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## TECHNOLOGICAL PROBLEMS OF NUCLEAR SAFETY

### THIRD PROGRESS REPORT

(Communication from the Commission to the Council)

COM(81) 213 final

Technological problems of nuclear safety

Third progress report

This report was drawn up pursuant to Item 8 of the Council Resolution of 22 July 1975 on the technological problems of nuclear safety; it covers the period from 1 July 1978 to 31 December 1980 and is a sequel to the reports COM(77)168 and COM(79)1973.

TABLE OF CONTENTS

	Page
Abbreviations	II
Introduction . . . . .	1
Point 1. Safety of reactors that have reached a high level of industrial development (water reactors)	4
1.1. Activities aimed at harmonizing safety techniques and standardizing equipment	4
1.1.1. Light-water reactor safety "Methodology, criteria, codes and standards"	4
1.1.2. Safety analyses of specific projects	14
1.1.3. Environmental implications	15
1.2. Activities centred on research	18
1.2.1. Activities aimed at coordinating national research programmes	18
1.2.2. Community programme at shared expenses on reactor safety	21
1.2.3. Working Group on "Safety aspects of steel components in nuclear installations"	24
1.3. Contacts with national or international bodies active in the field of nuclear safety	25
Point 2. Safety of sodium-cooled fast breeder reactors (LMFBR)	26
2.1. Safety	26
2.2. Codes and standards	29
Point 3. Activities in the fields of plutonium recycling, radioactive-waste disposal and nuclear power-station decommissioning	32
Annexes : Objectives and membership of Working Groups	
Annex 1 Working Group on light-water reactor safety (methodology, criteria, codes and standards)	38
Working Group on Light-water reactor safety "Coordination of Research Programmes"	39
Annex 2 Working Group on fast-reactor safety	40
Working Group on codes and standards	41

Abbreviations used in the document

CEC	Commission of the European Communities
JRC	Joint Research Center
EUA	European Unit of Account
IAEA/NUSS	International Atomic Energy Agency; Nuclear Safety Standards
ISO/TC 85	International Organization for Standardization/ Technical Committee 85
KTA	Kerntechnischer Ausschuss
DIN	Deutsches Institut fuer Normung
OECD/NEA/CSNI	Organization for Economic Cooperation and Development/ Nuclear Energy Agency/Committee on the Safety of Nuclear Installations
USNRC	United States Nuclear Regulatory Commission
USDOE	United States Department of Energy
ICRP	International Commission on Radiological Protection
ASME	American Society of Mechanical Engineers
BWR	Boiling-Water Reactors
LWR	Light-Water Reactors
PWR	Pressurized-Water Reactors
TOP	Transient Overpower
UNIPEDA	International Union of Producers and Distributors of Electrical Energy
UNICE	Union of Industries of the European Community
CEEP	European Center for Public Undertaking

## Introduction

The Council Resolution of 22 July 1975 \* gave prominence to the important role which nuclear energy was called upon to play in energy supply and to the consequent increasing importance to the technological problems of nuclear safety. That Resolution also stressed the importance of approximating the national safety requirements and criteria and of cooperation in applied research in this field and requested the Commission to promote such approximation and cooperation.

On the basis of the principles expressed in that Resolution, the Commission continued its work on the harmonization of safety criteria and standards both in the field of reactors of proved type (mainly light-water reactors) and in that of advanced type reactors (mainly sodium-cooled breeder reactors) with the aim of providing an equivalent level of protection for the public and the workers concerned in all the Member States, of contributing to the removal of technical barriers and of stimulating and facilitating intra-Community trade on behalf of the nuclear industry.

In these tasks, the Commission is assisted by experts working under study contracts.

The Commission has also continued its work on information exchanges and on coordination of the national research programmes in the field of reactor safety.

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\* O.J. C 185 of 14.8.1975

In addition, the Commission is responsible for managing the shared-cost research programmes (shared between the Commission and the national research laboratories or institutes) which form a harmonious supplement to the national research programmes and the JRC programme\*.

The areas covered by these programmes are:

- . the safety of light-water reactors,
- . the management and storage of radioactive waste,
- . the final shutdown (decommissioning) of nuclear power stations,
- . plutonium recycling in light-water reactors (being brought to a close).

It should be pointed out, however, that the three last-mentioned programmes cover areas which include but also go beyond technological safety problems.

The accident which occurred at the Three Mile Island 2 (TMI 2) reactor in the United States in March 1979 profoundly influenced the activities relating to the safety of light-water reactors; it was the subject of detailed studies carried out by the Commission and the Working Parties concerned from the standpoint of the consequences in respect of both the regulatory aspects and of applied research in the various Member States and with regard to the lessons to be drawn from it in orienting the Commission's work and in establishing the priority to be accorded to the various projects that are under way or have been planned. In this context, it is as well to mention the setting-up by the Commission on 16 May 1979\*\* of a "Group of High-Level Independent Experts"; the task assigned to this Group is to advise the Commission on all problems relating to the present situation regarding nuclear safety within the Community and simultaneously to evaluate the activities currently conducted by the Commission in this field.

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\* The activities in the field of nuclear safety covered by the programme of the JRC are not resumed in this report; only some aspects of this programme are mentioned which are particularly connected with the activities described in the following chapters

\*\* Commission Decision of 16 May 1970, O.J. L141 of 9.6.1979.

