-4000 Roskilde, Denmark

Lederman, L.
Division of Nuclear Safety,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Lee, T.R.
Department of Psychology,
University of St. Andrews,
St. Andrews, Fife KY16 9JU, United Kingdom

Lettner, H.
Division of Biophysics,
University of Salzburg,
Hellbrunner Strasse 34,
A-5020 Salzburg, Austria

Levin, I.
Nuclear Research Center-Negev,
Israel Atomic Energy Commission,
P.O. Box 9011,
Beersheba 84190, Israel

Li, Deping
China Institute for Radiation Protection,
P.O. Box 120,
Taiyuan, 030006 Shanxi, China

Lochard, J.
Centre d'étude sur l'évaluation de la protection dans le domaine nucléaire,
Commissariat à l'énergie atomique,
B.P. 48,
F-92263 Fontenay-aux-Roses Cedex, France

Loshchilov, N.O.
Scientific Research Institute of Agricultural Radiology,
Kiev, UkrSSR

Louvat, D.
Agency's Laboratory,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Lovranich, E.
Österreichisches Forschungszentrum Seibersdorf GmbH,
A-2444 Seibersdorf, Austria

Lubin, E.
Beilinson Hospital,
Petah Tiqva, Israel

Lutsev, S.D.
State Committee of the USSR Council of Ministers on the Rectification of the Consequences of the Accident at the Chernobyl Nuclear Power Plant,
Gorkij Street 33,
Moscow, USSR

Luykx, F.
Environment, Nuclear Safety and Civil Protection,
Commission of the European Communities,
Rue de la Loi 200,
B-1049 Brussels, Belgium

Ma, Xiuseng
Permanent Mission of China to the IAEA,
Steinfeldgasse 1,
A-1190 Vienna, Austria

Mabuchi, K.
Radiation Effects Research Foundation,
5-2 Hijiyama Park, Minami-ku,
Hiroshima 732, Japan

Malátová, I.
Institute of Hygiene and Epidemiology,
Centre of Radiation Hygiene,
Šrobárova 48,
CS-100 42 Prague 10, Czechoslovakia

Maldonado, H.
Comisión Nacional de Seguridad Nuclear y Salvaguardias,
Avenida Insurgentes Sur 1806,
GL Florida, Delegación Alvaro Obregón,
01030 Mexico City, Mexico

Maringer, F.J.
Bundesversuchs- und Forschungsanstalt Arsenal,
Faradaygasse 3,
A-1030 Vienna, Austria

Marti, J.
Federal Office of Public Health,
P.O. Box 2644,
Bollwerk 27,
CH-3001 Bern, Switzerland

Matsuzaki, T.
Radiation Protection Policy,
Nuclear Safety Bureau, STA,
2-2-1 Kasumigaseki 2, Chiyoda-ku,
Tokyo 100, Japan

Matsuzuru, H.
Japan Atomic Energy Research Institute,
Tokai, Ibaraki-ken 319-11, Japan

Matveenko, I.I.
Republican Centre for Radiation Control,
Minsk, BSSR

Merkulov, G.N.
Permanent Mission of the USSR to the IAEA,
Erzherzog Karl-Strasse 182,
A-1220 Vienna, Austria

Mettler, F.A., Jr.
Department of Radiology, School of Medicine,
University of New Mexico,
915 Camino Salud NE,
Albuquerque, NM 87131, United States of America

Meyer, H-F.
Division of Public Information,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Moberg, L.C.
National Institute of Radiation Protection,
P.O. Box 60204,
S-104 01 Stockholm, Sweden

Moore, B.
Division of Nuclear Safety,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Moriguchi, Y.
Permanent Mission of Japan to the IAEA,
Prinz Eugen-Strasse 8-10,
A-1040 Vienna, Austria

Moschini, G.
Istituto Nazionale di Fisica Nucleare,
Via Romea 4,
Legnaro (Padua), Italy

Moyukhov, A.
Ministry of Foreign Affairs of the BSSR,
Minsk, BSSR

Mrabit, K.
Division of Nuclear Safety,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Mukherjee, R.
Division of Life Sciences,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Napalkov, N.P.
World Health Organization,
Avenue Appia,
CH-1211 Geneva 27, Switzerland

