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NUCLEAR ENERGY AGENCY
COMMITTEE ON NUCLEAR REGULATORY ACTIVITIES

REGULATORY ASPECTS OF AGEING REACTORS

1998 CNRA Special Issue Meeting

June 1998

English text only

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ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Pursuant to Article 1 of the Convention signed in Paris on 14th December 1960, and which came into force on 30th September 1961, the Organisation for Economic Co-operation and Development (OECD) shall promote policies designed:

– to achieve the highest sustainable economic growth and employment and a rising standard of living in Member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;
– to contribute to sound economic expansion in Member as well as non-member countries in the process of economic development; and
– to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

The original Member countries of the OECD are Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The following countries became Members subsequently through accession at the dates indicated hereafter; Japan (28th April 1964), Finland (28th January 1969), Australia (7th June 1971), New Zealand (29th May 1973), Mexico (18th May 1994), the Czech Republic (21st December 1995), Hungary (7th May 1996), Poland (22nd November 1996) and the Republic of Korea (12th December 1996). The Commission of the European Communities takes part in the work of the OECD (Article 13 of the OECD Convention).

NUCLEAR ENERGY AGENCY

The OECD Nuclear Energy Agency (NEA) was established on 1st February 1958 under the name of OEEC European Nuclear Energy Agency. It received its present designation on 20th April 1972, when Japan became its first non-European full Member. NEA membership today consist of all OECD Member countries, except New Zealand and Poland. The Commission of the European Communities takes part in the work of the Agency.

The primary objective of the NEA is to promote co-operation among the governments of its participating countries in furthering the development of nuclear power as a safe, environmentally acceptable and economic energy source.

This is achieved by:

– *encouraging harmonization of national regulatory policies and practices, with particular reference to the safety of nuclear installations, protection of man against ionising radiation and preservation of the environment, radioactive waste management, and nuclear third party liability and insurance;*
– *assessing the contribution of nuclear power to the overall energy supply by keeping under review the technical and economic aspects of nuclear power growth and forecasting demand and supply for the different phases of the nuclear fuel cycle;*
– *developing exchanges of scientific and technical information particularly through participation in common services;*
– *setting up international research and development programmes and joint undertakings.*

In these and related tasks, the NEA works in close collaboration with the International Atomic Energy Agency in Vienna, with which it has concluded a Co-operation Agreement, as well as with other international organisations in the nuclear field.

COMMITTEE ON NUCLEAR REGULATORY ACTIVITIES

The Committee on 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.

The Committee is responsible for the programme of the NEA, concerning the regulation, licensing and inspection of nuclear installations. The Committee reviews developments which could affect regulatory requirements with the objective of providing members with an understanding of the motivation for new regulatory requirements under consideration and an opportunity to offer suggestions that might improve them or avoid disparities among Member Countries. In particular, the Committee reviews current practices and operating experience.

The Committee focuses primarily on power reactors and other nuclear installations currently being built and operated. It also may consider the regulatory implications of new designs of power reactors and other types of nuclear installations.

In implementing its programme, CNRA establishes co-operative mechanisms with NEA’s Committee on the Safety of Nuclear Installations (CSNI), responsible for co-ordinating the activities of the Agency concerning the technical aspects of design, construction and operation of nuclear installations insofar as they affect the safety of such installations. It also co-operates with NEA’s Committee on Radiation Protection and Public Health (CRPPH) and NEA’s Radioactive Waste Management Committee (RWMC) on matters of common interest.

ABSTRACT

Each year the CNRA selects a topic of special interest to members for discussion. The topic chosen for 1998 was Regulatory Aspects of Ageing Reactors. The report predominantly looks at answers provided by the Member countries and the analysis performed by a task group established by the Organising Committee group. Additionally, insights from the CNRA discussions are provided in appropriate sections.

FOREWORD

As in all the types of work performed by CNRA the success of the Special Issues Meeting and this resulting report are due to the time and efforts put in by the organising committee members. Special acknowledgement is given to Dr. Görtz, Dr. Kuo and Mr. Koyama who provided additional time and their considerable knowledge towards preparing and presenting the results to CNRA at the Special Issues Meeting. Dr. Lennart Hammar was instrumental in compiling, analysing and co-ordinating all the different comments into a workable and readable document.

The members of the organising committee, who developed the questionnaire and were involved in compiling the national responses, were C. McDermott and P. Paquette, AECB, Canada, Dr R. Görtz, BfS, Germany; L. Hammar, ES-konsult, Sweden; J.R. Hernandez, CSN, Spain; F Kolonitis, HAEC, Hungary; M. Koyama, JAPEIC; Japan, P.T. Kuo, US NRC; M. Ojanen, STUK, Finland; P. Ruiz Lopez, CNSNS Mexico; P. Tendera, SONS, Czech Republic; D.M. Watson, NII, UK; and L Van der Wiel, SZW, The Netherlands. The project has been managed by B. Kaufer, NEA. This report and the compilation of abstracts of the national reports were compiled by L. Hammar.

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1 EXECUTIVE SUMMARY

This report integrates the work performed by the Organising Committee for the 1998 CNRA Special Issues meeting and the resulting discussions which took place during the meeting. It is important to note that the concept of ageing can be interpreted in various ways. This was clearly shown in the analysis of the responses to the questionnaire and during the Special Issues meeting. The report predominantly looks at answers provided by the Member countries and the analysis performed by a task group established by the Organising Committee group. Additionally, insights from the CNRA discussions are provided in appropriate sections.

1.1 Work of the Organising Committee

The views presented cover the topic in a general way as was understood to be the intention of the CNRA.

Accordingly, ageing management is defined here in the broader sense gradually gaining use, i.e. covering not merely ageing management of hardware, in the traditional sense, but in addition the management issues on keeping up in general with developments of the state-of-the-art in technology and management practices. The topic for discussion by the CNRA would thus be seen in the way the nuclear safety authorities and the nuclear utilities provide, in general, for capability of managing nuclear safety with regard to changing conditions, perspectives and prerequisites ("management of change").

The report covers following specific issues of interest for the discussions on the topic:

- the relevant safety aspects (section 4)
- the related needs for research and development (section 5),
- actions actually taken in the different countries on related issues (section 6),
- what is thought to support necessary initiatives in the safety work (section 7),
- what strategies are used (section 8),
- the matter of communicating related information to the public (section 9), and
- certain specific questions are suggested for discussion (section 10).

Among conclusions reached, the following could be emphasised:

- The "broad concept" of ageing management has definite merits but remains to be generally accepted and understood in order to serve constructively in discussions about developments in regard of nuclear safety.

- The importance assigned to "traditional" ageing management, as seen from the national reports, and issues related to hardware degradation problems is clearly very high. The other aspects, like engineering developments, or other types of management developments, in regard of general progress of the state-of-the art are considered important as well, but are less emphasised.

- Some countries see needs to develop the event reporting systems to reflect more accurately the ageing problems.

- There is common interest in enhanced practices for in-service inspections and maintenance as well as "risk informed" approaches, also as applied to selection of research projects.

- There may be reason, in regard of the need to establish safety requirements in terms of safety upgrading in ageing management, to consider developing the use of specific criteria for that purpose (safety goals).

- There is some notable shift in focusing the regulatory efforts, in some countries, in the direction from verifying that systems and equipment meet the requirements to verifying that proper organisational arrangements are in place, that they are used in the utility processes, and that there is also development going on based on learning from experience. Some countries, however, continue to rely primarily on verifying the state of the plant

- Matters concerning communicating ageing related information to the public appear to be assigned special importance in most responses. Proper arrangements seem anyhow to be in place.

1.2 CNRA Special Issues Meeting and Discussions

Similar to past meetings, the format of the special issues meeting consisted of presentations by the organising committee and a few selected presentations followed by open discussion by CNRA members. A list of possible issues (Section 10) as well as a short list of questions were provided to support the discussions.

In preparing for the presentations, the Organising Committee reviewed and analysed the responses provided to the questionnaire and structured them as follows:

- Introduction

- Main Issues

- Strategies / Factors

- R&D / Related Programmes and Achievements

- Communications
- Summary & Conclusions
- In addition a presentation on aspects of ageing management was given by an IAEA representative.