The report prepared by this Group of Experts was examined by the Commission and forwarded to the other Community institutions on 3 December 1980<sup>\*</sup>. A considerable number of the recommendations set out in that report, which covers a more extensive field than the technological problem of nuclear safety, form a basis of support for the Commission activities already under way or planned for the near future. Other recommendations can provide a basis for new projects; as regards, more particularly, the technological problems of nuclear safety, it would be advisable to adopt the recommendations relating to :

- . the exchange and dissemination of information on the normal operation of installations and the accidents that occur in them,
- . the study of the technical problems associated with site selection, including emergency plans,
- . the man-machine interaction (operators qualifications, use of simulators).

Finally, the Commission has maintained and, in certain cases, strengthened its cooperation with international or national bodies outside the Community which are active in the field of nuclear safety.

In the following text, the details of the Commission's activities in the various fields covered by the Council Resolution of 22 July 1975 are presented. The Commission believed that it was better to wait until the main points of concern arising from the TMI 2 accident had been identified before presenting this report; for this reason, it covers a period of two and a half years.

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<sup>\*</sup> COM(80)808

1. Safety of reactors that have reached a high level of industrial development (water reactors)

1.1. Activities aimed at harmonizing safety techniques and standardizing equipment

1.1.1. Light-water reactor safety "Methodology, criteria, codes and standards".

In carrying out its harmonization activities, the Commission is assisted by a specialized Working Group (Working Group No 1, the membership and objectives of which are presented in Annex 1).

1.1.1.1. Work programme

Working Group No 1 continued its activities, also taking due account of the implications of the Three Mile Island 2 accident in the United States. A point which deserves special attention is the formulation of recommendations in accordance with the provisions of Article 124 of the Euratom Treaty. A logical outcome (for which provision is made in the Council Resolution of 22 July 1975) of some of the work of Working Group No 1 is the preparation of recommendations in accordance with the provisions of Article 124 of the Euratom Treaty; a procedure for formulating such recommendations had, moreover, already been discussed and finalized with the participation of all the bodies represented in the group.

A first attempt to formulate specific recommendations was made on the basis of subjects that were considered to be the most suitable, but, after the representatives of the safety authorities had intervened, it was agreed that, before any specific recommendations were formulated, it would be necessary first of all to have a general outline in order to obtain coherent whole. Top priority was therefore given to laying down the general safety principles, starting with the basic principles of radiation protection, and to establishing a sequence of specific subjects to be dealt with subsequently.



The task of formulating the general principles was assigned to an ad hoc group (task force), composed of representatives of the national safety authorities, the secretariat being provided by the Commission. This ad hoc group presented a draft document to the members of Working Group No 1 in October 1980. A final version of the document is to be prepared during the first half of 1981 and may subsequently form the subject of a Communication from the Commission to the Council.

#### 1.1.1.2 Specific activities

- a) Comparison of the practices and criteria used for the protection of nuclear power stations and analysis of accident conditions.

A study of the causes and consequences of accidents that may affect a nuclear power station and of the measures taken to protect the power stations would cover too vast an area to be treated as a whole in a Community context; for this reason, a certain number of specific subjects were selected in view of their importance from a safety standpoint and of the lessons to be learned from the TMI 2 accident.

The study on the various subjects dealt with progressed unevenly in view of the complexity of the subject and of the rate of technological and regulatory development in this field in the various Member States (which sometimes causes delays). The initial objective of the studies undertaken is to collect the information available in the various Member States and then to compare these data with each other and, where possible, with corresponding information from other countries, such as the USA; a general report is then to be prepared, which identifies and analyses the points of convergence and divergence. Where certain subjects are concerned,

these general reports could subsequently serve as a technical basis for the formulation of recommendations in accordance with Article 124 of the Euratom Treaty (see sub-section 1.1.1. above); this could, in particular, be the case initially with the two following subjects:

- Protection of nuclear power stations against seismic effects.

The general report has been completed and, in the experts' opinion, it can serve as a technical basis for recommendations.

- Protection of nuclear power stations against a failure of the electrical power supply system.

In this field as well, detailed conclusions on specific technical points are now of great assistance in drawing up safety rules at national level and would facilitate the formulation of recommendations in future.

Studies on other subjects have also reached the general report stage, but, for the moment, in view of the continual developments observed in the Member States and the complexity of the problems, the reports are only being updated or extended. Amongst these subjects are:

- The protection of nuclear power stations
  - . against aircraft crashes
  - . against the effects of external explosive gas clouds
  - . against floods
- The study of the mechanical and thermo-hydraulic effects of a loss-of-coolant accident (LOCA) on the primary circuit and the containment structure
- Evaluation of the radiological consequences of a LOCA.

In this field, revision of the general report will necessitate further detailed studies.

- Evaluation of the consequences of a fuel-handling accident. Since the consequences of such an accident are of the same type as those of a LOCA (dispersion of fission products in the atmosphere), the study on this subject will be merged in future with that on the preceding subject.

Finally, for certain subjects, the study is less advanced (collection of data, general reports being drawn up), particularly:

- the study on steam-line brakes inside and outside the containment in the case of boiling-water and pressurized-water reactors;
- the study on the protection of the primary circuit against overpressure;
- the study on ATWS\* : transient phenomena taken into account during design not causing a scram.

The study on these phenomena was undertaken by the JRC and four general reports are planned (some of them have already been completed):

- . availability of the emergency shutdown system (scram),
- . type and frequency of the transient phenomena taken into account during the design of the power station,
- . consequences of the transient phenomena,
- . regulatory practices in this field.

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\* Anticipated Transients Without Scram

b) Study and comparison of the practices, rules and standards used for site selection and for the design and construction of nuclear power stations.