Nauman, J.
Department of Endocrinology,
University Medical School,
Banacha 1a,
PL-02-097 Warsaw, Poland

Nesterov, M.
(Interpreter)
Ministry of Atomic Power and Industry of the USSR,
11910 Moscow, USSR

Nishiwaki, Y.
International Radiation Protection Association,
Jagdschlossgasse 91,
A-1130 Vienna, Austria

Nofal, M.
Division of Life Sciences,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Nordin, R.M.
Permanent Mission of Malaysia to the IAEA,
Prinz Eugen-Strasse 18,
A-1040 Vienna, Austria

Ogris, R.
Agency's Laboratory,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Okakura, S.
Office for the Public Acceptance of Nuclear Energy,
1-3-1 Kasumigaseki, Chiyoda-ku,
Tokyo 100, Japan

Ottoy, H.
KMI,
Ringlaan 3,
B-1180 Brussels, Belgium

Ouvrard, R.
Agency's Laboratory,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Palacios, E.
Comisión Nacional de Energía Atómica,
Avenida del Libertador 8250,
Buenos Aires, Argentina

Papadimitropoulos, P.
Permanent Mission of Greece to the IAEA,
Argentinierstrasse 14,
A-1040 Vienna, Austria

Park, C.M.
Korean Atomic Energy Research Institute,
P.O. Box 7,
Daeduk-Danji, Taejon 305-353, Republic of Korea

Park, W-S.
Department of Safeguards,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Parr, R.M.
Division of Life Sciences,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Pavlicek, P.
Division of Public Information,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Pellerin, P.
Service centrale de protection contre les rayonnements ionisants,
B.P. 35,
F-78110 Le Vésinet, France

Peng, Zhaosheng
Permanent Mission of China to the IAEA,
Steinfeldgasse 1,
A-1190 Vienna, Austria

Perminov, S.
(Interpreter)
Ministry of Atomic Power and Industry of the USSR,
11910 Moscow, USSR

Persson, B.Å.
National Institute of Radiation Protection,
P.O. Box 60204,
S-104 01 Stockholm, Sweden

Petryaev, E.P.
Department of Radiation Chemistry VI,
BSSR State University,
Minsk, BSSR

Pettengill, H.J.
United States Department of Energy,
1000 Independence Avenue,
Washington, DC 20585, United States of America

Piasecki, E.
Polish Atomic Energy,
Goławicka 9 m 108,
PL-03-550 Warsaw, Poland

Piermattei, S.
Direzione per la Sicurezza Nucleare e Protezione Sanitaria,
Comitato Nazionale per la Ricerca e per lo Sviluppo dell'Energia Nucleare e delle Energie Alternative,
Via Brancati 48,
I-00148 Rome, Italy

Pinto, F.
United Nations Development Programme,
Room DCI-2056, TAD/BPPE,
United Nations,
New York, NY 10017, United States of America

Piskov, I.
Permanent Mission of Bulgaria to the IAEA,
Schwindgasse 8,
A-1040 Vienna, Austria

Placer, A.
Consejo de Seguridad Nuclear,
Justo Dorado 11,
E-28040 Madrid, Spain

Plug, K.
Ministry of Housing, Physical Planning and the Environment,
P.O. Box 20951,
Leidschendam, Netherlands

Pokutnyj, P.P.
Pripyat Scientific Production Group,
Chernobyl, UkrSSR

Popov, D.
Permanent Mission of Bulgaria to the IAEA,
Schwindgasse 8,
A-1040 Vienna, Austria

Pramov, C.
Permanent Mission of Bulgaria to the IAEA,
Schwindgasse 8,
A-1040 Vienna, Austria

Ramzaev, P.V.
Leningrad Scientific Research Institute of Radiation Hygiene of the Ministry of Health of the RSFSR,
197101 Leningrad, USSR

Randell, A.W.
Food and Agriculture Organization of the United Nations,
Via delle Terme di Caracalla,
I-00100 Rome, Italy

Rank, D.
Bundesversuchs- und Forschungsanstalt Arsenal,
Faradaygasse 3,
A-1030 Vienna, Austria

