30 Years of NRWG activities towards harmonisation of nuclear safety criteria and requirements

May 2003

TABLE OF CONTENTS

EXECUTIVE SUMMARY **3**

1. INTRODUCTION **6**

2. CREATION OF NRWG **6**

3. OBJECTIVES, MANDATE AND WORKING METHODS **7**

4. PERIOD UP TO 1981 .... **8**

5. SAFETY PRINCIPLES FOR LIGHT WATER REACTOR NUCLEAR POWER PLANTS : COM (81) 519 .... **9**

6. PERIOD UP TO THE CONSENSUS DOCUMENT OF 1988 .... **10**

7. ASSISTANCE TO THE SAFETY AUTHORITIES OF CENTRAL AND EASTERN EUROPE **13**

8. SYNTHESIS DOCUMENTS TILL END 1995 .... **14**

9. TECHNICAL SUBJECTS WITH VARIOUS DEGREES OF HARMONISATION **18**

9.1 A Regulatory Concept : The Periodic Safety Reviews (PSRS) 18
9.2 Probabilistic Safety Analysis (PSA) 19
9.3 Radiological consequences of design basis accidents 20
9.4 Qualification of non-destructive testing systems 22
9.5 Application of the leak before break (LBB) concept 23
9.6 Environment qualification of electrical and I&C equipment 24
9.7 Risk-informed inservice inspection 25
9.8 Safety critical software - Licensing issues 26
9.9 Regulatory assessment of the effects of economic deregulation of the nuclear industry 27
9.10 Future reactors 28
9.11 Work under progress 29

10. CONCLUSIONS **30**

10.1 Importance of NRWG for the European regulators 30
10.2 Impact of the work done 31
10.3 Future work of NRWG 31

LIST OF EUR REPORTS MENTIONED **33**

LIST OF COM REPORTS MENTIONED **34**

Executive summary

This report describes the work performed and the results achieved by the NRWG since its creation in 1972 to advise the Commission on nuclear safety matters (safety methodologies, criteria, standards, etc).

It is composed of representatives of the Member States from « the licensing and regulatory authorities and associated safety and control organisations ».
It worked in parallel with the Reactor Safety Working Group, disbanded at the end of 1998, which comprised also representatives from the utilities and the vendors.

The mandate of the NRWG is derived from the Council Resolution of 22 July 1975 which aims at a progressive harmonisation of safety requirements and criteria in order to provide an equivalent and satisfactory degree of protection of the population against radiation risks with no lowering of the safety level already attained and which asks for listing and comparing requirements and criteria, drawing up a balance sheet of similarities and dissimilarities.

Up to 1981 NRWG work centered on the comparison of practices on topics deemed important to safety : postulated accidents inside the nuclear installations, natural hazards (earthquakes, floods, fires, …), man-made hazards (aircraft crash, toxic or explosives gases, …), training of personnel and use of simulators,…

From the experience gained, NRWG felt the work should be more structured and put in the framework of safety principles for light water reactors (LWR). It issued in 1981 a set of « Safety principles for LWR nuclear power plants », published as COM (81)519. The pioneering role of this document can be underlined, as it paved the way to later international documents on the main safety principles, e.g. those elaborated by the IAEA.

The TMI and Chernobyl accidents stressed the importance of the work on severe accidents, and on international collaboration.
The « Consensus » documents issued by the NRWG in 1988 and in 1995 showed the convergence of safety practices in the Member States : ALARA (As Low As Reasonably Achievable) policy to reduce the doses to the personnel and the public, emergency planning, defence in depth and integrity of the successive barriers between the radioactive products and the environment, radiological consequences of postulated accidents, probabilistic safety analysis, severe accidents analysis and management.

Since 1990, the members of NRWG have also provided assistance to their colleagues of Regulatory Bodies in the Central and Eastern European countries. The guidelines developed to better define the assistance needed have served also as a basis for the IAEA to develop its IRRT (International Regulatory Review Teams) missions. The « Accessing States » from Central and Eastern Europe are now represented in the NRWG.

The report also lists a number of technical subjects where NRWG has played a leading role :

- the « Periodic Safety Review » is a concept developed within NRWG countries : its main objectives are now adopted at the international level,

- through benchmark exercises and comparison reports, the methodology of the « Probabilistic Safety Analysis (PSA) » studies has been refined and there exists a consensus on the main properties and technical requirements for such studies,
- the large differences in the evaluation of radiological consequences of design basis accidents have been explained by different degrees of conservatism in the assumptions made, and more realistic models have been developed,
- the « common position of the European regulators on qualification of non destructive testing (NDT) systems » gave clear indications to the utilities and the nuclear industry for the development and qualification of NDT systems,
- the report on the application of the leak before break (LBB) concept examined the safety philosophy and the technical principles governing the design specifications and subsequent modifications for the implementation of LBB to existing plants ; it gave recommendations on items to be checked before using the LBB concept,
- the « common position of European nuclear regulators for the licensing of safety critical software for nuclear reactors » has important implications in practice as the number of applications of digital systems to perform safety functions is increasing rapidly. This work has already been used by European Regulators as a guidance document and is praised by manufacturers and I&C suppliers as helping them in their design work.

Other topics presently under study are the regulatory assessment of the effects of economic deregulation of the nuclear industry, the use of risk-informed considerations for inservice inspection or other applications, the gathering of information on future reactors. The aim is to share among all regulators the experience gained by those of them already encountering these issues, in order to develop a common understanding.

It can be concluded that NRWG has played an important role for the European regulators. It is an active network among them for discussion of technical issues in a regulatory perspective, using the benefit of lessons learnt in different countries.
It is also a forum for investigation and further study of specific issues in a European perspective, between countries sharing similar industry tradition, uses of standards, worker protection and safety culture.

In that spirit the NRWG has studied many technical issues, has produced numerous technical documents and has synthetized the results achieved in "consensus" documents.

The feedback of this long lasting networking is a progressive change, from the early times, in the national regulatory frameworks either to improve existing regulations or to enlarge their vision of different possible practices to cope with a given requirement.

The contribution of NRWG to the key objectives put forward in the Council Resolution of 22 July 1975, in particular in relation to the harmonisation of safety requirements and criteria, has been this forum of mutual explanation and understanding to reduce or eliminate unexplained differences in approaches. It is thus a convergence process, i.e. harmonisation through consensus on common positions, not through mandatory legal ways, leaving to each National Safety Authority the responsibility to adapt national regulations.

The advisory role of NRWG to the Commission, stated in the Council Resolutions, has never been clearly requested and NRWG has defined its work programme to tackle the subjects of main interest to its members. As no Regulators group other than NRWG exists in the field of nuclear safety, the Commission might solicit the opinion of NRWG before it takes initiatives in the field of nuclear safety.

1. Introduction

The objectives of this report are to summarize the work done by the Nuclear Regulators Working Group (NRWG) since its creation at the end of 1972 and to point out the achievements in a pragmatic approach towards harmonisation. It explains how the Group has worked, in line with the Council Resolutions, lists technical topics which have been tackled, the progress made with respect to common understanding of the problems, leading to more consensual views on criteria and requirements in order to reduce unnecessary differences.

This report is structured along the time periods corresponding to the milestones and main results achieved, which have been summarized in Consensus documents issued in 1981, 1988 and 1995 and in reports of the European Commission to the Council.

Following this part it discusses selected technical topics deemed important to safety where various degrees of harmonisation have been reached, and presents subjects where work is still in progress at the end of 2002, or will be examined in the next years.

2. Creation of NRWG

The European Commission created at the end of 1972 two advisory Working Groups:

- WG1 composed of representatives of the Member States from « the licensing and regulatory authorities and associated safety and control organizations on one hand, and the utilities and vendors on the other », to advise on nuclear safety matters (« Safety methodologies, criteria, standards etc »)
- WG2 composed of representatives of the Member States from the national Research Centres to advise on the EURATOM Research Programme.

This paper relates to the work of WG1, as a whole.

As some topics needed to be discussed only between safety authorities, meetings became specialized in the late seventies, with WG1A composed only of safety authorities and associated safety and control organisations, while WG1B kept the same composition as WG1, with both working groups meeting back to back.

In 1992 names were made more explicit: WG1A became the "Nuclear Regulators Working Group (NRWG)" and WG1B the "Reactor Safety Working Group (RSWG)". The latter was disbanded at the end of 1998.

All Member States of the European Union are represented in these Working Groups. Some countries with nuclear activities, like Sweden and Finland, were already invited to attend the meetings before they joined the European Union. It is also the case now for Switzerland and for the Central and Eastern Europe countries, which are engaged in the accession process.