These studies are being carried out on a certain number of specific subjects including, in particular :

- . Comparison of safety practices and criteria applied in the selection and evaluation of nuclear power station sites.

This subject also embraces the problems associated with accident hypotheses, emergency plans and the procedures to be used in emergencies.

It is, moreover, the subject of a recommendation for action in the report drawn up by the high level independent experts (see Introduction).

The discussion on the criteria used for the selection and evaluation of sites from the standpoint of safety and of the effect on the health of the public in the vicinity has been continued. This is a difficult field where it is only possible to advance at a slow pace.

A questionnaire on the technical aspects of emergency plans for the exteriors of site has been sent to the members of the Working Group.

- . Pressure boundary of the reactor primary circuit.

The detailed comparison of the codes used in this field in the USA on the one hand and certain European countries on the other was continued and completed and a document is now available which could serve as a basis for the progressive harmonization of the national standards and codes that exist in this fields (chiefly in liaison with ISO/TC 85).

. Containment structure and protection systems.

A report has been drawn up on the methods and procedures applied in various Member States by the operators to test the leak-tightness of containment structures; it presents a detailed review of the different methods. A general report presenting an overall view of the methods used and of a comparison between them which will provide an important contribution to the reciprocal provision of information by the specialists concerned is being prepared.

. Quality assurance.

The work in this field comprised the compilation and comparison of the quality assurance rules or practices for reactor operation applied in certain Member States and the USA. An initial report has been prepared; it is being revised at present and will serve as a basis for proposals for modifying the quality assurance programmes in order to harmonize them with each other.

- . Consequence of the application of the ALARA<sup>\*</sup> principle to professionally exposed workers with regard to design and operation. The Council Directive "Laying down the basic safety standards for the health protection of the general public and workers against the dangers of ionizing radiation"<sup>\*\*</sup>, which is based in this regard on ICRP publication No26, prescribes the application of the ALARA principle to the doses received by the workers professionally exposed to nuclear radiation; this may have consequences with regard to the design and operation of power stations. Non-uniform application of the principle may give rise to considerable divergences from one constructor to another and from one country to another.

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\* As Low As Reasonably Achievable

\*\* Council Directive of 15th July 1980, OJ L246 of 17.9.1980.

Discussions are under way in the various Member States between the authorities and the operators and there are plans to hold a special meeting on this subject for the purpose of comparing the views of all the parties concerned within the Community.

c) Training and qualifications of control-room operators.

The study on this subject has been initiated.

A questionnaire was prepared and the replies provided reflect the situation as it stood before the TMI-2 accident; after that accident, far greater importance was attached to this subject and it was reviewed in detail in the Member States. In addition, the Group of high-level independent experts (see Introduction) recommended that the Commission implement projects in this field. In order to take account of developments in the situation, there are plans to prepare an updated questionnaire and to use the replies to draw up a general report. The Joint Research Center, moreover, elaborated a report about the assistance of control-room operators in emergency situations; part of this report treats the question of operator training and they held two working meetings in 1980; the final report will be presented in 1981.

d) Use of risk concept in safety analysis and application of risk analysis in the Member States.

An investigation was made of the extent to which the concepts of risk and probability are used at present in safety analysis by the industrial and regulatory organizations in Member States. A general report was prepared, which provides an overall picture of the current situation in the Member States and will be of considerable assistance in work on harmonization and in establishing safety criteria, due regard being paid to the fact that this is a rapidly developing field. The main points can be summarized as follows :

. Risk concept

Attempts to translate the risk concept in a single numerical value, obtained by the multiplication of consequence and probability values, are vain. It is the most widespread opinion that risk can be more properly represented through a graph or an equivalent form (e.g. histogram or table) where the consequences of different size and their integral probability appear.

As a synthesis of the present state, it can be said that the approach applied in the design phase and in licensing process for nuclear power plants is generally the deterministic one, often derived from USNRC rules. Such an approach is nevertheless very often integrated, or at least supported, with probabilistic analyses.

. Application of risk analysis

There are essentially two levels in which the risk analysis may be performed :

- a general level, with the purpose of an assessment of the safety of a given activity
- a specific level, with the purpose of an assessment of the safety in a particular case of an implementation of an activity (e.g. transportation system, industrial plant) in both the design and regulatory phases.

In the nuclear field plants risk analyses performed for nuclear plant on a general level already exist in some countries\*, while similar studies are in progress in other countries. Among the purposes of such studies are the assessment of risk from nuclear power plants and its comparison with risk from natural and from other man made sources. Other results are the discovery of possible weak points in the plants and the need for harmonization of safety requirements.

The situation is different as far as the specific application of risk analysis to the design phase and the licensing process is concerned. In these cases a risk analysis covering all systems of the plant is not used at present, nor its use is foreseen shortly.

e) Development of national and international technical rules (criteria, codes, standards).

- . Several national and international drafts of technical rules, codes and standards of general interest to the Working Group have been submitted to it for its opinion.
- . A compilation of the technical rules, codes and standards in the field of nuclear safety being drawn up in the Member States, certain non-Community countries and international bodies was prepared and distributed to those concerned in mid-1979. The document will be revised and updated every year.

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\* For example the "German Risk Study", carried out by the "Gesellschaft fuer Reaktorsicherheit" for the German Federal Ministry for Research and Technology.



f) Systems for reporting accidents and incidents (abnormal occurrences) in nuclear power stations.