Much of the CNRA discussions focused on the definition of ageing and the need to recognise all the different components which it entails. An important part of this issue is the necessity to understand that it is a long term problem and also that licensee need to maintain good control over all the various aspects to be covered. The general consensus of members identified 'life time safety management' as perhaps the most appropriate terminology for this subject. This evolved as a way to distinguish the concept of ageing being discussed from established definitions used by other organisations and groups studying ageing issues, such as management of change.

While no clear overall consensus was established on future work in this area, it was clear from the discussions that regulators needed to continue to address both physical and non-physical ageing and that life time safety-management would be continued to be discussed at future CNRA meetings.

2 INTRODUCTION

The CNRA decided in June 1997 to select the topic “Regulatory Aspects of Ageing Reactors” for discussion at its ’98 Special Issues Meeting. An organising committee was appointed to prepare for the meeting.

2.1 Scope and Objectives

The CNRA wanted the topic to be covered in a general way, including aspects as standards to be applied, integrity and reliability, maintaining safety culture and competence, criteria for continuing operation and communications with the public.

The topic can be viewed in the perspective of future regulatory challenges, recently dealt with by the Working Party headed by Mr Chris Willby. In the final report of the Working Party, entitled ‘Future Nuclear Regulatory Challenges’, the following point was made concerning ageing.

- “ageing” manifests itself in various forms, i.e. not only in the physical ageing of components and structures but also in the ageing of, e.g., analytical techniques and documentation, rules and standards and technology

This view, becoming gradually established in the nuclear community, was accordingly chosen in preparing for the discussion of the matter by the CNRA. Incidentally, as further commented below, this broad concept of ageing, covering in effect a substantial part of the entire nuclear safety, did raise some discussion in the organising committee.

The objective accordingly assumed was to bring up important aspects on ageing management:

- with specific regard to problem areas and potentials or needs for improvement and

- covering ageing in a traditional sense as well as the needs for keeping up with the state of the art in technology and management practices.

The intent was thus not to cover in any detail common, well established working practices or arrangements in ageing management. Approaches to problems commonly met and related experiences were rather to be covered.

2.2 Approach

Current views on ageing management among the regulators were explored through a questionnaire. The questions aimed at finding out about safety aspects considered particularly important in regard of ageing, prioritisation of related research, ageing management matters actually being acted on, and general strategies and management principles applied. The importance of each question in regard of safety was also usually required to be rated on a scale in terms of relevance or priority.

In addition, questions were asked about the information to the public in related matters.

In response to the questionnaire, reports were eventually received from most of the regulators. The reports were discussed in a meeting with the organising committee in February 1998, which lead to certain adjustments and clarifications. Further adjustments have been made later in finalising this report and the basic documents.

2.3 Reporting

The work of the organising committee has resulted in following reports:

- This report, providing a summary of the findings of the committee. It is aimed primarily for initiating the discussion by the CNRA.

- National responses, forming the basis of the information summarised in this report. Reports have been received from Canada, Czech Republic, Finland, Germany, Hungary, Japan, Mexico, Spain, Sweden, UK, and USA. Further contributions have been received from the Netherlands, however limited to assignment of priorities to issues indicated in the questionnaire, and Belgium, in the form of meeting notes in other context concerning life extension of nuclear installations.

- A compilation of abstracts from the national reports, in order to facilitate overview.

This report does not cover examples given in the national reports on various programmes and achievements relating to the management of ageing of the nuclear plants. A summary can be found in the compilation made of abstracts from the national reports.

2.4 Importance rating of related issues

The questionnaire requested the importance of the various issues to be indicated by ranking in order of importance or rating *relevance* and *priority* on a scale. The suggested distinction was that while an issue might be highly relevant it may still be assigned low priority in regard of the remaining *attention* it requires with regard to measures already taken. Assigned measures of relevance were later felt to add little to the general picture, however, and were thus not included in this report.

Although it may be difficult to rank the importance of, or to assign priorities to various, possibly even interrelated issues, it was felt desirable to convey, in this way, an impression of the attention currently paid in the safety work to the various matters in the different countries. Assigned priorities are meant (in the Questionnaire) to indicate the *relative importance of acting in any way on the particular issue*, e.g. assuming a campaign to be initiated. However, a low priority rating could possibly reflect low rating of the relevance of the issue, which can be checked in the compilation of responses.

All prioritisation or importance ranking is made between issues covered under a main heading in this report (sections 4-9). In some cases, unique priority or rank was assigned to each matter; in other cases, the matters were categorised in a few classes according to rating. To be at all comparable, the ratings are presented, in the compilation of responses, together with the corresponding number of categories (or uniquely prioritised matters). In the following, priority ratings are represented in words.

It is obvious that the relevance and priorities given in the national responses are more or less subjective figures. This has been taken into account in the analysis performed by reflecting the significant trends only.

2.5 Acknowledgements and Annotations

The members of the organising committee, who developed the questionnaire and were involved in compiling the national responses, were C. McDermott and P. Paquette, AECB, Canada, Dr R. Görtz, BfS, Germany; L. Hammar, ES-konsult, Sweden; J.R. Hernandez, CSN, Spain; F Kolonitis, HAEC, Hungary; M. Koyama, JAPEIC; Japan, P.T. Kuo, US NRC; M. Ojanen, STUK, Finland; P. Ruiz Lopez, CNSNS Mexico; P. Tendera, SONS, Czech Republic; D.M. Watson, NII, UK; and L Van der Wiel, SZW, The Netherlands. The project has been managed by B. Kaufer, NEA. This report and the compilation of abstracts of the national reports were compiled by L. Hammar.

There was considerable need for discussions in the organising committee and for re-iterations, mainly owing to difficulties in establishing a common view as to the definition of the subject and its scope. Only one meeting could be devoted to resolving the various matters, after most of the national reports had been made available, and all members of the committee were, unfortunately, not able to participate. Although electronic mail provided opportunity for a great deal of further discussion, it has not been possible to reiterate all matters as would have been desirable due to the heavy commitments in other respects on part of those involved. Inconsistencies thus still remain in the reporting, usually relating to what is understood to be relevant with regard to “ageing”.

Nevertheless, the committee members all appreciate that they were given opportunity to be involved in preparing for the CNRA discussion in this important matter of nuclear safety and to contribute their views.

3 THE CONCEPT OF AGEING MANAGEMENT

The responses to the questionnaire indicate fair acceptance of the broad concept of ageing (cf. above) although it may not yet be firmly established and applied as a habit.

The broad concept of ageing offers advantage in bringing “management of change” into focus in addition to the various specific issues as such which are affected by changes. No matter if changing conditions relate to ongoing degradation of hardware, to corresponding management practices, or to developing views and increased knowledge in regard of completely different issues, *the management aspects* clearly constitute a common denominator.

It has been pointed out also that management of ageing, in the sense used in this report, may rather be seen as a pure matter of quality assurance (QA). It should be observed, however, that QA rests on *quality systems*, covering the relevant aspects, and that ageing management should essentially be seen as constituting a part of the total quality system.

It was also pointed out that several documents exist which provide common ageing terminology, as applied to physical ageing. These documents, such as the EPRI Common Ageing Terminology have been developed to improve the understanding of ageing phenomena, facilitate reporting of relevant plant failure data ad promote uniform interpretations of standards and regulations that address ageing.

4 SAFETY ASPECTS

4.1 Ageing degradation

In nearly all responses priority is assigned at the highest level to managing the physical ageing of the plant components and structures. There are no real concerns expressed in regard of safety, however, but rather in regard of the service life of the various components and the amount of attention and efforts required for ensuring adequate management quality.

The need for improved understanding of the ageing phenomena in regard of predictability, e.g. incubation periods, degradation rates and relevant factors, is particularly emphasised. Systematic feedback of relevant experience is pointed out to form important basis.
Life extension of the plants is a related issue receiving considerable attention.

4.2 Obsolescence

Technical obsolescence of systems or components (meaning that they may still perform as intended but should be replaced with modern variants for practical reasons) is generally rated minor importance in regard of safety. When appearing, any obsolescence is likely to be brought to attention as required through experiencing practical problems, e.g. spare part problems. However, the I&C systems are frequently subject to modernisation, usually with significant safety implications. They thus offer considerable potential for safety improvements while, on the other hand, there are some challenging quality assurance requirements in implementing the advanced technology usually called for.

The importance of regularly conducted modernisation programmes is underlined.