From the beginning, WG1 has been a meeting point enabling people to better know their foreign colleagues and hence facilitating further bilateral contacts. It is a forum to exchange information and experience on selected technical topics, with the aim to reach a consensus on approaches judged as equivalent with regard to safety, which may deal with safety rules

and criteria, methodologies, hazards to be considered, design features,…
An important outcome of this long lasting exchange practice was and remains to enhance common views among European regulators on a lot of topical issues and then to be in good position to promote these views in international arenas. In particular this network was very efficient to strengthen the acceptance of views from European regulators within the development process of the international safety standards of IAEA. In that sense it can be said that the network built by the NRWG members is somewhat in the heart of a harmonisation process.

3. Objectives, mandate and working methods

The Council Resolution of 22 July 1975 on the technological problems of nuclear safety has served as the mandate of the WG and has defined its objectives and working methodologies.

Some excerpts of that Resolution are :

- « requests the Member States [….] to continue to collaborate effectively at Community level » ;
- « agrees to the course of action in stages indicated below by the Commission in respect of the progressive harmonisation 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 harmonisation should not involve any lowering of the safety level already attained [….]. The 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 » ;
- « requests the Member States to notify the Commission of any draft laws, regulations or provisions of similar scope concerning the safety of nuclear installations […] » ;
- « requests the Member States to seek common positions on any problems concerning the harmonisation of requirements and criteria and the coordination of research into nuclear safety being dealt with by international organizations » ;
- « requests the Commission to submit annual reports on the progress made [….] ».

In this framework the work programme of the WG is established, discussed and approved by its members. The Commission furnishes the secretariate and the logistic support. The chairman of the WG is chosen among its members and elected by them.

The work is performed by the members, most often via Task Forces on specific topics; sometimes the work is done through contracts paid by the Commission when the amount of work is important (synthesis report, state of the art report, …). The results are reported to and discussed in the WG; after approval they remain an internal document of the WG, or are published as an EUR report, or sometimes as a paper in a scientific magazine.

The working methods are thus quite similar to these of OECD/NEA Committees (CNRA[1] and CSNI[2]). Topics to be studied are chosen so that no duplication takes place with the NEA or the IAEA work on safety standards.
In 1999 the Terms of Reference and the mandate of the NRWG were established in a formal way.

4. Period up to 1981

In line with the Council Resolution the work in that period centered on the comparison of practices in the Member States on topics deemed important to safety.

Subjects considered were accidents from internal origin:

- loss of coolant accident : mechanical and thermohydraulic effects, radiological consequences ;
- spectrum of steam line breaks inside and outside containment ;
- anticipated transients without scram (ATWS) ;
- fuel handling accident ;
- turbine missiles, coolant pump flywheel integrity.

External hazards were also studied:

- aircraft crash
- external explosion including flammable vapour clouds
- seismic effects
- floods

Design features were also compared, like the containment structure and leak testing, the overpressure protection of the primary circuit, the in service inspection of the primary pressure boundary, the reactor protection and control systems, the loss of electric power supply, as well as operational provisions like quality assurance programmes or emergency planning.

A survey was also made of the authorization procedures for the construction and operation of nuclear installations within the EC Member States and within certain non-member States (EUR 5284 and EUR 5525 respectively).

[1] The Committee of Nuclear Regulatory Activities (CNRA) of the OECD Nuclear Energy Agency (NEA) is an international committee made up primarily of senior nuclear regulators. It was set up in 1989 as a forum for the exchange of information and experience among regulatory organisations and for the review of developments which could affect regulatory requirements.

[2] The NEA Committee on the Safety of Nuclear Installations (CSNI) is an international committee made up of scientists and engineers. It was set up in 1973 to develop and co-ordinate the activities of the Nuclear Energy Agency concerning the technical aspects of the design, construction and operation of nuclear installations insofar as they affect the safety of such installations. It constitutes a forum for the exchange of technical information and for collaboration between organisations which can contribute, from their respective backgrounds in research, development, engineering or regulation, to these activities and to the definition of its programme of work. It also reviews the state of knowledge on selected topics of nuclear safety technology and safety assessment, including operating experience.

Note that some of that work extended over a large period of time: the Task Force on seismic effects, after having defined the earthquakes to be considered in the design (EUR 8371), drew up a catalogue of all historic earthquakes relevant to Western Europe (EUR 11344 and EUR 13406) later extended to the former Soviet Union (EUR 17245 published in 1997).

The assessment of in service inspection methods and procedures performed under the PISC project (EUR 6371 Volumes I to V) in cooperation with the CSNI (OECD/NEA) showed the inadequacies of some of the examinations (characterizing the defects in thick components) required by the ASME code and led to new PISC projects and much work on the qualification of non destructive testing methods, as described later in this document.

That work of explaining how problems were tackled in the different countries was a first step towards harmonisation.
There was also an extensive exchange of information on draft safety guides and standards both national (German, Italian,…) and international (IAEA).

5. Safety principles for light water reactor nuclear power plants : COM (81) 519

Member States concluded from the experience gained, that the comparison of practices on different topics was not enough and that the work needed to be structured and put in a more general framework of safety principles for LWR. The resulting report written by WG1 was published as a Communication from the Commission to the Council (COM (81) 519).

In its introduction the document states :

" - a harmonization of requirements and criteria, although possible at certain levels, is not practicable at all levels, because requirements and criteria often refer, for example, to a specific aspect of a protective function, which may be achieved in different ways;

- *any harmonization can only be based on a previous effort of harmonization of fundamental principles of safety, on which the requirements and criteria depend;*
- *although the aim is to achieve an equivalent and satisfactory degree of protection of the population and of the environment, the way to obtain this degree of protection may differ from country to country.*
  The basic principles, however, must and can be common, as far as they reflect the objectives but not the way to reach them."

In its first part the document enunciated ten fundamental safety principles in order to minimize the risks from the installation, reduce the radioactive releases and the doses to the workers and to the public (ALARA principle). The first four fundamental safety principles relate to normal operation of plant, but are also applicable to accident conditions. The prevention of accidents is addressed in the last 5 of these fundamental principles.

The second part of COM(81) 519 listed eleven general safety principles, as a way to implement the fundamental principles. It introduced inter alia the concepts of « defense in depth », of the successive barriers between the radioactive products and the environment, and stressed the importance of quality assurance, reliability and testability of the barriers and corresponding systems, the completeness of the safety analysis (which kind of events and combinations of them to be taken into account), the consideration of external hazards, the man-machine interface, and the training of the personnel.

The third part listed a number of specific topics that at the time were considered as possible subjects for future safety requirements. These issues have now been taken up by the IAEA and addressed within their safety standards.

Note the pioneering status of this document, which was the first in a series of international documents on the main nuclear safety principles. In 1988, INSAG (International Nuclear Safety Advisory Group at the IAEA) issued its report INSAG 3 « Basic safety principles for nuclear power plants ». A Task Force within WG1 compared the two documents and found no inconsistencies, even if INSAG 3 was much more detailed and put more emphasis on severe accidents topics, in the aftermath of the Chernobyl accident. That Task Force transmitted also its comments on INSAG 3 to the IAEA[3]. Meanwhile the IAEA also published the « Safety Fundamentals » (The Safety of Nuclear Installations, IAEA Safety Series N°. 110) listing 25 safety principles. These were reordered and better structured in the technical part of the text of the International Nuclear Safety Convention which was adopted in 1994. As these texts were developed at the international level with input from around the world (including WG1 members), WG1 did not consider necessary to update the COM (81) 519 document.

6. Period up to the Consensus document of 1988

The exchange of information on draft safety guides was important, as many French rules (Règles Fondamentales de Sûreté) were issued during that period, as well as Finnish safety guides. In the UK, the Sizewell B pressurized water reactor Public Inquiry resulted in the UK's nuclear safety regulator reissuing its nuclear Safety Assessment Principles and the preparation of a document on the "Tolerability of Risk" in society.

With respect to the integrity of the reactor coolant pressure boundary (second barrier), that comparison work centered on the overpressure protection system and on in-service inspection with the results of the PISC II programme.

For the containment (third barrier), the procedures for leak testing (EUR 11051) and the practices and rules applied for the design of large dry PWR containments within EEC countries (EUR 12251) were examined and the conclusive report of the containment expert group was published as EUR 11364.

Some work initiated in the previous period on hazards of internal or external origin was completed : loss of the outside electric power supply, anticipated transients without scram, flooding, main steam line break inside containment,… Results were summarized in internal reports.

[3] A revised version of INSAG 3, labelled INSAG 12, was issued in 1999.

The TMI accident, which occurred in March 1979, showed the importance of human factors in the evolution of accidents, in particular the qualification and training of operators. The practices on this topic in the different European countries and in the USA were compared in EUR 10118 and 10981. All countries recognized the importance of operator training both for normal operation and operation under fault conditions and in particular they stressed the importance of systematic training (and retraining) programmes using simulators. The training of maintenance personnel was also recognised as important, even if it was less formalized. Errors made during maintenance might induce common cause failures, and optimization of the work procedures should be done in order to reduce as much as possible the doses to the personnel undertaking the work.