Ricks, R.
Radiation Emergency Assistance Center,
Oak Ridge Associated Universities,
P.O. Box 117,
Oak Ridge, TN 37831-0117, United States of America

Rietveld, H.M.
Energieonderzoek Centrum Nederland,
P.O. Box 1,
NL-175526 Petten, Netherlands

Robertson, D.E.
Pacific Northwest Laboratory,
P.O. Box 999, MS P8-01,
Richland, WA 99352, United States of America

Rogov, A.N.
Permanent Mission of the USSR to the IAEA,
Erzherzog Karl-Strasse 182,
A-1220 Vienna, Austria

Rolevich, I.V.
Radiobiology Institute of the Academy of Sciences of the BSSR,
2 Godinskaya Street,
220600 Minsk, BSSR

Rosen, M.
(Vice-Chairman)
Division of Nuclear Safety,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Royal, H.D.
Mallingkrodt Institute of Radiology,
510 South Kings Highway Boulevard,
St. Louis, MO 63110, United States of America

Ruiz, J.
Permanent Mission of Spain to the IAEA,
Gonzagagasse 15/2,
A-1010 Vienna, Austria

Salo, A.
Lepolantie 54,
SF-00660 Helsinki, Finland
(Formerly: Surveillance Department, Centre for Radiation and Nuclear Safety, Helsinki, Finland)

San Martín, R.
Ministerio de Industria,
Paseo de la Castellana 160,
E-28046 Madrid, Spain

Sanmuganathan, M.
Secretariat of the Policy-Making Organs,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Sarmiento, F.
Consejo de Seguridad Nuclear,
Justo Dorado 11,
E-28040 Madrid, Spain

Schelenz, R.
Agency's Laboratory,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Schneider, T.
Centre d'étude sur l'évaluation de la protection dans le domaine nucléaire,
Commissariat à l'énergie atomique,
B.P. 48,
F-92263 Fontenay-aux-Roses Cedex, France

Schulman, M.
United States Department of Energy,
ER-70, 1000 Independence Avenue,
Washington, DC 20585, United States of America

Schwarz, G.
Gesellschaft für Reaktorsicherheit,
Schwertnergasse 1,
D-W 5000 Cologne, Germany

Sheppard, M.C.
University of Birmingham,
Queen Elizabeth Hospital,
Edgbaston, Birmingham,
Warwickshire B15 2TH, United Kingdom

Shigematsu, I.
(Chairman)
Radiation Effects Research Foundation,
5-2 Hijiyama Park, Minami-ku,
Hiroshima 732, Japan

Shimooka, K.
Division of Nuclear Fuel Cycle,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Shinohara, K.
Environmental Protection Section,
Tokai Works, PNC,
Muramatsu 4-33, Tokai-mura,
Naka-gun, Ibaraki-ken 319-11, Japan

Sigurbjörnsson, B.
Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Skjöldebrand, R.
(Formerly: International Atomic Energy Agency)

Skornik, K.
Division of Nuclear Safety,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Smales, E.
Department of Health and Social Security,
Hannibal House, Elephant and Castle,
London SE1 6TE, United Kingdom

Smith, K.
Nuclear Installations Inspectorate,
St. Peter's House, Stanley Precinct,
Bootle, Merseyside L20 3LZ, United Kingdom

Stadić, K.
Nuclear Energy Agency of the Organisation for Economic Co-operation and Development,
38, boulevard Suchet,
F-75016 Paris, France

Steger, F.
Österreichisches Forschungszentrum Seibersdorf GmbH,
A-2444 Seibersdorf, Austria

Steger, G.
EG+G GmbH,
Hohenlinder Strasse 12,
D-W 8000 Munich, Germany

Stegnar, P.
Institut Jozef Stefan,
Jamova 39,
YU-61111 Ljubljana, Yugoslavia

Steinhäusler, F.
Institute of General Biology, Biochemistry and Biophysics,
University of Salzburg,
A-5020 Salzburg, Austria

Stepanenko, A.V.
Academy of Sciences of the BSSR,
66 Lenin Avenue,
220077 Minsk, BSSR

Sterlinski, S.
Central Laboratory for Radiological Protection,
Konwaliowa 7,
PL-03-194 Warsaw, Poland