This subject was touched upon by Working Group No 1, which, however confined itself for the time being to drawing up a report reviewing the regulations in force in various countries of the Community and in Sweden and the United States. Having regard to the importance which these problems have assumed, particularly after the TMI 2 incident, and in view of the recommendations set out in the report prepared by the high-level independent experts (see Introduction), discussions are being held with a view to preparing a proposal relating to the measures to be taken at Community level to improve the exchange of information on accidents and incidents of nuclear origin.

### 1.1.2. Safety analyses of specific projects.

The Commission continued to participate in the safety analyses of Belgian Nuclear Power stations under construction : Tihange II and Doel III.

The group of experts set up by the Commission continued examining certain points in the safety reports which are of Community-wide interest. A number of meetings took place in which the constructors and contractors participated. Certain points were clarified, but, where others were concerned, it was necessary to ask the constructors or contractors to provide additional documents. In view of the slippage in the power station construction schedule and the corresponding delay in providing certain parts of the safety reports, the group of experts will only finish its evaluation work during the first half of 1981.

The comparison of the experts' opinions on specific safety problems, account being taken of national practices, makes it possible to adopt a pragmatic approach to the harmonization of safety criteria and rules.

### 1.1.3. Environmental implications

#### 1.1.3.1. Effluent discharges from nuclear reactors during normal operation.

This problem comes within the scope of Chapter III of the Euratom Treaty and is consequently not one of the objectives dealt with in this report. However, the solutions found for certain problems of radiation protection affect nuclear safety technology. It should be pointed out in consequence that :

- . The C.E.C. regularly publishes reports on releases to the environment of radioactive materials in airborne and liquid effluents from nuclear power stations and fuel reprocessing plants. These reports also present some estimates of the exposure of members of the public as a result of these discharges and compare them with the applicable radiation protection standards and exposure from natural radiation.
- . The Commission believes that the synoptic presentation and comparison of such data will demonstrate to what extent present day technology can restrict discharges and can therefore be a useful instrument for harmonising effluent controls within Member States.
- . The Commission established in 1978 a document giving a review and analysis of the criteria used at that time in Member States to determine discharge limits for nuclear installations<sup>\*</sup>. The aim of this report is to create a better mutual understanding in this field with a view of ultimately harmonising the different approaches used in the various countries to implement the ICRP principle "as low as reasonably achievable".

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\* "Limits used in the Control of Radioactive Effluents from Nuclear Installations ; a review and analyses". C.E.C V/2131/1/77.

- . A comprehensive methodology to evaluate the radiological impact of effluents discharged during normal operation of nuclear installations has been developed.

This methodology is based on a series of sequential models of sufficiently general character so that it can find wide application for the evaluation of the radiological consequences of discharges of radioactive effluents.

Because of the wide interest shown in this methodology and its potential application it was the subject of a Seminar organized by the CEC in Luxembourg in May 1979. Subsequently a tape library has been made available containing a matrix of results allowing the methodology to be applied to a wide range of circumstances.

1.1.3.2. Comparison of the risks arising from nuclear power stations with those associated with conventional activities.

A study undertaken in this field resulted in the publication of a report <sup>\*</sup>, greatly appreciated in the sectors concerned, which contained useful assessment criteria for comparing the various sources of energy which can also be used for other studies in the same field.

The study is based on the review of some practical cases and indicates that the absolute level of individual risk of death cannot be directly correlated with the acceptability, at professional or governmental level, or the public acceptance of any specific risk.

High probability risks have been identified which are not acceptable to professional safety advisors and are accepted by the public (for example the risk of death from lung cancer from smoking cigarettes); conversely, low probability risks have been identified which are acceptable to professional safety advisors and not always accepted by the public (for example risk of death in an aircraft accident or early fatalities from nuclear power generation).

The acceptance of high levels of individual risks is linked with the derived "benefits" and a number of perception-factors. Societal benefits are more the concern of the safety professionals as a tool for defining risk/benefit derived "acceptable levels".

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\* Nuclear and non-nuclear risk. An exercise in comparability  
EUR 6417 (1980).

## 1.2. Activities centred on research

### 1.2.1. Activities aimed at coordinating national research programmes.

In conducting these coordination activities, the Commission is supported by a specialized Working Group (Working Group No 2), the membership and objectives of which are presented in Annex 1. The work concerned the research programmes on the safety of light-water reactors in progress or planned in the Member States, including the implications of the accident that occurred in the American reactor TMI-2, with special emphasis on :

#### 1.2.1.1 The index of research projects.

The yearly updating of the index of European research projects concerning the safety of water reactors has continued, and it now contains information on well over 500 projects classified under 19 main headings (for example : Blowdown and emergency core cooling, core meltdown, external influences, etc).

The Commission forwards copies of this Community index as input for the OECD/NEA version and acts as a liaison point for Member States of the Community. Close liaison on the two systems is maintained, thus ensuring the maximum dissemination at any time of the current projects in each particular area of nuclear safety research.

#### 1.2.1.2. Study of key areas in reactor safety research

Having established an efficient procedure for rapid and accurate circulation of information on current research projects, Working Group No 2 continues to give considerable attention to the task of assessing key areas where further knowledge is still required. Its object is to promote cooperation between Community specialized institutes in these key areas and to formulate programmes of work on specific topics where useful work can be performed as agreed to be necessary by its members.

Examples follow of topics currently under such study, identified by WG 2 taking also into account the implications of the US Three Mile Island reactor accident. The assessment of this accident concluded in general that no new safety problems were uncovered, however the emphasis and priorities of some areas of safety research work would change.

