COMMISSION OF THE EUROPEAN COMMUNITIES

COM(87) 96 final

Brussels, 6 April 1987

TECHNOLOGICAL PROBLEMS OF NUCLEAR SAFETY

Report upon the implementation of the

Council Resolution of 22.07.75.

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1. INTRODUCTION

For some years the Commission has conducted exercises of consultation and analysis with the objective of inducing a progressive harmonisation of the safety requirements and criteria applied to nuclear installations in the Community. The Commission's aim in pursuing this work has been to ensure that as far as possible the safety criteria to which each nuclear installation is designed, constructed and operated enjoy the benefit of review and possible refinement in the light of the whole competence and experience of the designers, constructor, operators and safety authorities of the Community. The intended programme of actions to achieve this aim was proposed to the Council and to the Parliament and was endorsed by the Council in its resolution of 22 July 1975.(*)

At this time, when the incident at Chernobyl has re-emphasised the importance of effective measures to secure and maintain the safety of nuclear installations, it is pertinent to review the experience of implementing the programme, to report upon its achievements and its problems, to indicate those actions which require continuing effort and to suggest supplementary actions which should be undertaken. The Commission indicated, in its general communication on Chernobyl (**), its intention to address these areas: that intention is fulfilled in this communication.

In the analysis presented in this Communication, the emphasis has been put upon the principal objective of the above mentioned Council Resolution, i.e. "to provide an equivalent and satisfactory degree of protection of the population and of the environment against the risks of radiation resulting from nuclear activities and at the same time to assist the development of trade on the understanding that such harmonization should not involve any lowering of the safety level already attained".

This objective is still valid, but the ways and means of fulfilling it must take into account the experience accumulated in the course of implementation of this Council Resolution as well as the lessons from major events such as Three Mile Island incident.

Consequently the actions recommended in the final section of this Communication go beyond the continuation of the harmonization process, and represent a comprehensive approach, which is more adapted to the present situation.

2. INTRODUCTORY REMARKS ON TECHNOLOGICAL SAFETY

2.1 Safety philosophy and licensing procedures of nuclear reactors

The main actors in a licensing procedure are the utility, which is responsible for the safety submission, the constructor who designs and supplies the plant to the utility and the licensing authority. This latter is the guardian of the public interest in safety and is provided with wide powers for regulation and enforcement in the national context. Research organisations have a subsidiary but

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(*) OJ C185/1, 14.VIII.75 : copy at Annex I

(**) COM (86) 327 final

vital role in providing the scientific evidence upon which the proposed design and operating solutions are based. The Commission of the European Communities, by virtue of Euratom Community's Research and Development programmes in Nuclear Safety and Radiation Protection contributes to the generation of the scientific evidence, but has no direct role in the licensing procedure and in the regulatory field. (*)

Nuclear reactors have so far been designed and licensed on the basis of a set of requirements for normal operation and of a predetermined set of accidents (**), the so-called "design basis accidents", considered to lie within a sufficiently low range of probability of occurrence and to be the extreme cases of certain types of accident. In this way, designing against the extreme cases should automatically cover the less severe accidents.

More severe accidents with a still lower probability of occurrence than the design basis accidents need not be catered for by the design, since all design basis accidents contain already the multiple combination of different unrelated and unlikely events, but their effects upon the containment structures and consequences upon the environment and the population must be assessed in order to detect possible cost effective solutions even against them.

To this endeavour probabilistic safety analysis methodologies (***) have been increasingly used over the last 10 years as a complementary tool for designing and licensing e.g. to assess the risks from accidents more severe than the design basis accident and for assessing different technical solutions of a given safety problem on a comparative basis and to detect the cost effective solutions mentioned before. Furthermore they are beginning to be used for assessing the probability of a given critical occurrence, such as the probability of a core melt, also for reactors which have been already built, for the purpose of intercomparison and for identifying optimal strategies of backfitting.

The overall protection against nuclear risks has two quite different aspects :

- the first is related to environmental pollution considerations, i.e. to the release of radioactivity in the atmosphere or in liquid effluents during normal operation.
  These release rates are set as targets (****) in the design phase and their achievement can be actually measured in a continuous manner during the life of the reactor. The public understand this aspect relatively easily and it is in general recognised that the routine releases of radioactivity during normal operation of nuclear reactors do not pose major problems.

(*) The Council Directives issued in implementation of Title II, Chapter III, of the Euratom Treaty and concerning the basic safety standards are, of course, incorporated in national legislations.

(**) For this reason this approach is called "deterministic"

(***) The "probabilistic approach"

(****) Below the permissible levels derived from the basic safety standards. COM(86)434 final deals with these aspects, amongst others.

- the second is related to nuclear safety in the proper sense i.e. to the release of radioactivity in accidental conditions. At the extreme end of the class of accidental conditions there are severe accidents involving the partial or total destruction of the reactor core. In this case the safety performance is expressed as a probabilistic expectation. Probabilistic Safety Assessment techniques are used to estimate this probability and to describe the accidents, as explained in the preceeding paragraph, although the accuracy of the probability estimates needs to be improved and is the object of ongoing research.

2.2. Levels of regulatory provisions

Annex II contains a definition of terms currently used in national and international regulatory provisions. Three different levels of hierarchy are illustrated i.e. : general principles, criteria and guidelines, construction codes & standards.
From top to bottom there is a decreasing legal relevance and reduced lifetime. Conversely there is an increasing content of technical information. Broadly speaking the top level in the hierarchy, corresponding to the "basic safety standards", are embodied in national legislation and do not lend themselves to modifications other than by a relatively long legislative process.

The bottom level, i.e. the construction codes and the standards represent "industrial regulatory provisions" containing updated information. They are usually developed in national and sometimes international standard institutions by the consensus method, involving all relevant organisations and companies. Because of this they lend themselves well to harmonisation. The Construction Codes are particularly important in establishing the safety case for nuclear reactors. They do in fact prescribe the design methods and the fabrication and inspection procedures for structures, such as the primary circuits and they must assure with a high degree of confidence their structural integrity in operating conditions and in a prescribed set of accidental conditions or of events of external origin. It is useful to recall that the assurance of integrity of the primary circuit plays a central role in the safety case for all reactor systems.