Stern, E.
Licensing Division,
Israel Atomic Energy Commission,
P.O. Box 7061,
Tel Aviv, Israel

Stichler, W.
Division of Physical and Chemical Sciences,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Stieff, L.
RAD Elec. Inc.,
5310 H Spectrum Drive,
Frederick, MD 21710, United States of America

Stoll, E.
Department of Energy,
CH-5303 Würenlingen, Switzerland

Strachnov, V.
Agency's Laboratory,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Streit, S.
Österreichisches Forschungszentrum Seibersdorf GmbH,
A-2444 Seibersdorf, Austria

Suomela, M.T.
Centre for Radiation and Nuclear Safety,
P.O. Box 268,
SF-00101 Helsinki, Finland

Szepesi, T.
FAF/Austria,
Hermanngasse 21/1/3,
A-1070 Vienna, Austria

Sztanyik, L.B.
Frédéric Joliot-Curie National Research Institute for Radiobiology and Radiohygiene,
P.O. Box 101,
Budapest, Hungary

Taylor, R.H.
Nuclear Electric plc,
Bridgewater Road, Bedminster Down, Bristol,
Avon BS13 8AN, United Kingdom

Terasima, T.
Nuclear Safety Commission,
3-2-1 Kasumigaseki 2, Chiyoda-ku,
Tokyo 100, Japan

Togo, Y.
Permanent Mission of Japan to the IAEA,
Prinz Eugen-Strasse 8-10,
A-1040 Vienna, Austria

Tron'ko, N.D.
Institute of Endocrinology and Metabolism of the Ministry of Health of the UkrSSR,
Kiev, UkrSSR

Tsaturov, Yu.S.
State Committee for Hydrometeorology of the USSR,
Moscow, USSR

Tsyb, A.F.
Institute of Medical Radiology,
Korolev 4,
Kaluga Region, Obninsk, USSR

Tuor, S.
ETH-IMS,
Auf der Mauer 2,
CH-8001 Zurich, Switzerland

Turvey, F.
Nuclear Energy Board,
3 Clonskea Square,
Dublin 14, Ireland

Unger, K.
Permanent Mission of Germany to the IAEA,
Wagramerstrasse 14,
A-1220 Vienna, Austria

Valkovic, V.
Agency's Laboratory,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

van der Steen, J.
NU KEMA,
Beeklaan 6,
NL-6865 VH Woorwerth, Netherlands

Vetrov, V.A.
Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Vilain, G.
(Viscount Georges Vilain)
Permanent Mission of Belgium to the IAEA,
Operngasse 20b,
A-1040 Vienna, Austria

Villanueva, C.
Permanent Mission of Mexico to the IAEA,
Türkenstrasse 15,
A-1090 Vienna, Austria

Villaros, P.
Office of the Director General,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

von Baeckmann, A.
Department of Safeguards,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Voronezhtsev, Yu.I.
Supreme Soviet of the USSR,
Moscow, USSR

Vychtil, P.
Federal Ministry of Health, Sport and Protection of Consumers,
Radetzkystrasse 2,
A-1031 Vienna, Austria

Wachholz, B.W.
Radiation Effects Branch,
National Cancer Institute,
Executive Plaza North, Room 530,
Bethesda, MD 20892, United States of America

Waight, P.J.
World Health Organization,
Avenue Appia,
CH-1211 Geneva 27, Switzerland

Warming, L.
Risø National Laboratory,
P.O. Box 49,
DK-4000 Roskilde, Denmark

Wehrstein-Werner, E.
Agency's Laboratory,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Wenisch, A.
Forum für Atomfragen,
Strudlhofgasse 4,
A-1090 Vienna, Austria

Willis, J.D.
(Observer)
Greenpeace,
Keizergracht 176,
NL-DW 1016 Amsterdam, Netherlands

Xue, Weixian
Permanent Mission of China to the IAEA,
Steinfeldgasse 1,
A-1190 Vienna, Austria

Yiftah, S.
Technion-Israel Institute of Technology,
Haifa 32000, Israel

Zeiller, E.
Agency's Laboratory,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Zeisler, R.
Agency's Laboratory,
International Atomic Energy Agency,
Wagramerstrasse 5, P.O. Box 100,
A-1400 Vienna, Austria