4.3 Keeping up with state-of-the-art

This concerns the gap that might be seen on viewing the current provisions for the safety and the defence-in-depth in the light of the state-of-the-art. Such gap may relate to general advances in various areas, such as the integrated treatment of man, technology, and organisation (MTO); safety approaches like integrated, plant specific PSA; generally advancing safety standards and concepts in regard of what can be considered safe enough, etc.

The importance assigned to this aspect of ageing management (management of change) is reflected in the regulatory processes, providing for comparisons to be made against modern standards and implementation of improvements as reasonably practicable. In some countries periodic safety reviews (PSR) are conducted as part of the regulatory process.

Comments and assigned priorities were asked for with regard to following specific aspects:

Aspect	Priority[1]	Comment
Human factors (MTO), management and organisation, and safety culture	medium and above	The general attention paid to the matter is reflected by common emphasis laid on training, promotion and evaluation of safety culture, organisational means and practices for quality assurance, e.g. to ensure that safety related equipment is operational when required, etc.
Process instrumentation and control	typically medium and above	The rapidly developing technology with regard to I&C, causing in turn rapidly proceeding obsolescence, is reflected in a great deal of modernisation projects. The responses indicate that there are notable advantages to be gained with regard to safety in this field
Initiating events and internal hazards, dependencies, etc.	about medium	There are, in particular, needs for improving the separation of important safety systems and redundancies in the older plant with regard to internal hazards and dependencies. Needs for systematic hazards analysis is seen, e.g., in the WWER reactors. In-depth PSA using detailed systems modelling has proved efficient in revealing unknown dependencies and hazards in old reactors subject to modernisation.
External hazards, e.g. seismicity, plant behaviour under accident conditions and severe accident issues	Medium and below	Comments made indicate that these issues are in fact considered to have already received sufficient attention with due regard to current state-of-the-art. Furthermore, with regard to severe accidents, the emphasis is more on avoiding accidents than on mitigation. Undoubtedly, however, the research on severe accidents still going on internationally is followed closely. Specific aspects include monitoring accident conditions and accident management aiming at keeping the core melt inside the reactor pressure vessel.

4.4 Safety as perceived by the public

The majority of the responses may be understood as reflecting the view that expert opinion rather than public perception is decisive in considering safety requirements. The number of responses assigning definite relevance to public perception of safety in the present context is thus clearly less than the number of responses rating the relevance as minor. The priority of the matter is rated at bottom by all countries except one (of. section 3.2). From the comments can be seen that the attention paid by the public specifically to the ageing problems varies considerably from country to country and may not justify specifically addressing the ageing problems[2] in informing the public. A few countries emphasise, on the other hand, the importance of such information to people's trust in the ageing plants.

1. Cf. section 2.4 Importance rating of related issues

2. It should be noted, again, that it may not have been clearly established whether "ageing" was indeed understood in the "broad sense".

5 RESEARCH AND DEVELOPMENT NEEDS

The view taken in the present context of ageing management – or management of change – concerns research and development for implementation of advanced technology or advanced methods with capability of offering potential for safety improvements.

5.1 Ageing of plant components

Needs for further research is seen primarily with regard to ageing phenomena affecting the pressure boundary of the primary systems. Important areas include fatigue, thermal and irradiation embrittlement (and annealing), thermal shock, corrosion erosion and cracking, and crack initiation and propagation under the various environmental conditions prevailing and to be controlled (e.g. chemistry) in the various primary systems, particularly in the RPV, main coolant piping, steam generators etc.

The research needs related to ageing and environmental qualification of safety related, functional components are prioritised at rather low to medium level. Studies concerning long term maintenance programmes to ensure easy repairability and replaceability are foreseen in conjunction with life extension programmes.

Research needs relating to the integrity of reactor containments and building structures are less emphasised but there are on-going research programmes on the ageing of concrete structures. Specific areas include ensuring leak-tightness of the containment and integrity of tendons, with regard to possible exposure to corrosion, seismic resistance of aged building structures and methods for monitoring and inspecting degradation.

The research needs in regard of monitoring degradation are rated at varying level. The need for capturing degradation at earliest possible stage is emphasised with regards to both safety and commitment of radiation dose at required repairs and replacements. A related need is pointed out in establishing databases to cover operating experience and research results on a world-wide level to further enhance maintenance and ISI/IST work. Compilations of information on detected degradation problems, detailed backgrounds and remedies are thus reported to be considered or under way for piping and other safety related components.

5.2 Other safety management issues

The research needs with regard to safely managing introduction of new technology are rated minor, in part with reference to quality assurance being the main question. It is pointed out, however, that new technology can introduce unforeseen failures and that extensive work, recognising the absence of operating experience and the need for experiments, validation and qualification, is required to ensure necessary reliability. The need for generally accepted guides and standards for qualification of programmable automation is also emphasised.

A general need for research in the area of human factors and the interplay between man, technology and organisation is pointed out. Specific issues include organisational matters and information systems in regard of control rooms and maintenance, and conservation of competence, in general and for decommissioning purposes.

5.3 Severe accident management

While severe accident research continues to be conducted on a broad basis, for large part in international co-operation, the severe accident issues are given rather low priority in the responses, with some exceptions. Open issues include applying the methodology for severe accident analysis, developed in the western countries, to the WWER reactors. Particular attention is also paid to severe accident management procedures, e.g., in regard of the possibility of keeping a core melt inside the reactor vessel, at least in certain scenarios, as indicated by experience obtained from the TMI accident.

6 INITIATIVES

In this part, certain *types of current or recent initiatives* towards upgrading of the ageing nuclear plants in regard of safety (rather than just life extension) are substantiated by comments given in response to the Questionnaire together with priorities assigned for each type. Arrangements for similar purpose, commonly and for long times already in place, are not covered.

Type of action	Priority[3]	Comments
Enhancing feed-back of experience	typically at top, a few medium or below	Some countries consider adapting the event reporting systems, and the analysis of the data, to reflect more accurately the ageing problems. Need indicated for establishing databases covering the reported and analysed results to enhance maintenance and ISI/IST work.
Enhanced or complementary safety studies	typically well above medium	Thorough reconstruction of the safety cases of the NPPs, triggered by an occurrence, is reported from one country. Reported Individual Plant External Event Examinations for internal and external severe accident scenarios belong here. Particularly efficient updates of the safety cases were accomplished in conjunction with plant modernisation programmes. Updates of the safety studies as commonly conducted at regular intervals (e.g. in PSRs) are considered sufficient in several countries.
Enhanced and extended use of PSA	typically well above medium	The PSA for WWERs have been completely reworked. Enhanced treatment of CCF is relevant to ageing of safety related components. Increasing application of PSA as a basis for “risk informed” safety management (ISI, maintenance, research etc).
Enhanced in-service inspections	well above medium	Applies to inspections of a range of NPP components in several countries (RPVs, steam generators, piping etc.) based on systematic qualification of the procedures, systematic risk classification, the LBB concept, technical developments, etc.
Enhanced maintenance practices	above medium to well below	Developments are aimed at maintenance rules to be firmly based on experience and optimised in regard of the reliability requirements. Improvement is also to be achieved by rigorous management procedures. There are notes to the effect that reliability centred maintenance approach is not essential and may imply relying too much on failure rate statistics.
Enhanced working conditions or	above medium to	The question relates to general implications in regard of plant safety.

[3]. Cf. section 2.4 Importance rating of related issues.