2.3. Harmonisation/Intercomparisons

Even before the Council Resolution of 22.7.75 came into existence the Commission had performed actions of harmonisation/intercomparisons, in recognition of the benefits accruing both to the participants to such actions and to the Community itself. These benefits can be briefly summarised as follows:

benefits to safety

A major benefit from such activities from a safety point of view derives from the exchange and pooling of information and comments upon the approaches evolved by different organisations and countries to the design and licensing of nuclear installations. The ensuing process of analysis and the diversity of scrutiny of the various approaches tends to consolidate the confidence in each others' approach and to ensure that potentially severe sequences of accidents have not been overlooked. Furthermore, the countries with the smaller nuclear programme can benefit from the strength of knowledge and experience of the others. Overall the effect is to promote convergence to an equivalent assurance of safety throughout the Community.

benefits to market opening and to export potential

A major potential benefit derives from the removal of technical obstacles, motivated on safety grounds, to trade in components and materials needed for nuclear installations. This can only achieved if Codes and Standards for component design, manufacture and quality control as well as materials specifications are either harmonised or recognised as equivalent.

Eventually a reactor component designed for a given set of operating and accidental conditions accepted by a utility and by a licensing authority in one country should be acceptable by another utility and licensing authority in another country without substantial modifications other than those dictated by the site.

The reactor industries of the Community have an excellent record of achievement in both quantity and quality of their products and the safety record of European reactors is very good : the competitive position of these industries vis à vis the extra Community industry is therefore soundly based. The Commission has therefore stressed to the Member Countries, that their competitivity would be strengthened by the existence of coherent regulatory provisions enjoying acceptance at Community level : this should motivate them toward the harmonization goal.

3. ANALYSIS OF THE STATUS OF IMPLEMENTATION OF THE COUNCIL RESOLUTION OF 22.7.75

The Council Resolution, appended as Annex I, addresses a series of exhortations to the Commission and to the Member States upon the objectives and the lines of action to be followed concerning the progressive harmonisation of safety requirements and criteria throughout the Community. It covers, in principle, all nuclear activities, including those linked with the fuel cycle.

In its implementation, the Commission has chosen to focus the work, initially, on the Light Water Reactor (LWR) which represents by far the most numerous category of nuclear installations in the Commission. In 1975, Light Water Reactors were already commercially established in the Community and indeed in the world. They owed much to the U.S. technology which was transplanted in Europe during the 1960's. For this reason much of the regulatory framework had a common U.S. origin. The adaptation to European conditions required consideration of the specificity of European countries concerning geological conditions, population density, industrial environment and practices, and legal frameworks. The Liquid Metal Fast Breeder Reactor (LMFBR) being developed by a large group of Member Countries as a future generation of reactors has also been a main focus of attention. Fast Breeder Reactors development has been essentially based upon indigenous technology and has benefited from increasing collaboration amongst Member States.

Point 2 of the Council Resolution invites the Commission and Member States to list and compare the requirements and criteria applied to nuclear power stations, to draw up a balance of similarities and dissimularities and to develop recommendations. In 1975, when the Council Resolution was issued, the Light Water Reactor was already well into its phase of expansion within the Community, and separate independent industrial developments had already begun. Conversely the Liquid Metal Fast Breeder Reactor development was still at its prototype phase, with demonstration initiatives being planned or taken on a collaborative multilateral basis. These circumstances explain the different status of implementation of the 1975 Council Resolution and call for a separate treatment in this report.

In 1979 the Three Mile Island incident focused the attention of the nuclear community on a number of important safety issues for Light Water Reactors, such as containment, personnel qualification, quality assurance and "small" primary circuit breaks. In the ensuing period of evaluation and assimilation of the lessons learned from the incident it appeared that the Light Water Reactor lines within the Community had developed towards a remarkably uniform product if judged from the point of view of safety and reliability performance, in spite of the independent separate industrial developments and the fragmentation of the market. Such a healthy state of affairs can be attributed partly to the technical strength of the utilities within the Community and partly to the exchange of information and ideas promoted by the Commission under the 1975 Council Resolution, all leading to substantial paralel thinking in spite of diversities in the details of the applications. However the Three Mile Island incident made it necessary to adjust safety philosophies and practices both in US and in the Community.

In assessing the status of implementation of the Council Resolution of 22.7.75 it necessary to take into account that the dynamics introduced by the intense development of nuclear energy in the last decade as well as by the Three Mile Island incident, have rendered its implementation less straightforward than originally intended and delays have occurred in consolidating the results achieved in the field of Light Water Reactors into formal expressions of consensus.

3.1. Harmonization actions performed on Light Water Reactors and Fast Breeder Reactor

3.1.1. Light Water Reactors

In carrying out the activities related to the point 2 of the Resolution, the Commission is assisted by a Working Group on "Safety of Light Water Reactors : Methodologies, Criteria, Codes and Standards", composed by representations from licensing authorities, utilities and constructors.
This group has regularly discussed and exchanged information upon all matters related to LWR safety such as :

. Regulatory requirements and technological problems concerning the different phases in the life of a plant : siting, design, construction, commissioning, operation and backfitting.
. Regulatory requirements and technological problems which are

concerning more than one phase in the life of the plant and relate e.g. to the areas of : safety evaluation, quality assurance, ergonomies, emergency planning.

With reference to Annex II the level at which the harmonisation activities has been addressed is mostly level 2, i.e. Requirements (or Criteria) and Guidelines. This level is just below the level at which legal instruments are used in the national context. Level 3 i.e. design and construction codes and standards has needed less attention because of the reasons outlined above : for instance the ASME (*) Codes are commonly used in European countries.

Level 1 i.e. Safety principles has been the subject of a Communication to the Council (**) containing a set of basic safety principles and a scheme for subsequent requirements and criteria. These basic principles are intended to form a framework which can be used as reference for judgements that must be made in the safety evaluation process by regulatory bodies, licencing authorities, utilities, equipment vendors, architect engineers etc. to adopt a consistent and uniform approach.

The inventory of regulatory provisions, in the different Member States, is essentially completed even though it is necessary to update information periodically. The documents issued in this connection are published regularly (***).

Concerning the identification of similarities and dissimilarities and their assessment, different degrees of progress have been achieved in different subjects.

Thus the subjects which have so far been treated and for which reports and studies have been completed and are available to the participants organisations or published are given in Annex III as well as a list of subjects which are currently been treated.

The process of formalizing the technical consensus already reached is being initiated with the forthcoming issue of a special Publication on an important set of subjects related to the personnel for the operation of nuclear power plants i.e. : qualification, training, licencing/authorization and retraining. This publication contains information on practices in Community Countries as well as fundamental and generally valid concepts concerning shift personnel selection, training and licencing.

(*) American Society of Mechanical Engineers
The ASME Codes are regularly updated.

(**) Safety Principles for Light Water Reactor Nuclear Power Plants COM (81) 519 final

(***) EUR 5362 (1975); EUR 5649 (1977) + updated versions in 1981 and 1984

The basic data necessary as an input for providing safe designs against earthquakes is being also the subject of a forthcoming publication in the form of an European seismic catalogue and maps. The seismological data available on a national basis have been collected, the discrepancies analysed and solved in a view to establish a set of consistent data, a general European catalogue of earthquakes is established (51.000 events) in a homogeneous format on an informatic support. Based on this catalogue, seismic maps covering all the member countries and the neighbouring countries are being prepared. This material will benefit not only the nuclear industry but is applicable for the design of all seismic structures.