Other subjects considered by WG1 related to safety in operation were ALARA policy and emergency preparedness. The report EUR 11251 reviewed the application of ALARA in nuclear power plants : it addressed ALARA in design aiming at reducing the sources of radiation and reducing the exposure (shielding, lay-out, …) and ALARA during operation (organisational and protective measures, dosimetry, …) and gave examples from many countries.

Work on emergency planning began in 1981 and the synthesis report EUR 9623[4] was issued in 1985. Another report addressed in 1987 the organization of emergency action in the EU countries, Sweden and Switzerland. A workshop was held jointly with OECD/NEA in June 1989 (EUR 12595) discussing post-Chernobyl developments concerning the basis for off-site emergency planning (including countries with no NPP's), surveillance, monitoring and decision making, experience from emergency planning and response in the non-nuclear field, contribution of nuclear emergency exercises.

A Task Force on Quality Assurance looked at the rules and practices in the Member States, compared them to the IAEA codes and safety guides, and concluded that doing more than participating to the development and updating of the IAEA documents was not necessary.

With respect to the consequences of accidents, the report « Source Term - An evaluation of its impact on the safety of nuclear power plants » made in its first part an evaluation of various national practices and regulations concerning the source terms for a design basis LOCA and dealt in its second part with severe accidents.

The methodology to cope with accidents of internal and external origin was detailed in EUR 10782.

The TMI accident had made it clear that core melt accidents could happen. Many research programmes on severe accidents were started at that time, as part of the EURATOM Research Programme and in national and international programmes. The OECD/CSNI working group on severe accidents followed these developments with very close attention ; hence WG1 kept itself informed of the results.

The Chernobyl accident gave a new impetus to these programmes. A CEC seminar on studies of severe accidents in light water reactors took place in November 1986 (EUR 11019). The impact of Chernobyl in the different EU countries was also discussed in WG1,

---

[4] Title: The technical basis for emergency planning and preparedness in EC countries - An examination of criteria, practice and recent developments and proposals for a harmonized approach.

results which were summed up in EUR 11523 ("A preliminary assessment of the radiological impact of the Chernobyl reactor accident on the population of the European Community").

The work performed by WG1 during the period 1981-1988 was summarized in its paper « Consensus document on safety of LWR » which also served as the basis of the report of the Commission to the Council, « Assurance of safety of nuclear power plants - Objectives and methods » (COM (88) 788 final).

Both documents illustrated and made more explicit the safety principles enunciated in COM(81)519.
They recalled the three main safety functions to be fulfilled (control of the nuclear chain reaction, heat removal from the core, confinement of the fission products) and discuss the 3 methods used to ensure a safe design: the deterministic one, the probabilistic one and the systematic use of operating experience.

For each of these methods the work already done in WG1 was described, and proposals for future work were made.

In the deterministic method, the proof of the integrity of the second barrier was emphasized (non destructive testing, overpressure protection) with future work on the leak before break concept, and on the steam generator tube rupture accident. For the third barrier future work was suggested on the aptitude of containment buildings to withstand severe accidents, and on severe accident management. COM (88) 788 final concluded that the adoption of consistent sets of design and operating conditions was of the utmost importance to ensure safety and this had been achieved in all Member States. It was also concluded that the deterministic method was used in all the Member States to design nuclear power plants with the same basic hypotheses and concepts and with some differences stemming from their implementation and from different technological practices. This had led to differences in some areas, for example, containment systems and protection against external hazards, and methods applied to design the safety systems.

The report noted that probabilistic studies were more and more carried out to support or complement the deterministic approach. These studies related to reliability analyses of systems, consistency of overall design, quantifying the effects of external hazards to be considered in the design, feedback of operating data and overall risk analysis of scenarios of core melt down. The experience resulting from such studies was shared between Member States in particular via experts meetings and intercomparison ("benchmark") exercises. Such exchanges should be further developed.

In the systematic use of operating experience, the lessons learnt form the TMI and Chernobyl accidents were emphasized, for example operators training, improved accident procedures, control room ergonomy, hydrogen risk mitigation, reactivity initiated accidents, containment performance during severe accidents, emergency planning. The systematic use of experience gained from daily operation and from in-depth analysis of incidents was recognised as an important contribution to the safety of nuclear power plants, allowing improvements in design of new plants as well as in systems and operation of existing plants.

The report concluded also that safe operation of nuclear power plants required compliance with well defined and approved technical operating specifications, the existence of operating procedures for normal and accident conditions, the organisation of operating experience feedback and qualified and adequately trained operators having always safety in the forefront of their planning for action.

7. Assistance to the Safety Authorities of Central and Eastern Europe

Within the PHARE and TACIS programmes, NRWG has been involved since 1990 in the assistance to the Safety Authorities of Central and Eastern Europe.

In order to identify their needs, exploratory missions composed of a few NRWG member countries visited these organizations. The guidelines written for those missions were later on completed and formalized by the IAEA to become the review guidelines for the IRRT (International Regulatory Review Teams : TEC DOC 703).

In addition, the national reports prepared by the missions' members have served as basic documents for the beneficiaries to formulate and prioritise their requests for assistance programmes. The National Regulatory Authorities of the Central and Eastern European region have made a large profit from projects managed by both Regulators and Technical Safety Organisations of different EU member countries.

NRWG has also developed a report setting out the nuclear safety objectives and supporting principles upon which an effective nuclear safety regulatory regime should be based and providing guidance on legislative arrangements, the framework of the regulatory organization and the provisions for licensing, safety assessment, inspection and regulatory enforcement.

This report « Establishing an effective nuclear safety regulatory regime » was published in two parts :
Part I - Objectives and Requirements (EUR 15397)
Part II - Arrangements (EUR 16243)
It was translated into Russian.

On June 18, 1992, the Council published a new Resolution on the technological problems of nuclear safety, reaffirming the objectives of the 1975 Resolution and extending it to third countries, notably those of Central and Eastern Europe, and the Republics of the former Soviet Union, with the objective of bringing their nuclear installations up to safety levels equivalent to those in practice in the Community and to facilitate the implementation of the safety criteria and requirements already recognized throughout the Community.

The European Commission created two new Working Groups in order to deal with the specific tasks of assistance to the Eastern Safety Authorities that were initiated by NRWG:

– the Regulatory Assistance Management Group (RAMG) composed of representatives of the Regulatory Bodies from the countries members of the European Union, who are willing to give assistance,

- the CONCERT Group ("Concertation on European Regulatory Tasks Group") composed of representatives of the Regulatory Bodies from Western and Eastern European countries.

As a result NRWG was no more directly involved in the management of such assistance, but was informed about the ongoing activities on a regular basis. As the cooperation between the regulatory organisations of Western and Eastern European countries had further developed and had become more effective, NRWG decided at the end of 1996 to invite the regulators of the applicant countries of Central and Eastern Europe to participate in its meetings. They have attended the meetings since April 1997 (50th meeting).

8. Synthesis documents till end 1995

The Commission issued periodically, as requested by the 1975 Council Resolution, progress reports to the Council on the implementation of that Resolution.

In its document SEC(92)79 final it listed the topics being worked on and the technical publications issued since the 1988 Consensus document, for example on Periodic Safety Reviews, on the use of PSA's, on the comparison of thermal hydraulic computer codes, and emphasized the need of assistance to the Central and Eastern European States, proposing a draft of the future Council Resolution of 1992.

The document COM(93)649 final (« Towards a System of Safety Criteria and Requirements recognized throughout the Community and a genuine safety culture throughout Europe ») gave a historical overview of the achievements of the different working groups (NRWG, RSWG, RAMG, CONCERT) and placed them in the perspective of the European Single Market.

In the regulatory domain it reaffirmed some of the basic principles about responsibilities :

- « The safety of nuclear installations must remain the responsibility of the individual countries, meaning that there must be a legal framework to regulate nuclear activities and designate responsibilities : the principal responsibility for the safety of an installation must lie with the operating organization.
- The safety regulator is responsible for monitoring and implementing the safety objectives in accordance with the laws and regulations. »

It synthetized the progress made towards a safety system applicable in the whole community in three domains :

- the organization of the safety (what is now called in the IAEA documents the « Legal and Governmental Infrastructure ») where a consensus exists as written in EUR 15397 and 16243 cited above ;
- the safety assessment, where reference is made to COM(88)788, which should be completed to cover severe accidents ;
- the rules, standards and codes at the technical level, where the basic principles of COM(81)519 were mentioned, but where detailed technical guides would preferably be developed at the industrial level.