Type of action	Priority[3]	Comments
facilities for plant staff	below	Important measures taken include reduction of occupational exposure by enhanced water chemistry, cobalt elimination, automation of inspection tasks, careful planning of inspection and maintenance work in the plants, etc. Modernisation of control rooms and improved man-machine interfaces in specific cases utilising modern information systems are other examples.
Enhanced functional reliability of safety systems	mainly medium to well below	Examples include added double and separated redundancy to shutdown systems, adding diverse redundancy for decay heat removal, augmenting of redundant and diverse on- and off-site power supplies etc.
Enhanced prevention of initiating events	medium to well above	Examples include damping of vibrations giving rise to fatigue, particularly in combination with IGSCC, enhanced monitoring, inspection and surveillance programmes, replacement of materials for improved resistance to corrosion cracking, e.g. in reactor internals, and improved testability using NDT, etc. Such measures form important part of modernisation projects for the nuclear plants.
Enhanced protection of the safety systems against internal hazards	medium to well below	One response pointed out the finding that fires contributed most to the total core damage frequency. Measures included modernising the fire detection systems and enhancing the fire fighting systems. The Canadian nuclear standard on fire protection was revised in 1995. Reviews according to the new standards are under way. The fire alarm and fire fighting systems were improved for the WWER plants based on deterministic analysis and PSA. Systematic hazards analyses have been made for older western type nuclear plants and for WWER type reactors with regard to pipe whip, jet impingement, missiles etc., resulting in a number of proposals for design modifications. One response expressed preference for physical protection in regard of any adverse effects of pipe failures before demonstration of LBB.
Enhanced mitigation of severe accidents	mainly well below medium	

7 FACTORS SUPPORTING INITIATIVES

This part reflects views in regard of the extent to which certain factors contribute to promoting initiatives to upgrade the ageing reactors with regard to safety together with the assigned importance ranking.

Supporting factor	Rank[4]	Comment
Regulatory initiatives	1st - 2nd, equal shares	Regulatory supervision and initiatives are seen as indispensable complement to the licensee's responsibility for safety. *There is a remark that the combined roles of the safety authority and the licensee constitute the relevant factor rather than the single roles per se.*
Utility initiatives	Typically 1st - 2nd	All nuclear licensing regimes assign ultimate responsibility for the safety on the licensees[5]. There is common agreement that full reliance on the responsibility assumed by the utilities should be the goal. It is commented that there may in fact be needs to evolve the situation in this direction.
International or recognised national nuclear and conventional standards	medium and below (with a couple of exceptions)	The IAEA Safety Standards are valued in some countries for the reference and the guidance they provide in developing national, regulatory requirements and also for general guidance in managing the safety work[6]. Traditionally the US standards and regulations have had a large influence on safety considerations, because they were available when the plants were designed and built.
Common utility requirement standards	typically medium and below	Reference is made mainly to various national codes and guidelines, notably US guidelines (NEI) for licence renewal, maintenance, and for monitoring the conditions of structures. The EUR (European Utility Requirements, under development) and the URD (the EPRI Utility Requirements Document), are not mentioned. One note that these are likely to become important in

4. Cf. section 2.4 Importance rating of related issues

5. Initiatives in regard of safety upgrading relate, however, at least in part to the responsibility of the safety authority for setting main safety goals. The responsibility of the licensees would thus be expected to manifest itself mainly in

   – *high degree of integrity when assessing means and measures to provide for the safety as intended* and

   – *commitment to maintaining the plant safety performance*

6. The guidance in regard of assessing the safety of ageing reactors built to earlier standards should be mentioned in particular.

Supporting factor	Rank[4]	Comment
		the future, another that the impact may be limited due to differences in technical background.
Utility co-operation	typically medium and above	Operator co-operation and owners groups are noted as important, e.g., in feedback of experience, in considering generic safety issues, and in aiding research and development programmes, covering in part also the area of ageing. The importance of international co-operation for small countries is pointed out.
International co-operation on the management side and in research	typically medium and below[7]	It is notable that the importance is ranked high in the eastern European countries. The importance of research cooperation for small countries is pointed out.
Advanced safety concepts for new reactors, existing or announced	low	Believed to have little impact in the context of ageing management of reactors in operation. The advanced safety concepts are no doubt accounted for in the regularly performed safety reviews and valued on their possible merits for upgrading the safety of the existing reactors. They are also certainly seen as providing valuable hint as to what ways safety demands may possibly take in the future. There is a common view, however, that whenever a certain advanced safety concept cannot for practical reasons be used in an existing plant, it is usually possible to assure safety on reasonably required level by other means, as to be verified by analysis. Compliance with modern safety standards is not viewed as necessary provided it can be demonstrated that an acceptable case exists.

[7]. Ranking could have been affected by differences in the understanding the broad concept of "ageing".

8 STRATEGIES

Some countries have stated basic philosophies underpinning their strategies for plant ageing management. Following statement from Belgium may be seen as representative:

Basic aims are:

1. to confirm that the plant is as safe as originally intended;

2. to establish the exact plant status with emphasis on those structures, systems and components susceptible to ageing; and

3. to justify the current level of safety of the plant by comparison with current safety standards and practices, and identify areas where improvements would be beneficial and risks reduced at justifiable expenses.

The issues relate in this part to the *general approaches* in ageing management. Due to the broad meaning assigned to “ageing management” in the present context (cf. section 2.1 Scope and Objectives) most main approaches taken in the safety work – mainly in conjunction with the regulatory process – become relevant.

Following main views were expressed in the responses to the Questionnaire on various issues of strategy (again, the assigned priorities should be understood as explained in section 2.4 Importance rating of related issues.):

Strategy issue	Priority[8]	Comment
Use of regulatory goals	Typically well above medium, some very low[9]	Safety goals appear to mean quite different things, including "assurance that the safety is maintained at acceptable level", "avoiding radiological accidents or any incidents indicating weaknesses in the defence-in-depth", "provisions as required for the safety" (e.g. quality assurance) as well as various performance indicators.[10] Not all countries use safety goals. Some countries have, on the other hand, the basic philosophy of "goal setting" rather than using a prescriptive approach according to regulatory guidelines. Probabilistic safety goals are not emphasised, although the well-known INSAG goals are no doubt commonly referred to in actual practice. Specific probabilistic targets are, however, in common use as indicators of (assumed) safety performance. Some countries provide comprehensive guidance in regard of the regulatory use of safety goals, allowing the licensees to set their own safety goals. The importance of safety goals in regard of ageing management and backfitting for safety is pointed out.
Approaches to regulatory assessment of ageing management	above medium	Comments were asked for particularly in regard of the use of re-licensing or periodic safety reviews (PSR) of the plants at certain time intervals in the regulatory process. PSRs required as a condition for the license (rather than for license renewal) are performed in Belgium (every 10 years), Hungary (presently 8 years), Japan (10 years), Mexico (5 years), Spain (10 years), Sweden (8 years), and UK (10 years). In Germany, PSRs are conducted voluntarily, by the utilities, about every ten years. License renewal is practised in Canada (license issued for 2 years), Czech Republic (?), Finland (10 years; PSR required for renewal, and the US (license granted for 40 years with an option to apply for renewal). In Mexico, license is granted for 30 years with no option as yet provided for license renewal. Experience gained in PSRs, in some countries since the early eighties, indicate that this type of comprehensive safety review is indeed of great value. It is noted in one response that, for success, it is necessary to have a regulatory regime, which effectively makes such reviews mandatory.

8. Cf. section 2.4 Importance rating of related issues

9. Very low priority ratings coupled with low rating of relevance, with one exception

10. Safety goals may be considered as forming together with *prescribed safety approaches* (pertaining to design, construction, operation, maintenance etc.), *safety criteria*.

Focus of inspections and safety reviews		Comments were requested in regard of the emphasis placed by the safety authority on inspecting the utility processes for ageing management, to be assured of their adequacy and quality, vs. inspecting the actual state of the plant, being the result of the way it is managed. Several countries indicate that a substantial part of the regulatory efforts goes into ensuring that the licensees have adequate arrangements for managing the nuclear safety and that these arrangements are being applied efficiently. It is pointed out, however, that proper balance between the approaches is needed. A few countries indicate that the inspection activities are concentrated on the actual state of the plant. One of these countries indicates, on the other hand, that increased emphasis will be given to inspections of the utility processes.
Publicly communicated utility safety goals and policies	low	The question was asked in regard of the desirability that the utilities, ultimately responsible for the safety, publicly clarify their main safety policies in relation to the regulatory requirements. In one country, the utilities are obliged to communicate their policies to the public. Some countries state, on a voluntary basis, their safety goals and general policies, e.g. to maintain a high safety culture and to continuously strive for increasing the safety, and to ensure certain lifetime of the plants.
Bringing about safety improvements beyond current licensing conditions	typically medium and above	There are no clear-cut decision making procedures referred to that apply in general. It is rather pointed out that suitable conditions have to be provided to enable, in critical cases, all relevant information and views to enable proper balancing. In some countries, the safety authority can – in principle -impose any requirements in regard of safety, in addition to those foreseen in the licensing conditions, and accordingly impose shutdown on non-compliance. Pointed out, on the other hand, is the need to establish an efficient dialogue between the authority and the utility, whenever an issue of type would develop. The questions, in regard of what can reasonably be required to ensure safety, are then usually not difficult to resolve based on mutual understanding, as found in practice. Countries with a goal setting approach state their preference for imposing any new requirements in corresponding terms rather than by definite prescriptions, thus leaving it, at least in the first instance, to the utility to come up with possible solution.
Balancing safety requirements and related commitment of occupational radiation dose	low	The balance of occupational radiation exposure and safety aspects, which is relevant to decisions on the backfitting component of ageing, is not addressed in detail but rather in general terms. Many countries point out that formal cost-benefit-analyses are not conducted. The decision process between dose and safety seems to be a general balancing, there are no quantitative criteria quoted. The aspect of practicability is mentioned.