Finally it is useful to remark that philosophies and practices, which are important to safety are not necessarily codified within Member States even when a consensus exists. The philosophy of containment systems is a case in point which is worth illustrating.

Containment system designs have evolved in function of the requirement that they should provide radiation shielding and retain the steam, water and radioactivity discharged in a design basis accident. The design basis accident (of internal origin) for which LWR containments are conservatively designed is the largest double-ended primary pipe rupture which would cause maximum energy, pressure, temperature and radioactive release.

Another requirement has been the protection against external phenomena like aircraft crash and possible blast waves from gas cloud explosions.

Lastly, following the lessons of the Three Mile Island accident, the containment design must also to take into account accidents more severe than design basis accident.

The different initial situations and timings of development of nuclear energy in the different Member States have led in the past to a variety of containment philosophies and designs in the Community. However, today, one can observe that the containment philosophies for Light Water Reactors have converged, for instance all new reactors incorporate a double containment feature.

3.1.2. Liquid Metal Fast Breeder Reactor (LMFBR)

The Commission has performed an action of progressive harmonisation of regulatory provisions for Fast Breeder Reactors from the early 70's. In addition to the already mentioned Council Resolution of 22/7/75, the Council Resolution of 18/2/80 on Fast Breeder Reactors (*) applies to this work.

(*) OJ C51/5 of 29/2/80. This Resolution affirms the necessity to keep open an effective option of Fast Breeder Reactors within the Community, invites the Member States which have carried out Fast Reactor development to ensure continuity of effort and invites the Community to lend support to these objectives. It also reaffirms the role of the Fast Reactor Coordinating Committee in the work of gradual harmonization of safety codes and measures.

The fast Breeder Reactor being in the phase of development and demonstration, the regulatory provisions are in the formative stage and considerable evolution has to be expected. In planning its action the Commission has sharply focused its attention on those aspects which are specific to Fast Breeder Reactors, i.e. those related to the Nuclear Steam Supply System. Aspects like siting, emergency planning, the conventional part of the plant, etc. have not been treated, as they are common or similar to those for commercial thermal reactors.

The level at which the actions have been addressed are, with respect to Annex II :

Level 2, i.e. Criteria and Guidelines
Level 3, i.e. Codes and Standards

3.1.2.1. LMFBR Safety Criteria and Guidelines

In carrying out the activities directed at the harmonisation of LMFBR safety criteria and related guidelines the Commission is assisted by the Fast Reactor Safety Working Group (SWG) which is a subgroup of the Fast Reactor Coordinating Committee (FRCC) (*).

The Safety Working Group is composed of representatives of all parties involved in fast reactor development, construction and operation, i.e. representatives from governments, utilities, industry, research organisations and licensing authorities. It has regularly discussed and exchanged information upon all matters related to Fast Breeder Reactor safety, such as the results of safety research programmes, operational experience of prototypes, abnormal occurrences, etc.

The initial step in the harmonisation of safety criteria and guidelines was the setting up of a reference list of accidents considered as the design basis for fast reactors. These are grouped under five headings as follows (a more detailed list is given in Annex IV) :

- Primary Reactivity
- General Cooling
- Subassembly cooling
- External to the core
- Initiating events external to the station

Between 1970 and 1975 the safety measures designed to cope with these accidents were identified for each LMFBR project in construction or under design in the European Community (Superphenix 1, CFR 1, SNR 300, PEC), and a systematic comparison was made.

(*) Committee created by the Council in April 1970 with the mandate "to work out and implement plans for coordination and cooperation on the broadest possible scale between the various programmes by means of the most suitable procedures and to make any helpful suggestion in this connection".

For each accident and project

- the possible initiators
- the design provisions
- the protective actions
- any immediate consequences and possible evolution

were considered and compared and appropriate comments were made.

The comments refer to the general safety philosophy, the state of the reactor at termination of the accident, the worst situation analysed etc... In addition, a qualitative probability rating for the occurrence of an accident was made.

Differences in the safety approach and design measure envisaged in the projects were discussed in great detail in order to permit the arguments on which the designer had based his choice to be made mutually transparent. Generally common features could be identified which could serve as a basis for the formulation of criteria and guidelines for the future.

Building up upon the work described above, the formulation of common safety criteria and guidelines for future large commercial fast reactors began in 1975.

In the formulation of common safety criteria and guidelines the following approach has been adopted:

- Criteria and Guidelines have been associated in the same document; the examples given in the guidelines for possible design measure are not exhaustive but have been selected in such a way as to give assurance that a complete coverage can be reached, in due time.
- The criteria and guidelines are intended to be the basis upon which the national regulations will be formalised.
- They are based on present knowledge and proven technology and are consistent with the design philosophy of the already built prototypes (Phenix, the Prototype Fast Reactor, SNR 300 and Superphenix). Expected results forthcoming from current R&D programmes will be taken into account at a later stage.
- The safety criteria and guidelines refer essentially to design aspects putting main emphasis on the prevention of accidents, their early detection and finally the mitigation of possible consequences.

Present Status

A first formulation of accident oriented common safety criteria and guidelines for all the accidents in the reference list is now concluded and criteria and guidelines are in a draft form. Editing is currently underway in order to ensure consistency in the wording used throughout.

The fact that provisional common criteria and guidelines exist is in itself a positive element. The painstaking working over such a long period of time has certainly ensured a high degree of mutual understanding of the safety case for fast reactors in the Member Countries pursuing this line of reactor development. The mass of documentation and the records which have been kept of the discussion is large.

Also for the L.M.F.B.R. the double approach based upon design basis accidents and probabilistic analysis is used just as for Light Water Reactors.

3.1.2.2. LMFBR Codes and Standards

For this activity the Commission is assisted by the Fast Reactor Working Group on Codes and Standard (WGCS), a Sub-Group of the Fast Reactor Coordinating Committee.
This activity was initiated in 1974 but it is only since 1980 that substantial effort has become available. The design and manufacture procedures for LMFBR components having an important safety function are different from those for the Light Water Reactor and the pertinent national codes and standards need to be harmonised; in some cases they are being developed in common. The Commission, with the assistance of the above Working Group, has gathered together information from the Member States and has compared and analysed the different national documents relating to the design, the manufacture and materials properties of interest for LMFBR components having a safety function. These comparative studies have helped to identify discrepancies between the different national codes and standards as well as shortcomings of the design procedures based on the ASME Codes and shortage and/or uncertainties of materials data, particularly in the creep range. This has made it possible to envisage actions at national level to eliminate gradually or to reduce the main divergences observed as well as to improve the analytical tools and the materials data base.