Finally activities going on or to be started in the next four years were listed :

- codes and standards : practical implementation of the international codes and safety guides (IAEA-NUSS programme), industrial codes for manufacturing in relation with the EPR project which should show the needs of a specific standardization, qualification of components including software ;
- safety margins assessment : realistic evaluations of the steam generator tube rupture accident, and ultimate strength of the containment ;
- probabilistic studies : their use in the regulatory domain and the work done at the Joint Research Centre ;
- operational safety : periodic safety reviews and treatment of modifications ;
- safety principles : their practical implementation, like the single failure criterion.

It was concluded that the building of a Safety System is a constant endeavour with, as a final objective, the consolidation of a true safety culture in the European Community and its projection to the whole of Europe.

At the end of this period EUR 16801 on "Licensing procedures and associated documentation" was published, which compared the national licensing practices in regulating the safety of nuclear power plants in four Western European countries. The document reported that the national regulatory documents in those countries had in general a number of similarities.

- Their national legislations established and maintained systems of regulatory documents and regulatory organisations.
- Each country insisted that the primary responsibility for safety of nuclear installations was assigned to the relevant operating organisations.
- Nuclear legislation did not affect other provisions of the public laws requiring approvals and licences.
- The regulatory organisation in each country was responsible for coordinating during the licensing process with other relevant government organisations who implemented other legislation and regulations.
- All four countries defined similar principles and associated criteria to achieve and maintain nuclear safety. Regulation was also similar and achieved through licensing processes covering site selection, design, construction, commissioning and operation.
- The establishment and maintenance of adequate on-site and off-site emergency preparedness was required. Requirements to report safety significant events were similar, as were enforcement measures.

Finally the « 1995 Consensus document on safety of European LWR » (EUR 16803) written in common by the RSWG and the NRWG, gave quite a complete synthesis of the achievements of both working groups, making reference when useful to the work of IAEA or OECD/NEA, and indicated the topics where more work was needed.

Three main domains were discussed:

- Safety in operation,
- Source terms and off-site consequences for design basis accidents,
- Severe accidents.

The "Safety in operation" chapter covered in-service inspection, recalling first the safety objectives and the strong similarities of the ISI programmes in the European countries. It described next the work pursued on the qualification of NDT systems at the level of the regulators (EUR 16802) and at the level of the utilities and the European Network for Inspection Qualification to establish a European methodology for inspection qualification (EUR 16139). Maintenance and testing activities were also addressed, with provisions to be taken at the design stage (reference to the European Utility Requirements document), and with the main principles governing a good maintenance programme. It also recalled the need to evaluate and manage physical ageing and the resulting degradation of plant components, systems and structures, and the need to implement data collection and record keeping systems, as the condition for a valuable ageing programme.

That chapter followed naturally with the training of operation and maintenance personnel, the assessment of the training and the role of the safety authorities, whose involvement in the training programmes evaluation varies from country to country.

The concept of safety culture, as defined in INSAG 4, was presented, laying emphasis to the universal features of safety culture, noting that it applies to all persons whose work can impact safety, at all stages of the plant life. Apart from the utility, the organisations involved are thus the NSSS supplier, the architect-engineer, the manufacturers, the various firms involved in the construction of the plant, the third parties control and inspection services (e.g. non destructive testing) and the research community. In each organisation safety culture needs to permeate through all levels from senior managers to all staff.

The requirements of Safety Culture also apply to the public Authorities. The role of the Regulatory Body should not be underestimated, not so much as a watchdog but even more as an encouraging influence.

The implementation problems of safety culture and the pitfalls to be avoided were also mentioned.

The chapter on source terms and off-site consequences for design basis accidents described in a detailed way the results of calculations (made in the frame of benchmark exercises) for the radiological consequences of a large loss of coolant accident and of a steam generator tube rupture accident. There were very large differences in the licensing calculations due to the various degrees of conservatism made at each step of the calculation. Hence there was a need to examine more realistic assumptions and better define the degree of conservatism judged necessary for the different physical phenomena involved. It was recommended to pursue the work in these directions.

The chapter on severe accidents described the present status of knowledge regarding in-vessel debris cooling, high pressure core melt, core concrete interaction and ex-vessel debris cooling, steam explosion in containment due to water being in the cavity, late containment failure due to overpressure, hydrogen burning or detonation, fission product retention in the containment. These evaluations were based on the work at OECD/NEA and the results of the EC research programme and other international programmes.

It also considered the report issued in 1989 by the Task Force on severe accident management which compared selected procedures applied in member countries in order to maintain core cooling and containment integrity in case of a severe accident. The main conclusion of that work was that there was a consensus on interest, objectives and priority of severe accident management and on the need for further research.

The situation at existing plants was summarized and examples of improvements were given; the philosophy for future plants as presented in the European Utility Requirements document was sketched.

The conclusions on severe accidents were the following:

"There is a wide consensus on the use of improved procedures for existing plants both for preventing the development of a severe accident and for accident management to mitigate the consequences of a severe accident in the unlikely event of one occurring. The improved procedures include the monitoring and maintenance of critical safety functions, such as core-cooling, independently of the cause of the accident.

There is also a reasonable consensus on the severe accident phenomena of greatest importance for the successful containment of the severe accident consequences and the procedures for mitigating their effects. There is scope for reducing the uncertainties in the assessment of debris coolability and, for BWRs, the potential for damaging steam production if water is added in containment.

It is generally agreed that, while some modifications to plant hardware may be reasonably practicable means to prevent or mitigate severe accidents, these would be very design specific and it would not therefore be expected that different plants should adopt similar solutions.

There have been initial moves both between Utilities and between Regulators of different countries to achieve a harmonised position on the requirements for future plant. For example, there is a trend towards the objective to reduce the core melt frequency and to eliminate the large early releases. PSAs will be used to assess and verify the compliance with these objectives.
There is cooperation in the definition of design requirements for future plants, which take severe accidents into account at the design stage."

The work programme of NRWG and RSWG after 1995 has been largely based on the conclusions and recommendations of this "1995 Consensus document".

9. Technical subjects with various degrees of harmonisation

9.1 A Regulatory Concept : The Periodic Safety Reviews (PSRS)

Most Western European Regulatory Bodies have requested that the nuclear power plants be submitted to an overall reassessment on a periodic basis, in addition to the permanent supervision the Regulatory Body exerts on these facilities.
In the UK for example, where the first plants became operational in the late fifties, such a reassessment was requested when some plants had been in operation for more than twenty years : these reviews are known as Long Term Safety Reviews.
In Belgium, the licence of each nuclear plant requires such a periodic reassessment every ten years ; hence the first safety reviews took place in 1985.
In Germany, PSRs were recommended by the Reactor Safety Commission in 1988 and subsequently implemented and carried out. Today, the licensees are legally obliged to conduct safety reviews scheduled in an annex to the Atomic Energy Act.

The PSRs concept was discussed in the frame of the Nuclear Regulators Working Group of the European Community and the benefits of a standback review, allowing a global overview of the safety of the plant were recognized by all Regulatory Bodies.
In the late eighties, it became clear that periodic safety reviews were common practice in all EU Member countries : the objectives and the main topics covered in the reviews were summarized in EUR 13056 in 1990, revised as EUR 15555 in 1995.

The objectives of these PSRs are :
- to confirm that the plant is as safe as originally intended
- to establish the exact plant status with respect to ageing and wear out and evaluate any factors which may limit the safe operation of the plant in the future
- to justify the current levels of safety of the plant by comparison with current safety standards, and to propose eventual improvement.

The first criterion, by a comparison of the safety level at the time of the PSR with that intended by its design, tries to demonstrate that the safety level has not degraded during operation. It takes into account the feedback of operating experience of the plant and of other domestic and foreign plants; it also reassesses in a consistent way the modifications made to the plant since it began operation, to check that their objectives have been met and are in no way detrimental to safety.
Some modifications have been made in order to increase performance (power uprates, higher burn-ups,…) implying the use of more sophisticated computational models in neutronics, thermal-hydraulics, fuel rod design, or in order to replace obsolescent components like the shift from analog to digital instrumentation and control systems. A site reevaluation is also made to examine what changes may have occurred in the environment.

The second criterion implies to consider all ageing mechanisms and their monitoring by non-destructive testing methods, using the feedback of operating experience and the results of R and D programmes (e.g. the network AMES (Aged Materials Studies and Evaluation) established by the Joint Research Centre.)

The third criterion looks at an extension of the original design basis of the plant, in particular postulated initiating events not considered earlier, of internal or external origin. It is of course strongly linked to the research on severe accidents, their phenomenology and their management.
Like the safety assessment made when the plant got its licence, reassessments made in PSRs use deterministic safety analyses.
However, it is now more and more common that a probabilistic safety analysis (levels 1 or 2) complements the deterministic analysis, in particular to judge which modifications improve the safety in a significant way. It covers both the operation modes and the shutdown modes; for the latter modes it is usually a more systematic assessment than the previous deterministic analysis.