Practices to assure that vital information on matters of safety will in all events be promptly disclosed and shared within the nuclear community.	greatly varying	The answers obtained all imply that current practices are considered to provide adequate assurance. The exchange of all kind of operating experience thus is not only an obligation but also strongly promoted by the safety authorities. According to experience the desired assurance does not prevent confidentiality of information supplied to the safety authorities to be reasonably protected for, e.g., proprietary reasons.[11] One country states that there is express agreement between the utilities that the competitive situation shall not prevent sharing vital, safety related information.
Ensuring updating of documentation, procedures and safety analyses	medium	Reference is made to the pertinent QA requirements and auditing procedures, and to regulatory inspections. Two countries indicate that the matter needs further attention. There are major projects in one country involving reconstitution of the technical documentation of the safety cases of the nuclear plants.

[11]. The matter could have particular significance in regard of invented remedies to causes of observed incidents or fault conditions.

9 COMMUNICATING INFORMATION TO THE PUBLIC

The questions were asked on the assumption that the public perception of the safety of the ageing nuclear plants should rest on complete, relevant and correct information. However, the relevance assigned to these matters, as explicitly rated in the responses, is commonly rather minor. The comments indicate, on the other hand, that the safety authorities have definite policies, in some cases by obligation, to provide frank and open information to the public on all nuclear safety issues and events, and that there are extensive arrangements provided for the purpose. The utilities also recognise the benefits of openness and public understanding of nuclear power and thus provide, e.g., visitor centres and plant tours.

In most cases the utilities and the regulatory bodies inform the public independently. In one case the safety authority expects the utilities to inform the public about notable events in their plants. If such information would not be released in an appropriate manner, the authority would itself release the information. One regulator points out that its safety decisions are consistently based on the docketed information submitted by the utilities and that all such information is made available and accessible to the public.

10 SUGGESTED QUESTIONS FOR DISCUSSION

1. Views as to the meaning assigned to "ageing management".

2. Needs for generally enhanced assurance that the root causes of observed ageing degradation are indeed properly identified and verified and that all relevant information is secured prior to measures possibly preventing further observations.

3. Needs for enhanced feedback of information by improved reporting and recording of ageing degradation and associated data on a broadened, possibly international basis

4. Attention paid to inspectability and maintainability in modernisation of nuclear plants.

5. Needs and possibilities for enhanced quality assurance for improved reliability and safety of the nuclear plants to further ensure observation of the technical specifications of operation, e.g., in regard of ensuring operability of the safety systems after maintenance outages.

6. Need for enhanced strategies and methods in performing various types of safety review (e.g. reviews of proposed plant modifications, PSRs, re-licensing reviews etc.). – Distinctive characteristics of efficient PSRs

7. Distinctive characteristics of "properly balanced" regulatory inspection and reviewing to verify, on one hand that systems and equipment meet required standards and, on the other hand, that proper organisational arrangements are in place and used in the utility processes, including developments based on learning from experience.

8. The role of safety goals in establishing safety criteria. **-** Is "continual improvement of safety" by itself a sensible goal in nuclear safety?

9. Is ageing adequately addressed in PSAs regarding methods and data to support „risk-informed“ approaches?

10. Meeting the requirements of ageing management under increasing economic pressure

APPENDIX 1

Compilation of Abstracts from National Responses to a Questionnaire on Regulatory Aspects of Ageing Reactors

Note: For explanations in regard of assigned importance measures (relevance, priority), please refer to the main report prepared for the 1998 CNRA Special Issues Meeting

1. Safety considerations in regard of nuclear power plant ageing

Comments in view of the ageing of the nuclear plants as reflected by current national plans and programmes.

General

For issues representing specific aspects, please refer also to answers given to question 4 about issues currently on the agenda.

Belgium: The main safety aspects about ageing are 1) challenge to the defence in depth; and 2) failures of key safety systems. The concerns relate to ageing phenomena, under the various environmental conditions present in reactors, in mechanical components including elastomers and in electrical equipment.

1.1 Degradation of components and structural materials

	Relevance 1 Minor 2 Some 3 Definite 4 High	**Priority** n/N: ranked n among N levels
Canada: The related management issues are the most important.	4	2/4
Czech Republic: No specific concerns indicated. - The regulatory body requires systematic follow-up of the residual life-time of main reactor components important to safety according to recently devised procedure. The procedure allows preparation of periodic safety reports to the regulatory body being used for input into the NPP Ageing Management Programme.	4	1/4
Finland: No specific concerns indicated.	4	1/9
Germany: There are no particularly notable concerns in regard of degradation of components and materials. Prevention and mitigation of ageing is dealt with in a systematic manner as part of comprehensive quality assurance, including periodic testing and preventive maintenance. In addition, operational experience assessment and assessment of licensee event reports from other plants serve to recognise ageing, to identify unforeseen effects and to define countermeasures preventing further degradation (cf. Section 5).		

Hungary: The leading concern among others, already subject to the so-called Safety Enhancing Measures undertaken in the ‘80s, has been embrittlement and fatigue of the pressure vessels. The others relate, e.g., to deterioration of cabling, remotely actuated valves and concrete structures.	3	1/3
Japan: No specific concerns indicated. - Long-term integrity evaluation, constituting the basis for measures required, extends to 60 years following start of operation of the plant. (Cf. 4, General notes.)	4	1/2
Mexico	3	1/4
Spain: No specific concerns indicated. -	4	1/2
Sweden: An improved understanding is needed in regard of degradation incubation periods, degradation rates, factors affecting initiation and propagation of degradations and the maximum allowable degradation considered acceptable.	3	1/3
The Netherlands	4	3/4
The UK: Safety highly dependent on intact reactor pressure boundary and stable reactor internals.	4	1/9
The USA: No specific concerns indicated. - USNRC has recently issued a license renewal rule, which addresses the ageing management of structures and components subject to age related degradation. USNRC has also been reviewing a wide range of reports on the subject.	3	1/3

1.2 Operation and maintenance rendered difficult by using obsolete technology *(e.g., due to consequent shortage of spare parts, incompatibility problems or unfamiliarity with the old technology among new generations of staff).*

	Relevance 1 Minor 2 Some 3 Definite 4 High	**Priority** n/N: ranked n among N levels
Canada: Obsolescence may cause concern in regard of ensuring adequate performance when introducing new technology (cf. 2.5).	3	3/5
Czech Republic: Generally not a problem at present, but some cases occur – e.g. in regard of I&C components (cf. 1.3.2)	2	3/4
Finland	1	8/9
Germany: As an important example, the introduction of digital I&C is mentioned. The hard-wired I&C is not seen as „obsolete“, but on the long term the availability of spare parts would constitute a problem.		
Hungary: Minor attention up to now. Aspects of ensuring adaptation of the staff to western standards and requirements are being recognised.	2	3/3
Japan: Following technical progress is part of the quality assurance activities of the utilities.	4	2/2
Mexico:	2	2/4
Spain: Possible problems are dealt with by means of quality assurance.	3	1/2

Sweden: Swedish nuclear power plants have a continuos process of replacement, back-fitting and modernisation in order to avoid the problems indicated in the question. As to the new generation of staff and their knowledge of old technology, there is a feeling that the technology grows old faster than the staff. However, there is an awareness of the potential problem, which could arise if adequate action is not taken.		
The Netherlands	2	3/5
The UK	2	4/9
The USA: Considered in general not to be a problem	1	3/3

1.3 The gap seen on viewing the current safety case and safety defence-in-depth system in the light of current state-of-the-art

Czech Republic: The IAEA initiated in 1990 programmes in order to identify major design and operational safety issues in WWER plants judged to be safety significant by their impact on plants' defence in depth. About one half of safety issues of WWER 440/213 plants (from 87 safety issues) and one third of WWER 1000/320 plants (from 84 safety issues) have been identified by operational experience. The remaining safety issues have been identified as deviations from current standards and practices, which have evolved since the WWER NPPs were designed. The reviews of the safety features of WWER plants showed the main safety concept of these reactors to be similar to PWR units designed at the same time in other countries. Therefore, the backfitting process is not much different from that which is/was going on in other plants built to earlier safety standards all over the world.