Ziemer, P.L.
United States Department of Energy,
1000 Independence Avenue,
Washington, DC 20585, United States of America

Zombori, P.
Central Research Institute for Physics,
Hungarian Academy of Sciences,
P.O. Box 49,
H-1525 Budapest, Hungary

Zupnik, A.
Bernoullistrasse 4/32/7,
A-1229 Vienna, Austria

Zvonov, N.
Ministry of Atomic Power and Industry of the USSR,
11910 Moscow, USSR

HOW TO ORDER IAEA PUBLICATIONS

An exclusive sales agent for IAEA publications, to whom all orders and inquiries should be addressed, has been appointed for the following countries:

CANADA UNITED STATES OF AMERICA	UNIPUB, 4611-F Assembly Drive, Lanham, MD 20706-4391, USA

In the following countries IAEA publications may be purchased from the sales agents or booksellers listed or through major local booksellers. Payment can be made in local currency or with UNESCO coupons.

ARGENTINA	Comisión Nacional de Energía Atómica, Avenida del Libertador 8250, RA-1429 Buenos Aires
AUSTRALIA	Hunter Publications, 58 A Gipps Street, Collingwood, Victoria 3066
BELGIUM	Service Courrier UNESCO, 202, Avenue du Roi, B-1060 Brussels
CHILE	Comisión Chilena de Energía Nuclear, Venta de Publicaciones, Amunategui 95, Casilla 188-D, Santiago
CHINA	IAEA Publications in Chinese: China Nuclear Energy Industry Corporation, Translation Section, P.O. Box 2103, Beijing IAEA Publications other than in Chinese: China National Publications Import & Export Corporation, Deutsche Abteilung, P.O. Box 88, Beijing
CZECHOSLOVAKIA	S.N.T.L., Mikulandska 4, CS-116 86 Prague 1 Alfa, Publishers, Hurbanovo námestie 3, CS-815 89 Bratislava
FRANCE	Office International de Documentation et Librairie, 48, rue Gay-Lussac, F-75240 Paris Cedex 05
HUNGARY	Kultura, Hungarian Foreign Trading Company, P.O. Box 149, H-1389 Budapest 62
INDIA	Oxford Book and Stationery Co., 17, Park Street, Calcutta-700 016 Oxford Book and Stationery Co., Scindia House, New Delhi-110 001
ISRAEL	Heiliger & Co. Ltd. 23 Keren Hayesod Street, Jerusalem 94188
ITALY	Libreria Scientifica, Dott. Lucio de Biasio "aeiou", Via Meravigli 16, I-20123 Milan
JAPAN	Maruzen Company, Ltd, P.O. Box 5050, 100-31 Tokyo International
PAKISTAN	Mirza Book Agency, 65, Shahrah Quaid-e-Azam, P.O. Box 729, Lahore 3
POLAND	Ars Polona-Ruch, Centrala Handlu Zagranicznego, Krakowskie Przedmiescie 7, PL-00-068 Warsaw
ROMANIA	Ilexim, P O. Box 136-137, Bucharest
SOUTH AFRICA	Van Schaik Bookstore (Pty) Ltd, P.O. Box 724, Pretoria 0001
SPAIN	Díaz de Santos, Lagasca 95, E-28006 Madrid Díaz de Santos, Balmes 417, E-08022 Barcelona
SWEDEN	AB Fritzes Kungl. Hovbokhandel, Fredsgatan 2, P.O. Box 16356, S-103 27 Stockholm
UNITED KINGDOM	HMSO, Publications Centre, Agency Section, 51 Nine Elms Lane, London SW8 5DR
USSR	Mezhdunarodnaya Kniga, Smolenskaya-Sennaya 32-34, Moscow G-200
YUGOSLAVIA	Jugoslovenska Knjiga, Terazije 27, P.O. Box 36, YU-11001 Belgrade

---

Orders from countries where sales agents have not yet been appointed and requests for information should be addressed directly to:

Division of Publications
International Atomic Energy Agency
Wagramerstrasse 5, P.O. Box 100, A-1400 Vienna, Austria