In the frame of the closer cooperation with the Central and Eastern European countries, a project was launched to derive a set of guidelines (best practices) on the conduct of PSR for use by licensees and regulators of countries operating VVER reactors. An operator of VVER reactors took part in that project, and the final report has been issued.

It should be noted that PSR is a safety concept mainly developed in the EU countries. It has been introduced later on in the IAEA documents (Safety Fundamentals and Safety Guide 0-12). Some countries, like the USA, are reluctant to adopt it in their regulations (even though they assessed the safety of their ten oldest reactors in the early 80's in the Safety Evaluation Programme which is somewhat similar to a PSR).

9.2 Probabilistic Safety Analysis (PSA)

After TMI, the USA developed safety goals (i.e. probabilistic safety criteria) for nuclear power plants. A Task Force on safety objectives was created in WG1 to consider the need, possibilities and limitation of overall safety objectives for nuclear power plants, comparing also against major hazard industries (EUR 11373). It produced a summary report in 1988 (EUR 12273) with no overall agreement on such a concept among the EU countries, due to the large uncertainties in dose assessment and consequential health effects. Some countries, especially the UK and the Netherlands, introduced legally binding quantitative safety criteria in their regulatory framework.

But Probabilistic Safety Analysis (PSA) studies were followed with attention within WG1. Presentations of the German Risk Study were made to WG1 and the results discussed at length (phase A was covered in a two days seminar in June 1981 and phase B in 1985 and 1990). The work done at the Joint Research Centre at Ispra and the reports issued by the OECD/CSNI group on risk assessment were taken into account as valuable input. WG1 and later NRWG have always defined their work programmes complementary to those of IAEA, OECD/NEA and other agencies and institutions in order to avoid any duplication.

In the late seventies, the Joint Research Centre at Ispra launched a series of so-called « benchmark exercises », each one centered on a topic where the PSA methodology was not yet mature. It was the opportunity for the organisations participating to the exercise to compare different methodological approaches and at the end to conclude which ones seemed the most adequate.

Such benchmarks covered in particular system reliability (EUR 10696), common cause failure (EUR 11054), human reliability, and were quite effective in creating a community of people working in the same field and knowing each other (a concept now called a « network »). It was an excellent basis for the development of PSA studies in the European countries, and attracted also USA interest with the participation of the USNRC and of EPRI.

In the late eighties, probabilistic safety analyses were performed in most EU countries with nuclear power plants. The French studies showed the interest of considering also shutdown states, because their contribution to the core melt frequency is not negligible.

Another benchmark under the aegis of the JRC at Ispra was focussed on expert judgement techniques in PSA level 2 analysis. Other recent research projects are related to dynamic reliability.

Much work is being performed in the PSA field by the OECD/NEA/CSNI "Risk Assessment" Working Group, an excellent forum for PSA practitioners to exchange experience, write "state of the art" reports on most PSA aspects, reflecting consensus on topics considered as mature and on which ones still need further work. It has also launched projects for developing data banks on common cause failures or piping failures, where data are still scarce.

Hence the work in NRWG has mainly been an exchange of information on what was being done in the Member States.
In 1993 a review of current practices relative to regulatory action with respect to PSA's was made (EUR 15720) and in 1999 'good practices" documents were produced for level 1 PSA's based on the large experience available and some recommendations for further work were made.

With the progressive development of risk-informed applications, as shown in the next section 8.7., it is important for the Regulatory Bodies to be able to judge the validity of such approaches; it requires to define what quality and exhaustiveness criteria a PSA study should meet. The comparison between different PSA studies performed independently on more or less similar plants can increase the confidence in the methods used and in the results obtained, as shown by a recent bilateral (Franco-Belgian) collaboration, for power operation and shutdown modes.
More work must also be performed to better define the limitations of PSA studies for external events (fire, seismic PSA).

9.3 Radiological consequences of design basis accidents

As mentioned above the Task Force on Safety Objectives examined the degree of coherence in developments of safety objectives for nuclear power plants. In a status report published in 1983 it was pointed out that there appeared to be a considerable degree of coherence between the dose-frequency targets used in different Member States for application to design basis accidents. However, it was recognized that the coherence might be more apparent than real for a variety of reasons, including

- differences in the status of these dose-frequency targets in the regulatory framework of different countries,
- differences in the models and assumptions adopted in various countries to estimate doses from design basis accidents within a regulatory framework,

- differences in classification of accidents, and in the estimation of source terms of radionuclides released to the environment.

To clarify these points, different benchmark exercises were defined in order to make explicit and compare the assumptions made in different Member Countries.

In the frame of the first benchmark each participating country was asked to assess the doses by individual pathways resulting from the release of 10^{10} Bq of single nuclides in four release conditions (through the stack and at ground level, each case for two time durations). The results of the calculations showed that the calculated dose/activity factors were quite similar (dispersion of most results around one order of magnitude) and that the differences could be traced back to specific models (EUR 11408).

The aim of the second benchmark was to make very explicit and to explain all the models and assumptions used in the licensing process for the evaluation of potential releases of radioactive products outside the containment due to a given accident. These releases should be quantified, versus time if necessary, and their points of release indicated, in order to connect these results to the first benchmark exercise.

Taking account of the accidents considered in the licensing process in the various participating countries and of the information available, it was agreed that this benchmark exercise would use the “successfully terminated large LOCA” in a PWR as it is commonly treated in the safety analyses performed in the frame of the licensing process. This accident was thus the rupture of the largest pipe in a primary loop, with the safety systems actuated and performing their functions at the minimum values guaranteed by the technical specifications of the plant.

Starting from a reference core inventory to be used by all participants the different steps in the activity calculations were defined: activity released in the primary circuit, activity in the containment atmosphere shortly after the accident, activity in the containment atmosphere two hours after the accident, integrated released activity after respectively 2 hours, 24 hours and 720 hours.

The results showed for the various steps quite large differences: the activity released after 720 hours could differ by about four orders of magnitude for Xe 133 and nearly six orders of magnitude for I 131 and Cs 137. The differences were already large for the activity in the containment atmosphere (by factors between 1000 and 10.000) and were directly related to the assumptions on the source term: the countries applying the USNRC rules used a source term corresponding more to a core melt accident decoupled from the LOCA thermal hydraulic calculations while other countries better took into account the physical phenomena during the LOCA still with conservative assumptions.

Hence it was judged necessary to better define the conservatisms associated to a successfully terminated large LOCA, including the corresponding source term being different from the one linked to a core melt accident.

Different studies were made and published in that perspective:

- Realistic methods for calculating the releases and consequences of a large LOCA (EUR 14179)

- Reduction of conservatisms in the treatment of some aspects of aerosol behaviour following a large LOCA (EUR 15721)
- Fuel cladding failure criteria (EUR 19256)

The latest study (Determination of the in-containment source term for a large LOCA (EUR 19841)) made a synthesis of previous studies in order to define the source term in the containment for a successfully terminated large LOCA in a licensing perspective.
For each physical phenomenon intervening in the definition of the source term (failed fuel fraction, retention in the reactor coolant system or in the containment,…) a proposal was made on the value to be assumed in the calculations, on the conservative side of the uncertainty range, leading to a more harmonized approach.

Another benchmark exercise studied the steam generator tube rupture which corresponds to a failure of the second barrier and the by-pass of the containment. For this accident different scenarios are possible depending on the break location (at the tube plate, at the top of the bundle,…), on the loss or not of the recirculation in the steam generator, etc… and the assumptions to be made are specific to the scenario considered. Realistic methods have been proposed (EUR 15615), the sensitivity to important parameters was evaluated (EUR 16244) and a probabilistic study of the different scenarios was made (EUR 18550).

The benefits of these studies have been to clarify the different approaches used to define the source term and to motivate further efforts to agree on more realistic assumptions. It is then up to each country to decide when and how to implement these assumptions.

9.4 Qualification of non-destructive testing systems

In November 1992 the Nuclear Regulators Working Group (NRWG) decided to set up a Task Force on qualification of non-destructive testing (NDT) system for pre- and in-service inspection of light water reactors. The first task was to

- agree on the philosophy and principles governing the qualification of techniques, equipment, software, procedures and personnel for NDT to be used for inspection of structural components that are important to safety in nuclear power plants ; and
- to establish a common view on essential aspects of NDT qualifications.

The first task, which also included a comparison of the common views of the European regulators with the qualification approach outlined in Appendix VIII to Section XI of the ASME Code, was completed in 1996. The result of the first task has been published in the report “Common position of the European regulators on qualification of NDT systems for pre- and in-service inspection of light water reactor components” (EUR 16802).

In parallel, the European nuclear power industries had set up a working group, the European Network for Inspection Qualification (ENIQ), to discuss and agree on how to perform inspection qualifications. In 1995 ENIQ finalised their first version of “European methodology for qualification of non-destructive tests” (EUR 16139). A second version (EUR 17299) was then published in 1997. This second version is in relatively close agreement with the principles given in the regulators’ common position document. With these two basic documents a platform thereby had been established for the further development of qualification strategies in the European countries.