Annex V contains a list of completed studies, with indication of publication status.

The impact of these studies on national codes and standards is considerable, particularly in those areas, such as the design rules for components subject to thermal loads, where design codes were unsatisfactory.

3.2. Research Coordination (point 3 of the Council Resolution)

Coordination of safety research effort has so far been supported by the following means:

- The substantial R&D Community effort both as direct and shared cost action, has been a major tool to encourage coordination of Member States and Community research, particularly on those subjects which are included in the scope of Community programmes. The recently instituted Management and Coordination Committee N° 5 (Reactors and Safeguards) (*) covers the field of the nuclear safety programme.

(*) Before 1985 a similar role was performed by the Advisory Committee on Programme Management "Reactor Safety" + Working Group n° 2.

- The work of harmonisation of Safety Criteria Guidelines, Codes and Standards provides the participants with an opportunity to exchange information and views on a number of safety issues that though not directly concerned with the day to day management of safety research, can lead to anticipation of research trends and needs from an overall viewpoint.

3.3. Notification of draft legislation (point 6 of the Council Resolution)

Very few of these have been notified. This is not due to failure by the Member States to notify but rather by a low rate of production by the Member States. Legislation is notoriously difficult to modify and tends to be used only for the higher level of general safety principles (such as e.g. the basic safety standards).

Conversely non-legal instruments such as Criteria Guidelines, Codes and Standards have been freely communicated and assessed and have been the object of the harmonisation and intercomparison as per point 3.1.

3.4. Seeking common positions on safety harmonisation and research coordination in international fora (point 7 of the Council Resolution)

The Commission has vigorously pursued the implementation of this point. On the side of safety harmonisation one can mention the exercise of compilation of the Nuclear Safety Standards (NUSS) within the frame of the International Atomic Energy Agency of Vienna. On the side of research coordination one can mention the PISC (*) programme, initially born under the auspices of the Nuclear Energy Agency (NEA) of the OECD. The Joint Research Center (JRC) is now the operating agent and implements a supporting R&D programme. Similarly the JRC is the operating agent for the Incident Reporting System (IRS) of the NEA.

4. ACHIEVEMENTS AND PROBLEMS

4.1. After ten years of implementation of the Council Resolution of 22.7.75, one can recount the following achievements and the problems encountered.

- The exchange of information and the comparison of methodologies and practices have been fruitful to all participants and have permitted a better understanding of approaches. This has lead to a progressive harmonisation of safety philosophy which is real, though difficult to quantify into criteria, codes and standards at least for Light Water Reactors. In fact it has so far not been possible to complete the second stage (the identification of similarities and dissimilarities) because of the relatively rapid developments which have taken place in the last ten years both in the field of nuclear power installation and in the field of regulatory practices. However the numerous publications and reports which have been issued or are being prepared constitute the background material from which the detail status of convergence of regulatory provisions can be synthetized.

(*) Programme for Inspection of Steel Components

- The progress made in the field of Liquid Metal Fast Breeder Reactors appears to have been more easy and systematic than in Light Water Reactors. This is partly due to the fact that the harmonization work was started well in advance of commercial applications, and partly to the fact that fast reactor development and demonstration has benefited from the collaboration of Member States at both research and industrial level. However the present stagnation of initiatives towards a further stage of demonstration/commercialization of fast breeder reactors accounts for a certain lack of focus in the further development of regulatory provisions.

- The complexity of the subjects to be treated and the large number of participants from organisations from different Member States and having different roles in the national policies of implementation of nuclear programmes (utilities, constructors, licensing authorities, research organisations) has sometimes made it difficult to find consensus. Furthermore, most of these organisations are reluctant to envisage a central role of the Community on regulatory matters, beyond that enshrined in Chapter III of the Euratom Treaty.

- The rate of progress in the work has been governed partly by the rate at which participating organisations have been able to supply input documents, responses to questionnaires and evaluation effort and partly by the Commission's own efforts. Decreasing budget allocations in the last few years have not helped.

5. FUTURE ACTION

The objectives of the Council Resolution of 22 July 1975 concerning the technological problems of nuclear safety (*) are still valid and provide guidance for Community action. However, it must also be stressed that the Community has no direct role in the licencing procedure and in the national regulatory process.

There clearly remains a common interest to work together to ensure that nuclear installations in the Community are safe in all circumstances and to provide public opinion and decision makers with clear explanations of the means used to ensure this safety.
The Chernobyl accident has raised many fears and added a new challenge to nuclear energy.

To deal with this challenge, the Commission intends to pursue the following strategy :

a) to bring quickly to fruition the work already performed;
b) to initiate new actions which, though coherent with the objectives of the Council Resolution of 22.7.75, go beyond the continuation

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(*) i.e. "to provide an equivalent and satisfactory degree of protection of the population and of the environment against the risks of radiation resulting from nuclear activities and at the same time to assist the development of trade on the understanding that such harmonization should not involve any lowering of the safety level already attained".

of the harmonisation process pursued up to now. The full cooperation and support of the Member States is necessary to fulfil these actions.

The main thrust of this strategy rests upon four points :
(i) Harmonisation,
(ii) Safety reviews,
(iii) Continuity of effort,
(iv) International cooperation.

The Commission intends to implement this strategy and particularly the new actions in close consultation and with the support of the Scientific and Technical Committee.

5.1. Harmonisation

Harmonisation of criteria, guidelines, codes and standards is necessary to ensure an equivalent and satisfactory degree of protection of the population and the personnel against the risks posed by the exploitation of nuclear installation and, in particular, nuclear reactors.

5.1.1. The approach to harmonization as indicated at point 2 of the 1975 Council Resolution should proceed quickly towards an interim conclusion, on the basis of the information already available for Light Water Reactors.

Concerning Light Water Reactors the Commission intends to publish periodically descriptions of criteria and guidelines pertinent to the most important safety related issues in Member States, assorted with statements of convergence/divergence. A first important set of criteria and guidelines will be published within 1987.

5.1.2. The further development of fast breeder reactor criteria, guidelines, codes and standards will be pursued. Given the pattern of cooperative development in the Community, the work must proceed in step with the progress toward the demonstration/commercialization within the framework of collaboration amongst Member States (Belgium, France, Germany, Italy, United Kingdom). The Council Resolution on Fast Breeder Reactors of 18/02/1980 provides the guidance by which the Community can support the achievement of the objective of continuity in the development/demonstration of a system which is safe and licenseable in the Community.

In relation to fast breeder reactors, the Commission intends to continue to make its contribution toward achievement of the goal of a full set of criteria, guidelines, codes and standards. These should be applicable to the practical design of a family of reactors throughout the Community. They should be straightforward by-products of the construction and exploitation cooperation which is currently being pursued by a group of Member States.