A significant number of safety improvements are being or have been incorporated into the NPPs' designs already.

Germany: Identified gaps or weaknesses are treated in the regulatory frame of supervision (or licensing if required) on a case-by-case basis. The answers to question 4 comprise a couple of representative examples. Therefore, no specific comments on the single issues 1.3.1 to 1.3.7 were given

Japan: Periodic safety reviews are made by the utilities at ca 10-year intervals and the results are evaluated by MITI.

Spain: The "Provisional Operation Permits" (PEP) require continuous analysis of new license requirements in Spain and in the countries origin of the technology (US, Germany). In case of offering significant potential for improvement of the safety, the new requirements have to be included in the licensing basis. Examples include control room design, human factors, remote shut-down panel, integrated PSA programmes for each plant, safety evaluation programmes for older plants.

Sweden: In 1993 the so called Barsebäck event revealed that the strainers for the emergency core cooling system and the containment spray system were inadequate, and would be clogged rapidly by pipe insulation material in case of a LOCA. Hence the LOCA mitigating systems would become inoperable in case of a LOCA.

The experience prompted a large effort in the Swedish nuclear community to review in depth the

Final Safety Analysis Reports in regard of similar shortcomings of the safety analyses, using modern knowledge and experience. This “special design basis review“ is about to be completed in 1998.

The UK: The evaluation of deficiencies is one of the key objectives of the PSRs, together with comparing the reactors against modern standards and implementing reasonably practicable improvements to safety. This has caused the high priority ratings to the issues 1.3.2 **with regard to process instrumentation and control**, Initiating events and internal hazards, dependencies, etc and 1.3.4 **with regard to external hazards, e.g. seismicity**.

The USA: The regulatory process believed to be sufficient to adjust any gaps or weaknesses that may exist. This process includes, among other things, a generic issues prioritisation program. However, issues of high gravity are considered disregarding from any previously assigned priorities according to urgency. Cf. 5.

1.3.1 with regard to human factors, management and organisation, and safety culture

	Relevance 1 Minor 2 Some 3 Definite 4 High	**Priority** n/N: ranked n among N levels
Canada: The issue is of highest importance and priority	4	1/4
Finland:	1	6/9
Czech Republic: Safety principles and good safety practises are addressed in numerous training courses for NPP personnel. Training of the NPPs management is held regularly several times a year, where the negative and positive indicators of safety culture are presented, analysed and discussed. Conclusions are presented to the top manager for consideration and decisions. Training courses concerned with human factors, management and safety culture were also organised for the personnel of the safety authority.	3	2/4
Germany: (cf. 1.3)		
Hungary: Human factors requirements, although covered in a separate chapter in currently effective PSR guide (cf. 5.2), is not yet systematically linked to ageing management in the full sense of the word. The matter is clearly recognised as requiring attention in planning for the future safety work.	3	2/3
Mexico	2	3/4
Sweden: There is experience to show that this area, related to safety culture, is indeed important in regard of learning efficiently from experience so as to be able to ensure proper control of operation. It is, for example, important to ensure that that all safety related equipment are operational before start-up and that proper attention is paid to the growing needs to modernise the plant.	3	1/3
The Netherlands	4	2/5
The UK	3	5/8

The USA: The USNRC has a Human Factors Assessment Branch, whose responsibility includes, among other things, the assessment of management effectiveness, procedures, training and staffing. It also reviews human factors engineering design of the control room as well as organisational issues and management concerns at operating reactors.	2	2/3

1.3.2 with regard to process instrumentation and control

	Relevance 1 Minor 2 Some 3 Definite 4 High	**Priority** n/N: ranked n among N levels
Canada: Not aware of ageing processes requiring attention	2	4/4
Czech Republic: The I&C equipment used in the WWER 440/213 units is obsolete. Safety analysis has been undertaken for investigation of the safety implications. From probabilistic analysis the over-all reliability of the I&C systems still turned out to be sufficient, however, due to extensive redundancy and frequent surveillance testing, compensating for the inferior reliability of the I&C components as compared to Western standards. Nevertheless, the analyses indicated needs for paying attention to some of the I&C algorithms, to protection of the I&C equipment against common cause failure due to floods or fires, and to environmental qualification of the I&C equipment. Measures for implementation of the conclusions arising from the reliability analyses are under way. They include certain replacement of obsolete I&C systems by modern technology. In the case of WWER 1000/320 units the original Russian I&C system was replaced by a new on from Westinghouse.	3	2/4
Finland:	2	4/9
Germany: (cf. 1.3)		
Hungary: As an example, thorough modernisation of I&C has been initiated (4.10 **Design modifications (except 4.11) for improved functional reliability of the safety systems**).	3	2/3
Mexico	2	2/4
Sweden: The rapidly developing technology in this area, enabling considerable advantages to be gained with noteworthy safety implications, as well as causing rapidly proceeding obsolescence, has been the reason for several projects for renewal of the I&C systems in the plants.	3	1/3
The Netherlands	4	3/5
The UK	4	3/8
The USA: A great majority of process instrumentation and control is within the scope of the maintenance rule (10 CFR 50.65 Requirements for monitoring the effectiveness of maintenance at nuclear power plants) issued by the USNRC. This rule requires monitoring of the performance or condition of structures, systems, or components (SSCs), against licensee-established goals, in a manner sufficient to provide reasonable assurance that such SSCs as defined in the rule, are capable of fulfilling their intended functions.	2	2/3

1.3.3 with regard to initiating events and internal hazards, dependencies, degradation of materials and components etc.

	Relevance 1 Minor 2 Some 3 Definite 4 High	**Priority** n/N: ranked n among N levels
Canada: The approach used for identifying initiating events may need further consideration	3	3/4
Czech Republic: Insufficient protection of safety related equipment, e.g., from the consequences of high energy pipe breaks, is one of the major safety issues in WWER NPPs. Leak Before Break technology for all high energy piping in the reactor buildings has been applied or considered. A systematic hazard analysis to identify weak points is planned. Supplementary RPV surveillance programmes are under way as the RPV status monitoring used for the WWER 440/213 does not provide the currently required accuracy.	4	1/4
Finland: Concerns largely associated with poor original lay-out of the Loviisa VVER-440 plants with lacking separation of important safety systems and redundancies causing problems with internal hazards and dependencies.	3	2/9
Germany: (cf. 1.3)		
Hungary: Covered in the PSR Guide (5.2).	3	2/3
Mexico	2	2/4
Sweden: Unknown dependencies have been found during the systematic work associated with detailed PSA analyses. Such detailed analyses were carried out for parts of Oskarshamn 1 plant, a BWR taken into operation in 1973. As an example a study of the inside containment portion revealed possibilities that failure of a feed water pipe could destroy one of the two redundant emergency core-cooling sections.	3	1/3
The Netherlands	4	4/5
The UK	4	2/8
The USA: The USNRC issued final rules on fire protection (10CFR50.48), station blackout (10 CFR50.63) and other rules and regulations when needs became evident.	2	2/3

1.3.4 with regard to external hazards, e.g. seismicity

	Relevance 1 Minor 2 Some 3 Definite 4 High	**Priority** n/N: ranked n among N levels
Canada: (cf. 1.3.3)	3	3/4
Czech Republic: In order to follow new IAEA Safety guides 50-SG-01 and 50-SG-D15 the safe shutdown earthquake (SSE) and operational basis earthquake (OBE) values have been re-evaluated. Both western and Russian standards and codes have been used for these evaluations.	1	4/4
Finland:	1	7/9
Germany: (cf. 1.3)		
Hungary: The seismic risks have been considered during a long time and measures have been partly completed.	3	2/3
Mexico	2	3/4
Sweden: Sweden is a low seismic activity region, and seismic events of great importance are rare. Nevertheless, the seismic risks are not negligible in regard of the over-all, improving safety standards of the plants and have to be accounted for properly.	3	2/3
The Netherlands	4	4/5
The UK	4	4/8
The USA: In the seismic engineering area, the USNRC issued the Generic Letter 87-02 which resulted in the establishment of an unresolved safety issue, entitled “Verification of Seismic Adequacy of Mechanical and Electrical Equipment in Operating Reactors, Unresolved Safety Issue (USI) A-46”. The resolution of this issue required re-verification of the seismic adequacy of 61 early vintage operating units.	2	2/3