- a) Assessment of the production of hydrogen following an accident situation, its distribution and the consequential risk of an explosion in the containment.

This is a subject which has been considered in reactor safety analysis for some time but now requires a complete reassessment of available data, particularly following Three Mile Island.

b) Human factors and man-machine interactions.

This is again another area where the TMI incident has given some impetus to existing programmes\*. The whole subject of how man interacts with sophisticated machines (not just NPP) is receiving more and more attention. In the nuclear area it is particularly necessary to increase knowledge in such topics as :

- . processing of the operating data from the plant
- . presentation of data to the operator on the functioning of the plant
- . assistance to the operator to make crucial decisions, particularly in emergency situations
- . reliability of the human operator himself.

Related work is currently under way at the JRC and liaison will be maintained with similar work at other organizations.

The tendency in the Working Group N° 2 being to focus more on non-routine situations.

c) Structural integrity of NPP against an aircraft crash incident. Topics so far identified for further indepth discussions are :

- . the behaviour of materials including experimental verification and testing
- . vibration analysis on sharp-cornered input load transients
- . effects on safety related equipments.

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\* see also the recommendations of the "Group of independant high level experts" in the Introduction.



d) Alternative containment concepts

Considerations are now currently being given to alternative concepts in order to reduce the probability of containment failure in severe accident situations. Such postulated accidents would include core degradation and melting and subsequent release of radioactivity. Topics to be considered will include controlled venting to the atmosphere through appropriate filters but not fundamentally new concepts. Associated problems such as fission product release paths are also being discussed.

e) Fuel behaviour in severe accident situations up to core melt conditions.

In discussions on this subject collaboration between experts in the field of thermohydraulics and fuel specialists is envisaged. Areas to be considered will include the problems of long term cooling and unloading of a damaged reactor core.

1.2.2. Community programme at shared expenses on reactor safety.

On 27 March 1979<sup>\*</sup>, the Council approved the proposal for a programme put forward by the Commission in 1978 and based on the work and studies carried out in advance by Working Group No 2. The three technical aspects covered by the programme are as follows :

- a) Emergency core-cooling (ECC) phenomena following a loss-of-coolant accident (LOCA).
- b) The protection of nuclear installations against external explosive gas clouds.
- c) The escape of radioactive fission products following a postulated reactor accident and their dispersion in the atmosphere.

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\* O.J. L83 of 3.4.1979, p. 21

The appropriation for the programme amounts to 6.3 m EUA for the five years of the programme's validity (1 January 1979-31 December 1983), staff costs and administrative operating costs included. The programme is being implemented by means of shared-cost research contracts concluded with research bodies and laboratories in the Member States. The Commission's overall financial contribution to this work will be 5 m EUA for all three fields (amounting to 40-50 % of the costs in most cases), approximately half of which is earmarked for field (a) and a quarter of each for fields (b) and (c).

The major objective in field (a) is to evaluate and predict with the greatest possible degree of accuracy how an emergency reactor core-cooling system will function following an accidental loss of the primary coolant fluid. The programme obviously does not attempt to solve all the problems associated with a loss-of-coolant accident, which are being dealt with in a wide range of projects at the JRC and in Member States, but is concentrated on the thermo-hydraulic aspects of the phases of wetting and flooding the core fuel rods and assemblies, and thus on the initial stage of the emergency cooling operation.

The chief topic in field (b) is the protection of nuclear installations against the explosion of a hydrocarbon cloud released in the vicinity, e.g. following a transport accident (road, river, sea) or originating from a neighbouring petrochemical installation. The mechanism and effects of such an explosion are relatively poorly understood, with the exception of certain concrete examples (Flixborough, Port Hudson, Feyzin, etc). It is thus important to broaden our understanding of these phenomena, among other reasons for the evaluation of the risk of damage to nuclear installations and of possible countermeasures to be taken at the structural design stage.

The studies to be carried out in field (b) concern the three logical stages in the development of the accident :

- . the release of hydrocarbons and the formation and dispersion of the explosive cloud,
- . the explosion mechanisms, particularly the possible transition from a deflagration situation to a pseudo-detonation situation,
- . the interaction between the resulting pressure wave and the fixed structures.

The chief topic in theme (c) is the atmospheric dispersion of the active products (gaseous or volatile) released into the environment following a hypothetical major accident at a power station. The categories of accident involved here are those taken into consideration in the risk analyses. During such accidents, which obviously have a very low probability, the dispersion of activity could involve quite extensive areas.

The studies to be performed mainly concern the atmospheric dispersion mechanisms on a "regional or intermediate" scale (in the meteorological sense) and the various special effects which are also capable of affecting atmospheric transport : plume height, channelling effect of buildings close to the source, lifting effect above an urban area, channelling effect of valleys and sea breeze at greater distance, etc.

### 1.2.3. Working Group on "safety aspects of steel components in nuclear installations".

Technology as applied to light-water power stations makes use of large-scale steel components and structures that must be capable of withstanding high pressures, hence the reliance on steel parts of greater thickness and complex shapes which must, in addition, meet very severe safety requirements. The design, manufacture and quality control of these parts and observance of the quality standards laid down give rise to specific problems which are being studied by a joint OECD/NEA (CSNI) - Commission Working Group.

This Working Group made considerable progress during the period under review in the area of non-destructive testing and, in particular, in the European round-robin non-destructive testing programme coordinated by the Plate Inspection Steering Committee (PISC). The results of that programme were published in detail \* and revealed first of all the difficulties encountered in characterizing the defects in the thick parts by using the ASME code procedures and then how the application of alternative test procedures resulted in considerable improvements in defect detection; some of these alternative test procedures are already being used in European countries for the testing of heavy nuclear components.