5.2. Safety Reviews

The population of reactors in the Community comprises Light Water Reactors of different designs, sizes, ages as well as Gas Cooled Graphite Moderated Reactors. A number of Light Water Reactors are now approaching the age of 20 years, and a considerable proportion of Gas Cooled Graphite Moderated Reactors are even older. Of course Member States conduct safety reviews on individual reactors or classes thereof, using the most up to date methodologies, including Probabilistic Safety Assessment (PSA) in order to check their safety performance, to identify the possible needs for backfitting and to help taking decisions about withdrawal from service. These safety reviews permit, in the light of experimental data on incidents collected from similar reactors, to identify potentially dangerous sequences of events so far overlooked, the weak points of the design and the consequences of aging of components. Detail knowledge of the installations is obviously important and therefore such exercises can only be conducted with the participation of experts having such a detailed knowledge, i.e. from the utilities and constructors. Indeed the full responsibility of conducting these reviews rests with the Member States. However there would be added value in exchanging information upon the plans, the scope, the input data, the execution and the results of such reviews within a Community framework and with the participation of the Commission's Services within the limits of possibility. This approach would usefully complement the "harmonization" approach and would respond more directly to the concern of the public over the safety of nuclear reactors.

The Commission intends to promote cooperation at Community level in the field of reactor safety reviews so that the methodologies, the plans, the scope, the input data and the results concerning these reviews can become mutually transparent. This will improve the effectiveness of the safety reviews.

5.3. Continuity of effort

The role of nuclear energy in the energy balance of the Community is very important. Although the performance of Community nuclear power plants from the safety point of view has been consistently satisfactory, continuing effort to support the safe exploitation of nuclear installations must be assured.

The factors which have contributed to such a healthy state of affairs must be preserved and stenghtened. Stringent criteria, codes and standards are certainly one factor; however the human factor both in the phase of design and construction and in the phase of operation of reactors has plaid a major role. Expert teams of scientists and engineers have been created and maintained by the utilities, the reactor constructors, the licencing authorities and the research organization to support the steadily expanding nuclear programmes over the last 25 years. These human resources, together with the laboratories and facilities for safety research developed over the years are the main assets upon which the Member States can rely in the future for a continuing safe performance of nuclear installations. Continuity of effort and of its quality is necessary.

The excellence of the teams of experts and engineers created and maintained up to now must be efficiently safeguarded. Although the Member States of the Community possess the capability to maintain the necessary high standards and the human resources, economic pressures and some decline in the tempo of reactor development could threaten the continuing viability of some national capabilities. Continuing cooperation is essential for an effective management of these resources. Equally the future evolution of research laboratories and major safety facilities must be collectively reviewed so that decisions affecting the long term (e.g. construction, exploitation, abandonment of facilities) can be taken in a cooperative framework.

The Commission intends to review the situation concerning human resources and major facilities dedicated to safety of nuclear installations at periodic intervals.

5.4. <u>International cooperation</u>

The accident at Chernobyl has given fresh emphasis to the issue of overall safety of reactors worldwide and has provided a clear demonstration of the need for cooperation on nuclear safety well beyond the national or even regional boundaries.

At world level initiatives have been proposed within the frame of the International Atomic Energy Agency to review and improve the Nuclear Safety Standards (NUSS) as well as to take other actions to increase international cooperation on nuclear safety.

The International Atomic Energy Agency has a key role to play in bringing about rigorous standards of safety assurance in the different regions of the world and merits the full support of the Community and its Member States in this complex and long term task.

The Member States and the Community should actively support the initiatives taken within the frame of the International Atomic Energy Agency.

* * *

The Council is invited to lend support to these actions.

ANNEX I

I

(Information)

COUNCIL

Council resolution of 22 July 1975 on the technological problems of nuclear safety

THE COUNCIL OF THE EUROPEAN COMMUNITIES,

Having regard to the Treaty establishing the European Atomic Energy Community;

Having regard to the Opinion of the European Parliament (¹);

Having regard to the Opinion of the Economic and Social Committee;

Whereas the Commission has forwarded to the Council a communication and a general report on technological problems of nuclear safety;

Whereas it is necessary to keep the public adequately informed on this subject;

Whereas nuclear power has a considerable part to play in supplying energy to the Community;

Whereas the technological problems relating to nuclear safety, particularly in view of their environmental and health implications, call for appropriate action at Community level which takes into account the prerogatives and responsibilities assumed by national authorities;

Whereas, by aligning safety requirements, the national authorities responsible for nuclear safety and constructors and energy producers will be able to benefit from a harmonized approach to the problem at Community level;

Whereas nuclear safety problems extend beyond the frontiers not only of Member States but of the Community as a whole, and it is incumbent on the Commission to act as a catalyst for initiatives to be taken on a broader international plane,

HEREBY ADOPTS THIS RESOLUTION:

THE COUNCIL

1. requests the Member States as well as the licensing authorities and the safety and inspection authorities on the one hand, and the operators and constructors on the other, and finally the agencies responsible for applied research programmes to continue to collaborate effectively at Community level;

2. agrees to the course of action in stages indicated below by the Commission in respect of the progressive harmonization of safety requirements and criteria in order to provide an equivalent and satisfactory degree of protection of the population and of the environment against the risks of radiation resulting from nuclear activities and at the same time to assist the development of trade on the understanding that such harmonization should not involve any lowering of the safety level already attained; taking into account the state of industrial development in the respective families of

(¹) OJ No C 128, 9. 6. 1975, p. 24.

high-power nuclear reactors, these stages involve listing and comparing the requirements and criteria applied and drawing up a balance-sheet of similarities and dissimilarities; formulating as soon as possible recommendations pursuant to the second indent of article 124 of the Euratom Treaty, and subsequently submitting to the Council the most suitable draft Community provisions;

3. agrees to strengthen Community efforts to coordinate applied research programmes in order to make the best possible use of the resources available in the Community and the Member States both technically and financially whilst avoiding as far as possible unnecessary duplication; these efforts shall be aimed at improving systematic exchanges of information, promoting concerted action and cooperation between specialized bodies and institutes and stimulating where appropriate the development of Community programmes;

4. approves of the methods used and advocated by the Commission, namely, meetings of working parties of specialized experts, exchanges of information on specific operational problems and analytical studies and syntheses with which these experts are associated;

5. notes that the measures described above may require appropriations in order to finance analyses and syntheses and the appropriate technical secretariat;

6. requests the Member States to notify the Commission of any draft laws, regulations or provisions of similar scope concerning the safety of nuclear installations in order to enable the appropriate consultations to be held at Community level at the initiative of the Commission;

7. requests the Member States to seek common positions on any problems concerning the harmonization of requirements and criteria and the coordination of research into nuclear safety being dealt with by international organizations;

8. requests the Commission to submit annual reports on the progress made and the Member States and the Commission to continue and strengthen their efforts to ensure that the public is given the best possible information about both national and Community action in the field of nuclear safety.