1.3.5 with regard to plant behaviour under accident conditions

	Relevance 1 Minor 2 Some 3 Definite 4 High	**Priority** n/N: ranked n among N levels
Canada: The importance of the qualification process to ensure required qualification of the components until their end of life is pointed out.		3/4
Czech Republic: Tools for accident monitoring need some improving. Both types of NPPs are going to implement post-accident monitoring systems according to IAEA recommendations and NUREG 0737, RG. 1.97 Rev.3.	2	3/4
Finland	2	5/9
Germany: (cf. 1.3)		
Hungary: Measures already taken are considered sufficient for the time being.	2	3/3
Mexico	2	1/4

Sweden: Currently activities are directed to methods to verify that the dynamic and transient effects of a LOCA transmitted through the building structure will not jeopardise other safety relevant components and equipment needed to mitigate the consequences of the LOCA	3	2/3
The Netherlands	4	4/5
The UK	3	7/8
The USA: After the TMI accident, USNRC established the TMI Action Plan and published NUREG 0737 describing additional safety measures.	2	2/3

1.3.6 with regard to severe accident phenomena and consequences

	Relevance 1 Minor 2 Some 3 Definite 4 High	**Priority** n/N: ranked n among N levels
Canada: Beyond design basis accidents are not systematically assessed in Canada. However, the design basis includes low probability accidents (dual failure events). (cf. 1.3.3)	3	4/4
Czech Republic:	2	3/4
Finland	2	3/9
Germany: (cf. 1.3)		
Hungary: A new organisation, CERTA (Centre for Emergency Response, Training and Analysis), is concerned with pursuing these matters	4	2/3
Mexico	2	3/4
Sweden: Although large research efforts have been devoted to understand and predict the behaviour of nuclear power plants under accident conditions, there are still unresolved issues requiring further investigations. Currently the interest is not focused on weaknesses, but on strategies in coping with a severe accident, for instance for keeping the corium inside the reactor pressure vessel.	3	2/3
The Netherlands	3	1/5
The UK: Most management efforts are put into ensuring that accidents are avoided and less to how accidents would progress.	2	8/8
The USA: The USNRC issued Generic Letter (GL) 88-20, Supplements 1-4, Which requested all licensees to perform an Individual Plant Examination (IPE) and an Individual Plant Examination of External Event (IPEEE).	2	2/3

1.4 Declining confidence in the safety of the ageing plants on part of the public

	Relevance 1 Minor 2 Some 3 Definite 4 High	**Priority** n/N: ranked n among N levels
Canada	-	-
Czech Republic:	4	1/4
Finland: The safety of the Finnish plants are generally considered good, especially compared with some foreign nearby plants	1	9/9
Germany		
Hungary	1	3/3
Japan: There are indications of belief among the public that the safety of the aged nuclear plants is degraded, and that remedial measures, like core shroud replacement in some BWR plants, are associated with significant radiation dose inflicted on the workers. There is therefore a strive, on part of MITI and the utilities, to enhance the public's trust in the aged plants by referring to intensified inspection programmes and improved long term maintenance plans.	4	1/2
Mexico	1	4/4
Spain: The Spanish public perceives the older plants as "less safe" and the maintenance as "provisional activities to keep the plants in operation". The CSN policy is to inform about the true scope of the maintenance and plant modifications made.	1	2/2
Sweden: The information that the public gets from the regulatory body does not specifically address ageing effects. In the yearly report to the government on the safety of the nuclear power plants ageing is one of the aspects, but the conclusions are on total level of safety rather than on separate factors.	2	3/3
The Netherlands	1	5/5
The UK: cf. 7.1	3	6/8
The USA:	3	1/3

2. Plant ageing issues primarily in need of additional research and development

General

Spain: The Safety authority, CSN, has developed a "Five years plan on research and development (1.997-2001)", identifying the different research areas of interest

The UK: Ageing management includes bringing up plant to modern standards. This can include research to improve plant reliability or capability against hazards such as seismicity or high temperatures. This may concern hardware changes, alternative methods of working or analytical and predictive techniques

2.1 Degradation phenomena affecting the pressure boundary of the primary system with regard to being prevented or controlled.

	Relevance 1 Minor 2 Some 3 Definite 4 High	**Priority** n/N: ranked n among N levels
Canada: Examples: Chemistry control in regard of erosion and corrosion. – Management of degradation.	3	2/3
Czech Republic: Many research projects related to degradation mechanisms and their influence on WWER structural materials have been conducted to address specifically Czech manufacturers products behaviour (reactor pressure vessels, steam generators, piping etc.). Current research and development with regard to key ageing degradation mechanisms include ”An assessment of RPV lifetime – Pilot study for RPV ageing management”, LBB, integrity assessment of piping, repair techniques for RPVs etc. By comparing Western and Eastern approaches for fracture mechanics assessment of components parts dynamic behaviour of cracks are not considered at all in the fracture mechanics criteria. Needs have been identified to consider dynamic initiation of cracks due to rapid loading rates as well as crack arrest in order to homogenise the various assessment practises while taking into account particular material behaviour. Two research projects are under way in this regard, one supported by the safety authority and one by the European Union. The objective is to evaluate and validate the applicability of dynamic fracture properties and criteria, generally used in Western codes for fracture assessment of WWER reactor pressure vessels.	3	1/3
Finland: The critical weld of Loviisa 1 reactor pressure vessel has been annealed in 1996. Additional research is going on to determine the re-embrittlement rate of the weld after annealing.	4	1/7
Germany: Research currently under way: Analysis of warm pre-stress effects with probes; Structural material fatigue tests; Influence of thermal stratification on piping; Long-term thermal ageing of martensitic Cr-steel (approx. 350 °C); Austenitic steels (remaining life aspects, welds, low temperature sensitisation); Radiation induced material changes; Corrosion, crack initiation and growth and material integrity aspects in general.		

Hungary: Although much research has already been devoted to this area and the various problems related to the WWER design has been largely resolved, continuing research is still needed. Examples include pre-warming of ECCS fluid, modified procedures to reduce thermal shock, and simpler means than annealing for controlling the ageing of the reactor vessel.	3	1/2
Japan: MITI research underlying the basic concept for the measures for aged nuclear power plants (4, General notes): Reactor pressure vessel: Fatigue, neutron irradiation embrittlement, corrosion, stress corrosion cracking (PWR: Inconel 600); Main coolant piping: Fatigue, corrosion, stress corrosion cracking; Primary loop recirculation pumps: Fatigue, thermal ageing. – PWR: Fatigue of pressuriser, fatigue and corrosion of steam generator, degradation of steam generator tubing. In addition research has been or is presently conducted on a number of relevant themes.	4	1/6
Mexico: Radiation embrittlement of RPV materials.	3	1/3
Spain: Examples: PWR vessel head penetrations and core barrels; risk based inspection techniques.	4	1/2
Sweden: The extensive information obtained through operating experience and research world-wide should be phrased in terms usable for the utilities in their maintenance and ISI/IST work. The purpose is to have adaptive systems focusing on what is needed from a safety point of view, and allowing critical questioning of historical and current practices. The formation of a national database for degradation of piping components is under way. The efforts to establish a world-wide database have so far been less successful, mainly due to confidentiality concerns.	3	1/2
The Netherlands	1	3/3
The UK: Key importance, particularly for the Magnox reactors where the opportunity for in-service inspection is limited. Much has been done but studies continue as degradation increases.	4	1/7
The USA: USNRC has on-going research programmes on reactor vessel, steam generator and piping	3	1/2

2.1 Degradation phenomena affecting building structures and the reactor containment with regard to being prevented or controlled.