A second PISC programme was approved at the end of 1980 to start early in 1981 with the primary objective of examining the effectiveness of various alternative testing techniques.

The JRC participated in the first programme and assumed much of the responsibility for evaluating the results obtained and for verifying those results through destructive testing. It will continue to be active as operating agent in the second programme.

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\* Report EUR 6371 (1979)

In addition to its activities in the field of non-destructive testing under the PISC programme, the Group is conducting studies on the ultrasonic inspection of austenitic materials and on the applicability of acoustic emission.

As in the past, the Working Group was active in selected areas of fracture mechanics during the period under review. Several practical analytical methods of calculating critical defect sizes were compared.

### 1.3. Contacts with national or international bodies active in the field of nuclear safety.

The Commission maintains close contact with national and international bodies such as the IAEA-NUSS, ISO/TC 85, OECD/NEA, USNRC, KTA and DIN in order to be kept informed of activities under way both in respect of the development of codes, standards or criteria and in the field of research and in order to provide support for such activities should the need arise.

In particular, the Commission is participating in the work performed under the sponsorship of the IAEA in the field of nuclear safety codes and guidelines as part of the NUSS programme. These codes and guidelines are circulated among the members of Working Group No 1 with a view to harmonizing the positions of the Community Member States in this regard.

## 2. Safety of sodium-cooled fast breeder reactors (LMFBR)

The Council completed its discussions on the communication from the Commission entitled "The fast breeder option in the Community context - Justification, achievement, problems and action perspectives" and adopted a Resolution on fast breeder reactors on 18 February 1980<sup>\*</sup>.

In that Resolution, the Council states, inter alia, that "work on the gradual harmonization of safety codes and measures will be continued in the Coordinating Committee for Fast Reactors".

### 2.1. Safety.

#### 2.1.1. Safety criteria and technical recommendations.

One of the objectives of the work on the coordination of activities concerning the safety of fast breeder reactors is to encourage convergence in the development of safety criteria in the Member States. For this reason, the Safety Working Group (SWG) of the Fast Reactor Coordinating Committee (FRCC) devoted much effort to drawing up preliminary safety criteria and technical recommendations.

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\* O.J. 51 of 29.2.1980.

The work on the preliminary technical criteria and recommendations relating to primary reactivity accidents, general loss-of-coolant accidents and accidents of the same type in fuel assemblies has virtually been completed. Two categories of accident remain to be considered, namely: accidents external to the core and accidents external to the power station.

It should be pointed out that the progress of this work has been slowed down to some extent by the difficulties inherent in the various stages of development of fast reactors in the different Community Member States.

#### 2.1.2. Coordination of research and information exchange.

A further objective is the identification of fields of research on safety which are not adequately covered by the national or Community programmes. The index of the research and development work under way within the Community has been periodically updated. It contains information on 227 projects classified under 12 main headings.

After studying the range of activities conducted within the Community in the field of post-accident heat removal (PAHR), the Safety Working Group identified a certain number of sub-areas, in respect of which extra research work would be desirable. Several laboratories and bodies have made proposals for strengthening activities in these sub-areas. These proposals are being examined with a view to implementing them if possible as part of a Community project.

### 2.1.3. Whole-core accident codes (WAC).

After the results of a comparison of codes for a transient overpower accident (TOP) occurring in a non-radiated core had been compiled and published \*, a similar project was put in hand in respect of an irradiated core.

The codes that underwent the comparison were developed by the Member States and by the Community (European Accident Code prepared by the Joint Research Center), the USNRC and the USDOE are also participating in these projects with their own codes.

The results obtained so far are generally in agreement, despite the different approaches inherent in each code.

### 2.1.4. Codes concerning containment loading and response (CONT).

The studies and experiments concerning the comparison and validation of the codes developed by the national bodies for evaluating the effects of severe accidents on fast-reactor vessels have been virtually completed. Experiments on models of reactor vessels were conducted also at the JRC.

Similar studies on the effects of accidents occurring in a fuel assembly on adjacent assemblies have been initiated.

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\* EUR 6318 - 1979.



### 2.1.5. Miscellaneous

An initial exploratory study has been performed on the prospects opened up by recent developments in microelectronics in respect of the control and protection of fast reactors. The study confirmed the potential usefulness of these new technological developments for accident prevention.

### 2.2. Codes and standards

The objective of this activity is to establish a solid technical basis that would make it possible to eliminate gradually the divergences between the codes and standards for specific components of fast reactors, thus providing for an equivalent degree of structural integrity.

Assurance of the structural integrity of components plays an important role with regard to the safety of the power station and to savings in its construction and operation.

The Working Group on Codes and Standards divided its efforts between setting up a budgetary framework appropriate to a long-term technical harmonization activity (multiannual research programme) and performing a comparative analysis of the rules, standards, codes and specifications in the fields that concern it (manufacturing standards, structural analysis and materials).

It was thus that a proposal for a research programme (indirect action project) on codes and standards for fast reactors - structural integrity of components was prepared during 1978 and placed before the

Council by the Commission in September 1978. After discussion, that proposal was finally not adopted, but provision was made for annual appropriations<sup>(\*)</sup> to enable activities in this field to be efficiently conducted.

#### 2.2.1. Manufacturing standards and quality control

The benefits and usefulness of a quantitative analysis of the more significant differences between the national rules and standards has been demonstrated by comparative studies. The fields to which priority was accorded in these investigations are : welding processes, non-destructive testing and inspection of components.