The second task of the NRWG Task Force was to follow and evaluate the first ENIQ pilot study from a regulatory point of view. The objective of this pilot study was to explore ways of how to apply the European qualification methodology and to test its feasibility. The pilot study commenced late 1996 and was planned to be finalised a year later. Depending on unforeseen difficulties the pilot study has been delayed several times, and first in 1999 the main part of the pilot study was completed. However, results from one important part of the pilot study are still missing. This relates to a planned comparison with results from an in-service inspection simulation on cracked piping parts that have been removed from a nuclear power plant.

The Task Force view[5] on the first ENIQ pilot study was presented to the NRWG at their meeting on 20 May 2000. In the report it was concluded that the pilot study from an overall point of view was successful to more precisely explore ways of how to apply the European qualification methodology and to test its feasibility.

At the same meeting NRWG decided to continue the work within the Task Force on NDT Qualification. The objective of this third task was

– to compile a status report with information of actions taken, national developments and experience since the publication of the common position document (EUR 16802) in 1997,

– to follow the second ENIQ Pilot Study and evaluate the results from a regulatory point of view.

The third task of the NRWG Task Force will be finalised at the beginning of 2003.
Preliminary result shows however that NDT qualification requirements based on principles in the common position document have been introduced in most of the countries participating in the Task Force. These requirements are either in the form of regulations or regulatory guides or in the form of individual plant licence conditions. Transition periods still apply in some countries, but the requirements will become fully effective in the near future.

Qualifications according to the principles in the common position document are now applied in most countries. In several countries the amount of performed qualifications also represents a significant part of what is needed for the plants' in-service inspection programs.
Implementation experience to date shows that qualifications have contributed to a situation where more reliable NDT systems are used in in-service inspection activities. Implementation experience shows however also that there still are problems to be solved before the qualifications fully will produce effective NDT system and reliable inspections in a cost effective manner.

9.5 Application of the leak before break (LBB) concept

The Leak-before-Break (LBB) concept is associated with the nuclear power plant design principles as regards pipe failures and their safety implications. It has been introduced as a mean of partially relaxing the customary requirements concerning postulated double-ended

[5] A regulatory view on the first common pilot study of the European qualification methodology. May 2000.

guillotine breaks (DEGBs). During the past few years, LBB received increasing applications as a criterion for assessing or upgrading the safety of existing plants whose provision against DEGBs presents deficiencies compared to current requirements.

It has also been used to optimize the design when large modifications were made like steam generators replacement with respect to the location and number of pipe whip restraints.

Hence NRWG thought useful to examine the degree of implementation of the LBB concept in Member States and to agree on the safety philosophy and technical principles governing the design specifications and subsequent modifications when one applies the LBB criterion for pressure retaining components of existing plants.

EUR 18549 (European Safety practices on the Application of the LBB concept) first defined precisely the terms and concepts used, looked at the safety objectives, examined the technical substantiation including the efficiency of crack detection by NDT methods, assessed the overall methodology (fracture mechanics calculations and evaluation of leak rate), made a survey of the regulatory approaches to LBB in the USA and in ten European countries (including three Accessing States). In its conclusions the report gave recommendations on items to be checked before using the LBB concept.

9.6 Environment qualification of electrical and I&C equipment

The report EUR 16246 (A comparison of European practices for the qualification of electrical and I&C equipment important to safety for European LWR NPP) has provided a detailed comparison of the various practices used in European countries, showing that the general principles of the qualification and the main elements of the methodologies were similar between European countries but that the values of the environmental and seismic parameters used for qualification were strongly linked to the specific design of the plant.

Two obstacles to achieving a common acceptance of the qualification between the countries were identified :

- the test severities
- differences in test methods.

EUR 17563 (Guideline for the evaluation of European practices on the harsh environment qualification of electrical and I&C equipment) had the aim to identify and explain the principal obstacles to the mutual recognition of qualification documentation and to reach common acceptability.

It assessed the qualification practices with respect to the tests sequences, to the reference and functional limit tests, to ageing tests, to seismic tests and to accident tests. For each topic it explained the general rules for these tests and made recommendations.

The conclusion of this work was the following:
"The guidelines described in this document help to understand the differences in the European practices on Equipment Qualification and how the differences may be evaluated. The main conclusion of this work is that the qualification file produced in one country cannot be adopted in another country without a case-by-case appraisal of the specific qualification methods, the parameters, the equipment's required safety function and duration against those described in the qualification file.

The long-term objective should be to achieve the harmonisation of requirements across the European countries with the aim that new qualification will be acceptable in all countries. […].

The licensing authorities will have their role to play in the process of harmonisation, for they ultimately determine the requirements to be met in each country."

9.7 Risk-informed inservice inspection

The risk-based, now called risk-informed, regulatory approach has been much publicized since the mid nineties in the USA and applications are announced in several European countries. In order to better understand the gist and the limits of that approach, and to share the experience among its members, the NRWG decided in November 1996 to set up a Task Force (TF) to agree on the philosophy and principles governing risk-informed inservice inspection (ISI) and inservice testing (IST) of mechanical components of nuclear power plants (NPP) in order to maintain sufficient margins against leakages and failures, considering dose exposures to the public.

The Task Force performed a review and inventory of the existing approaches to risk-informed inservice inspection and testing in different countries, and completed its work in 1999 with a Current Practices Document, titled « Report on risk-informed in-service inspection and in-service testing » (EUR 19153). This document also contained conclusions and gave recommendations for future work. There was a broad consensus that the PSA methodology can contribute to the basis of a more systematic approach to the optimisation of ISI and IST programmes as compared to traditional approaches, which are deterministic or qualitatively risk-based without utilizing PSA tools or insights. It was judged, however, that the actual advantages or possible problems of risk-informed ISI schemes, compared with traditional schemes, would only come forward after operational experience over a sufficiently long period of time. Pilot studies, mutually agreed by utilities and regulatory agencies, were seen as extremely useful steps to develop the methodology and the guidelines for implementing risk-informed ISI and IST proposals. Therefore, it was recommended, after results from pilot studies would have become available, to organize a workshop in order to have a forum to discuss possible problems, insights, and lessons learnt, and to establish a new regulatory task force in a medium term to reach common conclusions on the key aspects associated to the application of risk-informed ISI and on the necessary conditions to be met in order to demonstrate the validity of such an approach.

Since 1998, pilot studies on risk-informed inservice inspection have been performed for NPPs in Finland, Spain, Sweden, and Switzerland. The regulators were involved in these studies in different ways: leading, actively in joint projects, or as observer.

In November 2001, the NRWG held a « Special Session on risk-informed applications, with emphasis on risk-informed inservice inspection », where the results and experiences from the pilot studies performed were presented and discussed. As a follow-up the TaskForce was reconvened with the objective to analyze, from a regulatory point of view, key aspects associated with the assessment of risk-informed inservice inspection programmes and to reach conclusions. This work is underway.

9.8 Safety critical software - Licensing issues

In the mid-nineties, as applications of digital systems to perform safety functions were becoming more frequent, a Task Force was launched with the mandate of “reaching a consensus on software licensing issues having important practical aspects”.

By that time, experts had recognized that the assessment of software could not be limited to the verification and testing of the end product, i.e. the computer code. Other factors such as the quality of the processes and methods for specifying, designing and coding had proved to have an important impact on the implementation. Existing standards provided limited guidance on the assessment of these factors. An undesirable consequence of this situation was that the licensing approaches taken by nuclear safety authorities and by technical support organisations were determined independently and with only limited informal technical co-ordination and exchanges. It was also notable that several software implementations of nuclear safety systems had been marred by costly delays caused by difficulties in coordinating the development and the qualification processes.

Eighteen issue areas were selected as being the most critical ones. They were partitioned into two sets: “Generic Licensing Issues” and “Life Cycle Phase Licensing Issues”. Issues in the second set were related to specific stages of the computer based system design and development process, such as for instance the specification of the initial requirements, the coding and programming practices or the verification and validation tests. Issues of the first set have more general implications and apply to several stages or to the whole system lifecycle, such as the problems raised by independent assessment, and the validation of tools.

For each issue area, the following main aspects were systematically analysed and developed:

- A Rationale for the issue in terms of a description of the technical problems to be resolved;
- A Common Regulatory Position on these problems in terms of the minimal evidence which could be required;
- A set of recommended practices.

The Common Positions were intended to represent the common denominator of practices in the Member States taking part in the task force. The Recommended Practices were those supported by most - but not systematically implemented by all - Member States represented in the task force. Some of the recommended practices also originated from proposed common position resolutions on which unanimity could not be reached.