ANNEX II

Definition for a number of terms used in safety rule of nuclear plants.

1. - Safety principles.

   Based on the requirements of radiological protection, they allow to reach the objectives deriving from it. They apply to all phases of plant life (siting, design, operation and even decommissioning). Sometimes the term of general criteria is used in the same sense.

2. - Safety requirements and safety guides

   Apply to one of the phases of plant life or to certain areas like quality assurance.
   (Sometimes the term specific criteria is used in the same sense as safety requirements).
   Safety requirements are specific applications of safety principles. Safety guides recommend different ways of satisfying safety requirements.

3. - Codes and standards for construction.

   Codes are a collection of rules for design, manufacture and inspection of systems and components assuring the respect of safety requirements.

   A standard is a technical description or definition representing consensus between interested parties and issued by a recognized organization.

The above-defined principles and rules may have a legal status of different kind running from obligations (law, rule) to plain recommendations for use.

N.B. Safety Code : Collection of safety principles defining minimum requirements for structures, systems and components (e.g. Codes NUSS, series 50 of IAEA) refering to level 2 above.

ANNEX III

SUBJECTS DISCUSSED WITHIN THE WORKING GROUP "LIGHT WATER REACTORS SAFETY" CONCERNING MEMBER STATES' PRACTICES

- Subjects already fully discussed and susceptible to synthesis :

Siting	: - Criteria for site screening and site selection - Criteria for taking into account external events (man made and natural) like aircraft crash, gas cloud explosion, floods and seismic effects.
Design	: - Internal and external accidents sequences which constitute the design basis of the plant - Reactor coolant system overall design provisions - Reactor protection system - Electric power supply - Fire protection
Commissioning and Operation	: - Operator training and qualification - Containment integrity and leak testing procedures
Safety Evaluation	: - Deterministic methodology
Quality Assurance	: - Basic principles relevant to quality assurance
Emergency Planning	: - Onsite and offsite planning and preparedness

- Work is in progress in the following subjects pertaining to design and operation.

Design	: Comparison of rules and application practices of determinisitic design criteria for systems important to safety. Classification of electric equipment. Environmental qualification of safety related equipment Dynamic analysis of structures and systems under seismic loading and aircraft crash Control room layout and instrumentation
Operation	: Qualification and training of maintenance personnel
Safety Evaluation	: Probabilistic safety assessment methodology

LIST OF REPORTS ON THE SUBJECTS OF ANNEX III

/1/ Siting practices and criteria in EC countries and associated considerations.
Revision 1, March 1983.
DOC. WG1-82/P3.

/2/ CEC study report.
Methodology for coping with accidents of external and internal origin in PWR power stations. A comparison of the rules and codes of practice in use in Belgium, France, the Federal Republic of Germany, the United Kingdom and the United States od America.
August 1984.

/3/ CEC study report
Comparaison des pratiques et critères de site relatifs à la démographie et à l'hydrologie, d'application aux Etats-Unis, dans le pays du Marché Commun et en Suède.
Octobre 1980.

/4/ Protection of nuclear power plants against floods.
Revision 3, December 1984.
DOC. WG1-77/P20/Rev.3

/5/ Protection of nuclear power plants against seismic effects.
Reference ground motion : practice followed in European countries
EUR 8371
European Applied Research Reports, Volume 4, N°6, 1983.

/6/ CEC study
European seismic catalogue and seismic maps.
(Preparation of a special publication).

/7/ Protection of NPPs against aircraft crash.
Status report 1980.

/8/ Protection of nuclear power plants against external explosions.
DOC. WG1-78/P2, Revison 1, July 1979.

/9/ CEC study report.
Critical review of models of dispersion of explosive gas clouds.
December 1979.

/10/ EEC sponsored theoretical studies of gas cloud explosion pressure loadings.
EUR 6119

/11/ CEC study report
Caracteristiques du champ de pression engendré par une flamme accélérée en espace libre.
EUR 8010, 1983.

/12/ CEC study report.
Inventory and comparison of methods and procedures to investigate mechanical problems caused by accidents of external origin. 1985.

/13/ CEC study report.
Comparison of design specifications for loss-of-coolant accidents in light water reactors applicable in EC member states and USA. September 1982.

/14/ CEC study report
Comparison of design specifications for fuel handling accidents in light water reactors applicable in EC member states and the USA. 1978.

/15/ CEC study report
Protection of BWR nuclear power plants against steamline break outside containment. 1979.

/16/ CEC study report
Comparison of the design specifications for protection of PWR nuclear power plants against main steamline break outside contaiment. November 1980.

/17/ CEC study report
Comparison of design specifications for protection of PWR nuclear power plants against main steamline break inside containment. September 1981.

/18/ ATWS status report
Part I : Scram unavailability (1979)
Part II : Type and frequency of anticipated transients (1980)
Part III: Consequences (1981)

/19/ CEC study report.
Compilation of basic fire proteciton principles and criteria related to design, engineering, construction and operation for light water reactor nuclear power plants constructed and operated in European Community countries. 1983.

/20/ CEC study report
Inventory of national specifications, regulations and guidelines and description of methods and procedures applied in leak testing of LWR containment systems. 1976.

/21/ CEC study report
Containment integrity and leak testing procedures applied and experiences gained in European countries. 1985.

/22/ CEC study report
Comparison of codes and standards applied in European countries and the USA in the design of primary system components.
November 1986.

/23/ CEC study report.
LOCA design specifications.
November 1980.

/24/ CEC study report.
Collection and comparison of the existing guidelines and provisions on design, manufacture, testing and inspection of steel reactor pressure vessels.
1978.

/25/ CEC study report.
Inventory and comparison of analytical methods and experimental procedures existing to investigate the dynamic loadings on primary pipework in nuclear power plants caused by accidents of external origin, in particular by seismic response.
1984.

/26/ Protection of primary system and its components against overpressure.
Status report. Revision 3, December 1984.

/27/ PISC report
EUR 6371, Volumes I to V.

/28/ CEC study report.
Assessment of residual stresses in reactor pressure components and their significance in relation to non destructive testing (NDT).
Support of PISC II programme.
November 1983.

/29/ The use of acoustic emission methods as aids to the structural integrity assessment of nuclear power plants
International Journal of Pressure Vessels and Piping
21 (1985) 157-207

/30/ The significance of residual stresses in relation to the integrity of LWR pressure vessels
International Journal of Pressure Vessels and Piping
Vol. 17, N°4, 1984

/31/ Collection and comparison of the existing guidelines and provisions on design, manufacture, testing, and inspection of steel reactor pressure boilers, Volumes I, II, III
EUR-Report 5402

/32/ CEC study report.
Human factors and man-machine interaction. A comprehensive and critical survey classification and analysis of current relevant work. November 1984.