The future lines along which this activity is to be conducted take account, on the one hand, of the budgetary limitations and, on the other hand, of the new regulations applied in the Member States.

#### 2.2.2. Structural analysis

The work on the first phase of the reference calculations concerning verification of the numerical precision of the inelastic computer programmes has been completed. The results obtained revealed considerable differences which are being studied in detail before the subsequent phases of this computer programme are dealt with.

The preparation of an initial report describing the state of the art in a precise field of structural analysis, the phenomenon of creep-free rock, has almost been completed.

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(\*) Appropriations for commitment : 300 000 EUA in 1980.

The main object of the report is to enable the best possible recommendations regarding design procedures to be drawn up on the basis of an evaluation of current theoretical and experimental knowledge. These recommendations will be presented in the form of a technical report. Other reports on the state of the art are planned in the future programme as are the continuation of the inelastic reference calculations and an initial numerical verification of the seismic computer codes.

### 2.2.3. Materials

The materials initially studied are the steels currently being proposed as structural materials in the various projects. The comparative analysis of the national data concerning the creep-rupture properties and the tensile strength properties of type 316 austenitic steels has been completed. The results of this work will be presented at the International Conference on Mechanical Behaviour and Nuclear Applications of Stainless Steel at Elevated Temperatures, in Varese, on 20 - 22 May 1981.

The analysis of the mechanical properties of chrome alloys and the study on the defects of types 304 and 316 austenitic steels have been put in hand.

### 2.2.4. Classification of components

An initial draft document on the classification of components has been drawn up. At present, it is being critically reviewed by the national bodies concerned.

3. Activities in the fields of plutonium recycling, radioactive-waste disposal and nuclear power-station decommissioning

Certain projects with direct implications for nuclear safety technology are also being conducted by the Commission as part of the indirect action programmes on plutonium recycling in nuclear power stations, the management and storage of radioactive waste and the decommissioning of nuclear power stations, which are briefly described below.

3.1. The 1975-79 five-year programme on plutonium recycling in light-water reactors is in its final phase.

The continuation in the 1980's of research on the plutonium cycle and its safety conducted at Community level by means of indirect action projects has been brought to a halt, at least for the moment, through a lack of agreement in the Council of Ministers on the Commission's proposal of March 1979<sup>(\*)</sup> concerning a new five-year programme in this field.

The studies on safety, performed as part of the 1975-79 programme, cover the following fields :

- study on the static and dynamic behaviour of plutonium-fuelled LWR power stations ;
- study on the impact on the environment of plutonium transport ;

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(\*) COM(79)87.

- study of the impact on the environment of plutonium recycling in LWR power stations (development prospects for the end of the century).

The results were either communicated to the Member States (Article 13 of the Euratom Treaty) or published in the form of EUR reports. They demonstrate, in particular, that :

- the plutonium recycling rate with which a LWR power station can cope without modifications to the control systems depends on the design of the power station and on the degree to which recharging has been optimized ; each power station studied can be fuelled as to 30 % with plutonium assemblies (the additional fuel being uranium) without modifications to the control devices ; an overall review of the static and dynamic behaviour of LWR power stations will be published during 1981 ;
- it is possible to transport the plutonium resulting from the first recycling stage (second-generation plutonium) in existing containers without exceeding the limits for the radiological exposure of workers laid down in the basic Euratom standards relating to the protection of workers and the public from the dangers of ionizing radiation ;
- plutonium recycling in LWR power stations does not involve any appreciable change in the impact on the environment in comparison with the uranium cycle ; a summary of the studies performed will be available in 1981.

3.2. The first multi-annual research and development programme on the management and storage of radioactive waste was completed at the end of 1979.

Satisfactory progress was achieved, in particular, in the following fields :

- medium-activity solid waste : pilot-scale development of a process for coating such waste with thermosetting resins ;
- high-activity solid waste : decontamination and immobilization of cladding waste in various matrices ;
- plutonium-contaminated solid waste : development and final adjustment of various incineration processes and study on the recovery, where possible, of the plutonium ;
- high-activity liquid waste : comparative study on the characteristics of various matrices for the immobilization of such waste (in particular glass) with a view to its ultimate storage.

Work on the disposal of waste in geological formations on the mainland has suffered a number of delays caused by external factors (public acceptance).

It should be pointed out, however, that a European catalogue of geological formations possessing characteristics suitable for the disposal of high-activity and/or long-lived waste was compiled with the assistance of all the competent national bodies<sup>(\*)</sup>.

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(\*) A publication (atlas) is in preparation.

A study on problems of a legal, administrative and financial nature associated with the management of waste was continued with the assistance of an ad-hoc group of experts ; a report was recently published<sup>(\*)</sup>. In addition to the numerous working meetings with the Community's experts, a seminar on the migration of long-lived radionuclides in the geosphere was held in 1979 in cooperation with the Nuclear Energy Agency (NEA) of the OECD, and a meeting held in Luxembourg from 20-23 May 1980 made it possible to take stock comprehensively of what this programme had achieved. Furthermore, 1980 was marked by three other important events in this field :

These events were :

- the approval by the Council on 18 February 1980 of a twelve-year (1980-92) plan of action<sup>(\*\*)</sup> in the field of radioactive waste which expanded Community cooperation, until then mainly limited to the R&D aspects, to all aspects (logistic, administrative, regulatory, etc) of waste management with the aim of progressively harmonising the policies of the Member States in this field ; this plan is centred on the five following points :
  - . continuous analysis of the situation with a view to adopting the necessary solutions ;
  - . examination at Community level of the measures likely to be suitable for the long-term or ultimate storage of radioactive waste under optimum conditions ;
  - . consultation on the practices connected with the management of waste, the quality and properties of the conditioned waste and the conditions governing the disposal of waste ;
  - . continuity of the Community's research and development work for the duration of the plan ;
  - . periodical public information.