The results of this work have been published in the report “Common position of European nuclear regulators for the licensing of safety critical software for nuclear reactors” (EUR 18158 and EUR 19265).

It has already been used by regulators as a guidance document and was praised by manufacturers and I&C suppliers as helping them in their design work

9.9 *Regulatory assessment of the effects of economic deregulation of the nuclear industry*

A **Task Force (TF)** has been set up by NRWG in 2000 to develop a common view among European regulators on the assessment of typical safety consequences resulting from economic pressure on operators as a result of economic deregulation of electricity markets.

Deregulation had increased the merger activity within countries' energy sectors and some mergers had also resulted in changes in nuclear power plant ownership. The generic safety issue associated with a **change in ownership and permit to operate** arises from the new owner or licensee's potential lack of resources, be they financial, organisational or concern technical knowledge. It is crucial that the legislation regarding ownership and permit to operate cover all these aspects. The regulator should also be allowed to make decisions or give advice to the deciding body regarding changes in ownership and new licensees. **Outsourcing** presents similar generic safety issues, but here the focus of interest is centred at the licensee's ability to keep and develop enough competence within his organisation to maintain full control over safety in the short and long term perspective. The issue of **downsizing** is also associated with concerns regarding resources and competence : fewer resources dedicated to safety-related activities and reduction of technical knowledge. Another concern is that psychological and safety culture side effects may occur.

Although the TF did not discuss the issue of what actions a regulator should take if a licensee goes **bankrupt**, it must be recognised that it is important that legislation can deal with such an event in an open market. The financial capacity of the owner/licensee and his capacity to exercise control of the finance and safety of operations are crucial questions here. The long-term perspective of nuclear waste must also be considered.

The report of the Task Force is nearing completion. Its preliminary findings are that although deregulation is not the only reason why nuclear operators have intensified their efforts to reduce costs and become more efficient, it is clear that the industry is changing due to deregulation and as a result regulators must be prepared for new situations.

The work has identified that the effort for cost reduction and increased efficiency has affected financial, organisational and technical areas as well as the relationship between regulators and licensees. It is believed that there will be a number of innovative ways in which the licensees will try to rationalise and cut their costs. As a result, the regulator must be prepared to address new issues as they appear before the issues adversely affect safety.

As the situation varies to such an extent between the countries, prioritising between deregulation and other safety issues must follow from the assessment of the local situation.

Regulators must take a proactive view and think in terms of legislation and approaches that will account for several situations even if they have not yet been encountered and try to cover all organisational changes important to safety rather than to specify each example.

Regulators should continue sharing experiences in this area, including organising a workshop during 2003. Also, collaboration and sharing information with other relevant international organisations and groups should be considered.

9.10 Future reactors

The discussion on the safety features of the next generation or future NPPs started in the late eighties. In 1989 a report was published that examined the role of inherent design features in achieving the safety of NPPs as an alternative to the practice of achieving safety by the addition of «engineered safety features » (EUR 12525).

The work continued with the publication in 1993 of a report aimed at the identification of improvements of advanced light water reactor concepts (EUR 14296). The collection of safety features was meant to be an information basis for further studies, especially those which aim at safety evaluation.

Building on those early results, the NRWG continued to keep the safety of future reactors on its agenda. In that frame, a consortium of European Technical Safety Organisations (TSOs) started work in 1993 with the aim to arrive at common views on technical safety issues related to large evolutionary PWRs in Europe. The TSOs involved were : AVN (Belgium) (Technical project leader), AEA Technology (United Kingdom), ANPA (Italy), CIEMAT (Spain), GRS (Germany) and IPSN (France). The work was carried out in three phases from 1993 to 1997, and a public version of the results was published in 2001 (EUR 20163). The study constituted an important step forward in the development of a common approach of the TSOs to the safety of advanced evolutionary pressurised water reactors. This goal was mainly achieved by an in-depth analysis of the key safety issues, taking into account new developments in the national technical safety objectives.

The study focused notably on the EPR project initiated by the French and German utilities and vendors. It also considered relevant projects, even of plants of different size, developed outside the European Union. It was expected that the study would constitute a significant step towards the development of a common safety approach in EU countries. The study also made use of the requirements developed by the European utilities and took advantage of the recommendations made by the French and German nuclear safety advisory committees (GPR/RSK).

First a survey of the technical approaches, objectives and requirements for future PWRs of the TSOs themselves or of their respective national licensing organisations was performed. Then, for the characterisation of safety features of a variety of reactor concepts, short surveys of selected designs, including tables with the main characteristics and safety options, were written. Although initially a wide range of reactor designs was considered, it was later decided to focus on a restricted number of them, whose design approaches to safety were examined in detail. These designs were : EPR, Sizewell B, System 80+, AP600, APWR, and the Russian WWER 640/N-407. On the basis of the survey of advanced PWR concepts, and in preparation for the consolidated analysis, a list of 30 key issues was prepared. After discussing priorities and considering the possibility to group some key issues together, 12 revised key issues, covering 15 of the original list of 30 key issues, were selected for in-depth analysis. These selected key issues, listed below, were judged to have the greatest safety significance :

- Use of Probabilistic Safety Assessment in design and licensing
- Reduced environmental source term and emergency plan

- Identification of postulated initiating events (PIEs) and associated acceptance criteria
- Instrumentation and control systems important to safety (hardware and software aspects)
- System architecture
- Passive systems behaviour
- Practical elimination[6] of core melt in shutdown states with open containment
- Practical elimination[6] of high pressure core melt
- Practical elimination[6] of core melt with containment bypass
- Practical elimination[6] of large early releases resulting from containment failure
- Mitigation of low pressure core melt and vessel melt-through
- Identification of severe accidents : methodology and acceptance criteria

For all the key issues considered, conclusions have been developed covering the state of knowledge, safety approaches, and the approaches taken in selected reactor designs. In addition, TSO group positions have been formulated regarding the development of a common approach for each key issue, highlighting any studies still to be done in order to reach the required common understanding and consensus. These common positions form the major achievement of the project.

In summary, an important step forward has been made in the development of a common safety approach of the TSOs. This was mainly achieved by an in-depth analysis of the key safety issues and a review of the European utility requirements, taking into account any new developments in the national technical safety objectives or in the EPR design. A continuation of this co-operation is considered to be an integral part of the process which is needed to meet the overall long term objective.

9.11 Work under progress

Two Task Forces that had been initiated by the Reactor Safety Working Group (RSWG) before it was disbanded at the end of 1998 recently published the results of their work.

These Task Forces dealt with the following subjects :

- Safe management of NPP ageing in the European Union (EUR 19843)
- Study of European safety practices during planned outages at NPPs (EUR 20311)

Moreover, work had been contracted by the European Commission in order to develop "Guidelines for periodic safety review for VVER nuclear power plants".

As NRWG had not followed these projects, it decided to examine them from a regulatory viewpoint to estimate any regulatory impact: that work should begin soon.

---

[6] A situation is considered practically eliminated if it is physically impossible or if proper design provisions are taken to make it extremely unlikely with a high degree of confidence.

There are also active Task Forces of NRWG whose work will continue in the coming years: safety critical software, NDT qualification, effects of deregulation of the electricity market, risk-informed applications.

Severe accident topics are not directly studied by NRWG, as OECD/NEA is quite active in this field, but NRWG keeps itself informed of new developments at periodic intervals (next update foreseen around 2004).

At each of its meetings, NRWG also reviews recent events of interest in the frame of feedback of operating experience, as well as new regulatory matters in the different Member States.

10. Conclusions

10.1 Importance of NRWG for the European regulators

It can be concluded from the report that NRWG fulfils two major functions for its members.

The first is the existence of an active network among the European regulators for discussion of technical issues in a regulatory perspective.
The network means that informal contacts can easily be taken to get an independent view of a current national issue, using the benefit of lessons learnt in different countries. The opinions given on these occasions are based on a long experience with the issue being investigated or with similar issues in a country with similar conditions for safety.
Access to such a network is most valuable when needed in order to check the quality of one's own regulatory activities, and for exchange of information in cases of nuclear events which may be safety significant or not.

The second function is to provide a forum for investigation and further study of specific issues in a European perspective. Although other groups such as OECD/NEA and IAEA are also available, experience has shown that there is a need to study technical issues in the European perspective.
A similar industry tradition has created similar views on industrial processes, uses of standards, worker protection and safety culture. Furthermore, the EU acquis, the EU research programmes and the European industry standards create a specific need for cooperation and establishment of common views.

In that spirit the NRWG has studied many technical issues, has produced numerous technical documents and has synthetized the results achieved in « consensus » documents.

The feedback of this long lasting networking is a progressive change, from the early times, in the national regulatory frameworks either to improve existing regulations or to enlarge their vision of different possible practices to cope with a given requirement.