/33/ CEC study report.
Human factors and man-machine interaction. Application of methods of expert systems to control and safety functions in NPPs. 1985.

/34/ CEC study report.
Human factors principles relevant to modelling of human errors in abnormal conditions of nuclear and major hazardous installations.
November 1985.

/35/ CEC study report.
Human factors and man-machine interaction. Application of artifical intelligence to control and safety functions in nuclear power plant early fault recognition. November 1985.

/36/ CEC study report.
Comparison of national specifications, regulations and guidelines relating to the reactor protection system.
1982.

/37/ Protection of NPPs against loss of electricity power supply.
Synthesis report, 1983.

/38/ CEC study report
Authorisation procedure for the construction and operation of nuclear installations within the EC member states, including supervision and control.
EUR 5284, Edition 1978.

/39/ Commission of the European Communities.
Nuclear Science and Technology.
Qualification, training, licensing and retraining of operating shift personnel in nuclear power plants.
Report EUR 10118 EN, 1985.

/40/ Qualification, training, licensing/authorisation and retraining of operating personnel in nuclear power plants.
Note-worthy topics identified by evaluation of the practices in countries of the European Community.
Proposal for a Communication from the Commission to the Council.

/41/ Reporting of abnormal occurrences
Status report. Revision 1, February 1979.

/42/ Commission of the European Communities.
Comparison of the design specifications for loss of coolant accident in light water reactors applicable in the EC Member States and the USA.
CEC Study report, July 1979.

/43/ CEC study report.
Examination of the scientific and technical foundation of models and scenarios used to evaluate the radiological consequences of a reference accident in PWR reactors according to French rules.
November 1983.

/44/ CEC study report
Radiological consequences of a LOCA.
Principles underlying the German position.
1980

/45/ CEC study report.
The assessment of hydrogen production, distribution and risk of explosion in the reactor containment as a consequence of a LOCA in a nuclear power plant. November 1982.

/46/ CEC study report
Hydrogen mitigation.
April 1982.

/47/ CEC study report.
Distribution of hydrogen and other gases within the reactor containment as a consequence of a loss coolant accident in a light water reactor. November 1983.

/48/ CEC study report.
Expert appraisal and analysis of relevant global work on light water reactor severe accident phenomena concerning degraded core and severe fuel damage conditions. November 1984.

/49/ CEC study report.
The source term. An evaluation of its impact on safety. November 1985.

/50/ CEC study report.
Aerosol behaviours in a condensing steam environment. November 1985.

/51/ CEC study report.
Aerosol and hydrogen stratification plus leak path retention in light water reactor containments. November 1985

/52/ CEC study report.
Chemistry of fission products at high temperatures.
November 1985.

/53/ CEC study report.
Survey of requirements for thermophysical properties arising from studies of PWR severe core accidents. November 1985.

/54/ CEC study report.
Fluid dynamic effects on aerosol plate-out in light water reactor containments. November 1984.

/55/ CEC study report.
Fission product source term phenomena.
Acqua iodine chemistry.
November 1984.

/56/ CEC study report.
Fission product source term.
Chemical form and release of fission products at elevated temperature.
Report EUR 10345 EN.

/57/ CEC study report.
Fission product transport and aerosol behaviour in the containment at various stages of a severe accident in a light water reactor, with special emphasis on their possible resuspension from sump and walls.
November 1984

/58/ CEC study report.
Retention of fission product aerosols due to diffusiophoretic deposition in the containment atmosphere of a light water reactor under post meltdown condition.
November 1984.

/59/ Benchmark exercise on dose estimation in a regulatory context.
Outline of calculation programme.
February 1986.

/60/ Use of risk concept in safety analysis
Synthesis report WG1-79/P8. March 1980

/61/ Definition of quality assurance criteria.
(Preparation of a special publication)
September 1986.

/62/ The technical basis for emergency planning and preparedness in EC countries.
Report EUR 9623 EN, 1985.

/63/ CEC study report
Les plans d'urgence interne dans les pays membres de la Communauté Européenne.
Novembre 1985.

/64/ CEC study report
Situation concerning offsite emergency planning and preparedness in EC countries and Sweden.
Overview and examination of practices and criteria.
November 1986.

ANNEX IV

REFERENCE LIST OF ACCIDENTS FOR LIQUID METAL FAST BREEDER REACTORS CONSIDERED FOR SAFETY CRITERIA AND GUIDELINES

Primary reactivity accidents

- Incorrect withdrawal of absorber
- Ejection of absorber
- Core loading error
- Reduction in sodium inlet temperature
- Addition of moderator
- Voiding by gas
- Variations of core geometry

General cooling accidents

- Pump failure
- Failure in operation of valves in main coolant circuits
- Loss of primary sodium (loss in vessel, break of primary piping)
- Leak in intermediate heat exchangers
- Failure of normal heat rejection system
- Failure of decay heat rejection system
- Failure of diagrid allowing bypass of core flow

Subassembly cooling accidents

- Incorrect positioning of a subassembly
- Inlet or outlet blockage in subassembly
- Local blockage or cooling defects within a subassembly
- Pin failure and damage propagation within a subassembly and the core

Accidents outside the core

- Fuel handling accidents
- Sodium-water reaction in steam generators
- Primary and secondary sodium fires
- Conventional fires
- Radioactivity release from leakage of active systems

Initiating causes external to the station

- Natural occurences
- Airplane or other missiles
- Explosions and hazardous effects of off-site gaseous releases
- Sabotage

ANNEX V

LIQUID METAL FAST BREEDER REACTOR CODES AND STANDARDS ACTIVITIES

LIST OF STUDIES AND PUBLICATIONS

1. MANUFACTURING STANDARDS, QUALITY CONTROL AND IN-SERVICE INSPECTION

TITLE	PUBLICATION
"Qualitative comparison of national standards which are used for the construction of FBRs in Belgium, France, Germany, Great-Britain, Italy and the Netherlands", WGCS/XII/1105/79. June 1977. (INTAT 77-73)	
"Comparative analysis of National Standards in the areas of weld procedure test, NDT and inspection of components, appropriate to reactor construction in the EEC", WGCS/XII/910/79, November 1979.	
"A quantitative analysis of the disparities between national fabrication requirements relating to weld materials and weld seams", WGCS/XII/919/80, March 1981.	
"Quantitative analysis of National Standards : Welding supervision, Testing of Welders, Testing of Specimen Welds, Measure adopted to prevent the incorrect use of welding materials". WGCS-1/XII/877/81, October 1981.	
"Quantitative analysis of national standards, relating to test procedures on semi-finished products and weld seams", WGCS-1/XII/803/83, November 1981.	
"Study of the Present Development Status in the In-Service Inspection of Sodium Cooled Fast Breeder Reactors", WGCS-1/XII/315/82, December 1981.	
"Quantitative analysis of national standards in the areas of NDT of semi-finished products", WGCS-1/XII/756/82, December 1982.	
"Quantitative analysis of national standards, relating to test procedures on components", WGCS-1/XII/802/83, September 1983.	
"Comparative analysis of quality assurance systems which effectively control, review and verify the quality of components manufactured for liquid metal cooled fast breeder reactors within the EEC", WGCS/XII/806/83, October 1983.	EUR 10123 EN
"Quantitative analysis of national standards, relating to definition of component requirements, WGCS-1/XII/484/82, December 1983.	
"Acceptance criteria for NDT on welded joints", WGCS-1/XII/178/85, March 1985.	