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(\*) Risks, regulations, responsibilities and costs in nuclear waste management - a preliminary survey in the European Community, EUR 6893, 1980.

(\*\*) O.J. N° C 51 of 29/2/1980.

- the approval by the Council on 18 March 1980<sup>(\*)</sup> of a second five-year (1980-84) research programme on the management and storage of radioactive waste, which more than doubles the Community's financial contribution (43 m EUA instead of the 19 m EUA granted for the 1975-79 period) ; this second programme, which is the world's most important multilateral cooperative project in this particular field, is a logical sequel to the first one, from which, however, it is distinguished by the following features :
  - . greater emphasis is placed on the management of low- and medium-activity waste in order to take account of the increasing production of that type of waste ;
  - . the projects relating to the processing of waste include a comparative analysis and an evaluation of the properties of the various types of conditioned waste to be performed jointly by the various laboratories involved on the basis of identical procedures ;
  - . as part of the geological evaluation, the feasibility of disposal in the seabed shall henceforth be taken into consideration ;
  - . special attention will be paid to the studies on the evaluation of the risks associated with the management of radioactive waste ;
- the conclusion on 3 November 1980 of a 5-year agreement for scientific and technical cooperation between the Commission and the Atomic Energy Commission of Canada, which is tacitly renewable beyond that period and mainly concerns, in its initial phase, the problems associated with disposal in crystalline geological formations. The agreement makes provision for exchanges of information and of scientific and technical personnel and for the holding of joint meetings.

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(\*) O.J. N° L 78 of 25/3/1980, p. 22.



3.3. As a result of a proposal placed before the Council by the Commission in April 1978, the Council, on 27 March 1979, adopted a research programme (indirect action project) on the decommissioning of nuclear power plants<sup>(\*)</sup> which is being implemented at present.

The aim of this five-year (1979-83) programme is the joint development of a system of management of redundant nuclear power plants and of the radioactive wastes produced in their dismantling which, at its various stages, will provide mankind and the environment with the best protection possible; the programme seeks to promote :

a) research and development projects concerning the following subjects :

- . long-term integrity of buildings and systems;
- . decontamination for decommissioning purposes;
- . dismantling techniques;
- . treatment of specific waste materials : steel, concrete and graphite;
- . large transport containers for radioactive wastes arising from the decommissioning of nuclear power plants in the Community;
- . influence of nuclear power plant design on decommissioning.

b) identification of guiding principles, namely :

- . in the design and operation of nuclear power plants with a view to simplifying their subsequent decommissioning;
- . in the decommissioning of nuclear power plants, which could form the initial elements of a Community policy in this field.

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(\*) OJ N° L 83 of 3/4/79, p. 19

ANNEX 1

Working Group on Light-water reactor safety  
(methodology, criteria, codes and standards)

Objectives and membership

The objective of Working Group N° 1 is to compare the practices, methodologies, criteria, codes and standards applied in the Member States for the purpose of enabling the Commission subsequently to formulate recommendations and place before the Council proposals judiciously geared to Community requirements. This Working Group was set up at the end of 1972 ; it is composed of delegates from the Member States who are appointed by :

- the authorities and/or the associated bodies responsible for nuclear safety, authorizations, supervision and inspection ;
- the electricity-producing bodies, through the intermediary of UNIPEDA ;
- the suppliers, through the intermediary of UNICE and CEEP.

Under certain conditions, Swedish experts have been participating in the meetings since the end of 1976.

Working Group on Light-water reactor safety "Coordination of Research Programmes"

Objectives and membership

The objectives of Working Group n° 2 concern the routine exchange of information and consultations on the national and Community (JRC) research programmes on nuclear safety. This Working Group was set up at the end of 1972.

It is composed of representatives from the Member States who are appointed by :

- the authorities and/or associated bodies responsible for nuclear safety ;
- the administration responsible for the management of research programmes financed by public funds ;
- the electricity-producing bodies, through the intermediary of UNIPEDE ;
- the suppliers, through the intermediary of UNICE and CEEP.

ANNEX 2

Working Group on fast-reactor safety

Objectives and membership

The objective of this Working Group, which was set up in 1971 within the Fast Reactor Coordination Committee, is the exchange of information on current research and development programmes, the discussion of problems of particular interest as regards fast reactor safety and the proposal of measures to be taken to solve them, and the preparation of common safety criteria.

Two study groups are assigned the task of studying, evaluating and comparing the computer codes :

The Study Group on whole-core accident codes (WAC),

The Study Group on containment loading and response (CONT).

The Working Group is composed of representatives from the Member States appointed by the various bodies involved in the development and construction of fast reactors :

- the government departments responsible for research and development programmes ;
- the representatives of research centres;
- the licensing authorities or associated bodies ;
- the constructors ;
- the electricity producers.

Working Group on codes and standards

Objectives and membership

This Group was set up in 1974 and its membership is similar to that of the Working Group on fast reactor safety. Its main objective is to draw up an inventory of the existing codes and standards that can be applied to fast reactors with the aim of identifying the fields in which additional knowledge is desirable.