The contribution of NRWG to the key objectives put forward in the Council Resolution of 22 July 1975, in particular in relation to the harmonisation of safety requirements and criteria, has been this forum of mutual explanation and understanding to reduce or eliminate unexplained differences in approaches. It is thus a convergence process, i.e. harmonisation through consensus on common positions, not through mandatory legal ways, leaving to each National Safety Authority the responsibility to adapt national regulations.

10.2 Impact of the work done

The previous sections of this report show that NRWG during its thirty years of existence has accomplished work of significant scope and valuable technical contents.

In 1981 the « Safety principles for LWR nuclear power plants » enunciated basic safety principles like ALARA, the prevention of accidents, the defence-in-depth concept, the role of multiple barriers, the exhaustiveness of the safety analysis, the consideration of external hazards, the man-machine interface, and the training of the personnel.
The practical implementation of most of these principles was the subject of technical work in the following years, with a synthesis in the Consensus document of 1988.
These common views were reflected in the participation of many European countries to the development of the Requirements and the Safety Guides developed in the NUSS programme of the IAEA starting in the early eighties.

The « Periodic Safety Reviews (PSR) » is a concept developed in the European countries which was afterwards introduced in the IAEA safety standards. It is considered as an excellent tool to maintain and even improve the safety of operating plants.

Documents were issued by NRWG on the basis of the regulatory regime and on the licensing procedures. These documents were helpful in the assistance and dialogue between Western and Eastern European Regulatory Bodies and underlined the primary responsibility of the licensee for the safety of his installations. Representatives of the Regulatory Bodies of the accessing states attend now the NRWG meetings.

The Consensus document issued in 1995 made clear the degree of convergence reached in the fields of safety in operation, source terms and off-site consequences of accidents, and severe accident knowledge and management. It listed topics where more work was needed, and also served as an indication for the safety level of Western reactors, as a reference for Central and Eastern European countries candidates to join the European Union.

In the domains of technologies under evolution, i.e. safety critical software and non-destructive testing qualification, the « Common positions of European regulators » have improved the knowledge of the regulators about these topics and have been quite helpful in the dialogue with the Utilities.

Work under progress now with respect to the effects of the deregulation of the electricity market and to the risk-informed applications is intended to share among all regulators the experience already gained by those of them already encountering these issues, in order to develop a common understanding of these rather difficult subjects.

10.3 Future work of NRWG

In the years to come the work initiated in different task forces will continue : safety critical software, NDT qualification, effects of economic deregulation of the electricity market, risk-informed applications.

The exchange of operational regulatory experience is considered by all members to be quite useful, focussing it a little more on quite safety significant events, on lessons learnt and on the actions taken in other countries.

In the past, when Member States were issuing new rules and standards, drafts of the documents were sent to NRWG which had the opportunity to comment them. This is not done any more : the interest of such consultation might be evaluated.

Work has been done by NRWG on the key safety issues of future reactors. The European Utilities Requirements documents have been partly examined by Western Regulators (not in the NRWG frame). As some characteristics of future reactors may be of interest for the improvement of the safety of existing reactors, and as work is going on at the international level on developing advanced reactor concepts, NRWG might in the future get some insights on these developments.

The advisory role of NRWG to the Commission, stated in the Council Resolutions, has never been clearly requested and NRWG has defined its work programme to tackle the subjects of main interest to its members. As no Regulators group other than NRWG exists in the field of nuclear safety, the Commission might solicit the opinion of NRWG before it takes initiatives in the field of nuclear safety.

List of EUR reports mentioned

EUR 5284 Authorization procedure for the construction and operation of nuclear installations within the EC member states, including supervision and control (1978)
EUR 5525 Authorization procedure for the construction and operation of nuclear installations within certain non-member states of the European communities (1976)
EUR 6371 Analysis of the PISC Trials - Results for Alternative Procedures - Report nØ 6 June 1980 (1980)
EUR 8371 Protection of NPP against seismic effects. Reference Ground Motion: practice followed in European countries (1983)
EUR 9623 The technical basis for emergency planning and preparedness in EC countries (1985)
EUR 10118 Qualification, training, licensing and retraining of operating shift personnel in nuclear power plants (1985)
EUR 10696 Systems reliability benchmark exercise (part I - description and results / part II - contributions by the participants) (1986)
EUR 10782 Traitement des accidents d'origine externe et interne dans les centrales PWR (1986)
EUR 10981 Qualification, training, licensing/authorization and retraining of operating personnel - Noteworthy topics (1987)
EUR 11019 Proceedings of the CEC seminar: Studies of severe accidents in light water reactors (1986)
EUR 11051 Containment integrity and leak testing - procedures applied and experiences gained in European countries (1987)
EUR 11054 CCF - RBE - Common cause failure reliability benchmark exercise (1987)
EUR 11251 Application of the ALARA principle to the occupationally exposed workers in nuclear power plants (1988)
EUR 11344 Catalogue of European Earthquakes and an atlas of European seismic maps (1988)
EUR 11364 Conclusive report on the activities of the containment expert group 1975-1987 (1988)
EUR 11373 Final report on a study of coherence in acceptability criteria for the technical aspects of risks associated with potential hazardous installations (1988)
EUR 11408 Consequence assessment for DBAs of NPPs: Results of a comparison exercise performed by the CEC (1988)
EUR 11523 Radiation protection - A preliminary assessment of the radiological impact of the Chernobyl reactor accident on the population of the European Community (1988)
EUR 12251 Practices and rules applied for the design of large dry PWR-containments within EC countries (1989)
EUR 12273 Summary report on safety objectives in nuclear power plants (1989)
EUR 12525 Inherently Safe Characteristics of nuclear reactors (1989)
EUR 12595 Emergency planning in case of nuclear accident. Technical aspects (1989)
EUR 13056 Periodic safety re-evaluations in NPPs in EC Member States, Finland and Sweden (1990)
EUR 13406 Catalogue of European earthquakes with intensities higher than 4 (1991)
EUR 14179 Realistic methods for calculating the releases and consequences of a large LOCA (1992)
EUR 14296 Identification of improvements of advanced LWR concepts (1993)
EUR 15397 Establishing an effective nuclear safety regulatory regime - Part I - Objectives and requirements (1994)
EUR 15555 Periodic safety reviews of nuclear power plants in EC Member States, Finland, Sweden and Switzerland: a review of current practices (1995)
EUR 15615 Realistic methods for calculating the release of radioactivity following steam generator tube rupture faults - A consensus document (1994)
EUR 15720 Regulatory action related to probabilistic safety assessment studies (1994)
EUR 15721 Reduction of conservatisms in the treatment of some aspects of aerosol behaviour following a large loss of coolant accident (1994)
EUR 16139 European methodology for qualification of non-destructive tests (first issue - 1995) - ENIQ Report 1

EUR 16243 Establishing an effective nuclear safety regulatory regime (1995)
EUR 16244 The key issues in transient analysis calculations which affect the radiological consequences following design-basis SGTR accidents (1996)
EUR 16246 A comparison of European practices for the qualification of electrical and I&C equipment important to safety for European LWR (1996)
EUR 16801 Licensing procedures and associated documentation (1996)
EUR 16802 Rev. 1 - Common position of European regulators on qualification of NDT systems for pre- and in-service inspection of LWR components (1997)
EUR 16803 1995 Consensus document of safety of European LWR (1996)
EUR 17245 Earthquake catalogue for the former Soviet Union and borders up to 1988 (1997)
EUR 17299 European methodology for qualification of non-destructive tests (second issue - 1997) ENIQ Report 2
EUR 17563 Guideline for the evaluation of European practices on the harsh environment qualification of electrical and I&C equipment (1998)
EUR 18158 European nuclear regulators' current requirements and practices for the licensing of safety critical software for nuclear reactors - Draft revision 8 (1998)
EUR 18549 European safety practices on the application of the LBB concept (NRWG Task Force on LBB) (2000)
EUR 18550 Benchmark exercise on the probabilistic safety assessment of steam generator tube rupture radiological releases (1999)
EUR 19153 Report on risk-informed in-service inspection and in-service testing
EUR 19256 Fuel cladding failure criteria (2000)
EUR 19265 Common position of European nuclear regulators for the licensing of safety critical software for nuclear reactors (2000)
EUR 19841 Determination of the in-containment source term for a large LOCA (2001)
EUR 19843 Safe management of NPP Ageing in the European Union (2001)
EUR 20163 TSO study project on development of a comman safety approach in the EU for large evolutionary pressurized water reactors (2001)
EUR 20311 Study of European safety practices during planned outages at NPPs

List of COM reports mentioned

COM (81) 519 "Safety Principles for LWR nuclear power plants"

COM (88) 788 final "Assurance of safety of nuclear power plants - Objectives and methods"

COM (93) 649 final "Towards a System of Safety Criteria and Requirements recognized throughout the Community and a genuine safety culture throughout Europe"