"Comparison of ultrasonic testing methods for austenitic steels", WGCS-1/XII/745/84, June 1985.

"Rapport sur l'état de l'art concernant les revêtements durs de composants pour réacteurs rapides", Avril 1985.

"Analyse quantitative des normes nationales relatives aux essais de réception de produits d'apport pour soudage". Octobre 1985.

"Corrélation des normes relatives à l'agrément des produits d'apport pour soudage", Octobre 1985.

"Corrélation des normes relatives aux techniques de contrôles non destructifs", Novembre 1985.

"Acceptance criteria for flaws under the conditions of non-destructive testing methods", April 1986.

"Comparative analysis of quality assurance in the manufacture of the vessel, pump, cold trap", May 1986.

2. STRUCTURAL ANALYSIS

"Comparative Theoretical and Experimentation Analyses of Benchmark Problems", ITB 78.127, December 1978.

"Elasto-Plastic Benchmark Calculations - Step 1. Verification of the Numerical Accuracy of the Computer Programmes". EUR 9874 EN

"Benchmark Calculation Programme concerning Typical LMFBR Structures", ASME, PVP-vol. 66, 1983 Pressure Vessel 1, Piping Conference & Exhibit, June 27-July 2 1982, Orlando, Florida. EUR 8013 EN

"Simplified Methods of Cyclic Structural Analysis within the Creep Range - Deformation Assessment", July 1982.

"Seismic Benchmark Calculations Fluid. Structure Interaction", January 1983.

"Shakedown and Ratchetting below the Creep Range", June 1983. EUR 8702 EN

"Ratchetting in the creep range". EUR 9876 EN

"Application de l'analyse limite et de la méthode de la contrainte de référence aux caissons mécanosoudés raidis", Juin 1983. EUR 8460 FR

"Comparison of the methods of seismic analysis applicable to the fast reactor components in the EEC countries", doc. WGCS-2/XII/893/83, September 1983. EUR 10586 EN/FR

"A state-of-the-art review of inelastic (static & dynamic) piping analysis methods, with particular applications to LMFBR", November 1983.

"Constitutive modelling in the range of inelastic deformations", doc. n° 68.09030.6, October 1984.

"State-of-the-art report on fracture mechanics for fast breeder reactors" (Fracture below the creep range), doc. n° MDD 84.099, December 1984.

"Benchmark study of shear buckling of a cylindrical vessel". September 1985. EUR 10592 EN

"Fracture mechanics relevant to LMFBR in the creep range", October 1985.

3. MATERIALS SPECIFICATIONS

"Comparison of Type 316 ss qualities in the CEC for high temperature application", Activity 3, reference document n° 23, 1978.

"Comparative study of the tensile properties of Type 316 Steel", 1980. EUR 7797 EN

"Comparison of extrapolated stress rupture values of British and German Type 316 rupture data", report ITB78.35, 1978.

"Comparison and creep rupture strength extrapolation methods with application of data for AISI 316 from Italy, France, UK and FRG", report T-ZA-5828, 1981. EUR 7796 EN

"Comparison of tensile properties of 9-12% Cr steels", Part 1, Data files, 1981. EUR 9875 EN

"Comparison of tensile properties of 9-12% Cr steels", Part 2. Assessment, 1983. EUR 9875 EN

"Comparison of low cycle fatigue data on 2 1/4 CrMo steels", December 1981. EUR 8501 EN

"A review of creep-fatigue interaction on AISI 304 and 316 stainless steel", Ispra Tech. Note 1.07.01.81.34, 1981. JRC ISPRA

"Joint exercise to compare fatigue crack growth data obtained on Type 304/316 stainless steel", Document INTAT 55.04973.8, 1981. EUR 8502 EN

"Joint exercise to compare creep crack growth data for Types 304 and 316 stainless steels", September 1982.

"The tensile properties of austenitic steel weld metal", Doc. ref. 3742, September 1982. EUR 10125 EN

"The stress rupture properties of austenitic steel weld metal", Doc. ref. 3743, September 1982. EUR 10124 EN

"Stress rupture behaviour of AISI Type 316 steel in the creep regime", ref. n° T-ZA 5831, 1982.

"Compilation of European Data on creep/fatigue interaction on austenitic steels", D Tech. SMRA (82) 1202, December 1982.

"A review on the creep crack growth on AISI 304 and 316 stainless steels". Doc. JRC/1.07.01.83.12, July 1983. JRC ISPRA

"Second phase joint exercise to evaluate creep crack growth data for types 304 and 316 stainless steels obtained by CEC Member States", February 1984.

"Comparison of low-cycle fatigue data of 2 1/4 % CrMo steels, Part II - Creep fatigue data", September 1983.

"The inelastic behaviour of welded joints of steel AISI 304 and 316 at high temperature", December 1983.

"Compilation of European data on creep fatigue interaction on austenitic stainless steels. Report II. Creep fatigue evaluation." Note technique D. Tech. (84) 1316, April 1984.

"Comparison of material properties specifications of austenitic steels in fast breeder reactor technologies"., Doc. n° 098.64/020/M/093, BN 8412-02, December 1984. EUR 10126 EN

"Comparison of fast breeder reactor allowable stresses for austenitic steels". Doc. n° 3432, November 1984.

"Fracture toughness properties of austenitic stainless materials", Report 1 and 2, April 1985.

"Surveillance programmes and requirements for LMFBR systems", September 1985.

"Fracture toughness of austenitic steel : round robin tests", December 1985.

"Comparison of material property specifications of ferritic steels in Fast Breeder Reactor Technology", January 1986.

"Stress relaxation analysis of austenitic stainless steels", May 1986.

4. CLASSIFICATION OF COMPONENTS

"Sodium Cooled Fast Reactors Classification of Mechanical Systems and Components", R403-AG4(1)HB, June 1983.