	Relevance 1 Minor 2 Some 3 Definite 4 High	**Priority** n/N: ranked n among N levels
Canada	3	2/3
Czech Republic: The effectiveness of WWER 440/213 containment depends on the performance of bubble condenser. The mechanical design of bubble condenser is unsatisfactory and its strength behaviour and actual structure must be verified and fluid-metallic structure interactions validated (weaknesses identified in design basis). The problem is solved mainly in the frame of the international project, which is based on large-scale experiments. The safety authority sponsors a research programme on ageing of concrete structures of WWER 1000/320.	3	3/3
Finland	2	7/7
Germany: cf. 1.1		
Hungary: The research efforts in this area need to be considerably increased	4	1/2
Japan: The basic concept of measures against ageing (4, General notes) requires attention to and evaluation of the performance aspects of concrete structures and the reactor containment structures, like deterioration of structural strength and leak tightness.	4	4/6
Mexico	2	3/3
Spain: Examples: corrosion of grouted tendons; cracking of building structures.		
Sweden: Three main areas are to be considered: concrete, tendons and leak tightness including liner. A review of the Swedish containments is currently under way, and based on the findings research activities may be initiated. The activities in the CSNI/PWG3 subgroup on concrete is followed closely, so international activities are considered. Tendon degradation and pre-stress loss may be a problem in plants where tendons are not accessible for inspection and tightening. In some Swedish plants, after pre-stressing of the tendons, the tubes containing the tendons are filled with expanding concrete in order to establish a favourable environment. If water is trapped in pockets during this process, the environment may locally be very unfavourable, and local corrosion may occur. Methods to inspect tendons in concrete-filled tubes are currently not developed. In Swedish containments the liner is located inside the concrete wall, approximately 200 mm from the inside surface. Experience shows that degradation phenomena caused by even slight deviations from prescribed procedures during manufacture may cause corrosion penetration of the containment liner. If trapped water has contact with the atmosphere, the corrosion may be rapid. The difficulty encountered is to find out all possible deviations that could have occurred, and to judge their consequences. Remedies would be to keep track of degradation by monitoring and/or inspection. Methods for local inspection and leak tightness measurements can be considered in this context.	3	2/2

The Netherlands	1	3/3
The UK: Ageing of building structures and concrete is becoming more important for the older Magnox reactors and for the concrete pressure vessels on AGRs.	4	3/7
The USA: USNRC has recently amended its regulation, 10 CFR 50.55a to promulgate requirements for in-service inspections of containment structures. The Commission also has an on-going research program for structural ageing and an international co-operative program for seismic resistance of structures under degraded conditions.	3	1/2

2.3 Degradation phenomena affecting safety system components with regard to being prevented or controlled, including environmental qualification12

	Relevance 1 Minor 2 Some 3 Definite 4 High	**Priority** n/N: ranked n among N levels
Canada:	3	2/3
Czech Republic: The safety authority requires environmental (re)qualification of selected electrical, electromechanical and I&C equipment for both types of WWER NPPs to be consistent with IAEA recommendations and applicable IEC and IEEE standards. Some problems of equipment (re)qualification in operating units are solved in projects supported by European Union.	2	3/3
Finland: Mention about need to complete the qualification of I&C equipment outside the containment. Will be done in 1998.	2	5/7
Germany: Research under way: Radiation induced material changes; Ageing of electric components;		
Hungary: The research efforts in this area need to be considerably increased.	4	1/2
Japan: The basic concept of measures against ageing (4, General notes) requires attention and evaluations for qualification of cabling in the reactor containment. Evaluations are made by the utilities for formulating long-term maintenance programs, including easily repairable and replaceable components, after more than 30 years after commissioning of the plant. Further studies of the relevant deterioration phenomena will possibly be needed for long-term integrity evaluations.	4	3/6
Mexico	3	1/3
Spain: It is considered to use component data bases and compilations of information on detected problems and remedial measures, as regularly reported to the safety authority, in the research of degradation phenomena. (Cf. section 2.4)	4	2/2
Sweden: Considerable attention is paid to environmental qualification of the safety related components, particularly I&C components.	3	2/2
The Netherlands	2	2/3

12. Environmental qualification: ensuring that a component will resist environmental working conditions according to design basis.

The UK : In addition to other types of degradation, ageing of the graphite moderator is specifically mentioned as a key area in view of a number of graphite moderated gas cooled reactors being operated. Particular issues are irradiation effects on graphite distortion and strength.	4	4/7
The USA: USNRC has two ageing-related generic issues in the process of being resolved: one on environmental qualification of electrical equipment and one on fatigue of metal components for 60 year plant life.	3	1/2

2.4 Monitoring degradation as above (including development and qualification of NDT techniques and systems)

	Relevance 1 Minor 2 Some 3 Definite 4 High	**Priority** n/N: ranked n among N levels
Canada: An important aspect is to understand the mechanisms involved. Concerns, i.a., pressure tubes, steam generators, PHT piping, cables, containment structures etc.	3	1/3
Czech Republic: The main emphasis is on understanding the degradation processes and developing tools for condition monitoring and failure trending for components which are very difficult or practically impossible to exchange. Most related R&D projects are sponsored by the NPPs. Programmes are under way concerning development and qualification of NDT systems for RPV and piping and for WWER materials.	3	2/3
Finland: Development and qualification of NDT techniques and systems pointed out as essential to enable reliable in-service inspections. (Note: the priority rating refers to Monitoring degradation in other ways than by NDT, given own rating of Relevance 4 and Priority 2/7)	2	6/7
Germany: Research under way: Further methods on non-destructive testing		
Hungary: Enhanced condition monitoring and a data recording system to serve as a basis for life management are on the agenda.	3	2/2
Japan: Research and development issues: MITI: Detection of thermal embrittlement of duplex stainless steel and neutron irradiation embrittlement by NDT; Technology for reconstituting reactor vessel surveillance test pieces. Utilities: High accuracy neutron flux calculation; Non-destructive monitoring of cable degradation; Establishing toughness degradation on micro samples of primary coolant piping, core internals etc.	4	2/6
Mexico: Wall thinning of piping caused by corrosion-erosion.	3	2/3

Spain: Monitoring of radiation embrittlement of the reactor pressure vessel (RPV) (estimation of neutron dose, metallurgical interactions, methods for mechanical testing, interpretation of test results. Degradation of RPV internals (irradiation assisted stress corrosion). Development and qualification of non-destructive testing (wrought austenitic piping welds, ferritic piping welds, clad/base metal interface of RPV, nozzle inside radius section of RPV, reactor pressure vessel welds, nozzle to vessel weld of RPV, bolts and studs, cast austenitic piping welds, dissimilar metal piping welds and full structural overlaid wrought austenitic piping welds. The degradation mechanism considered are: thermal fatigue, stress corrosion cracking, localised corrosion and corrosion due to flow.	4	1/2
Sweden: In general the monitoring of degradation phenomena should attempt to capture the degradation as early as possible, and long before the degradation becomes a safety issue. This is because if the degradation is found early, relevant mitigating, repair or replacement programmes may be planned and the action required is carried out in an orderly manner. This will reduce both cost and dose to the personnel. Due to resource restrictions the inspection and monitoring has to be done selectively. In the selection process the risk studies may be useful, provided they have a quality relevant for the intended purpose	4	1/2
The Netherlands	2	2/3
The UK: cf. 2.8	3	5/7
The USA: The USNRC has an ongoing research program on NDT techniques for concrete structures.	2	2/2

2.5 Safety and reliability aspects of introducing new technology with regard to process control and monitoring, e.g. new operator aids in the control rooms, programmable electronics in safety systems and safety related process control etc.

	Relevance 1 Minor 2 Some 3 Definite 4 High	**Priority** n/N: ranked n among N levels
Canada: Pointed out that new technology can introduce unforeseen failures. Extensive work, recognising the absence of operating experience and the need for experiments, validation and qualification, is required to ensure necessary reliability. This applies to new reactor designs as well as existing plants in need of modernisation.		2/3
Czech Republic:	3	2/3
Finland: Mention about urgent need for generally accepted guides and standards for qualification of programmable automation	4	3/7
Germany: Research currently under way: Evaluation of strategies for changing of electronic and computer systems; Qualification of digital I&C systems for safety grade requirements.		
Hungary: There are on-going evaluations on the safety impact of new technology, such as in I&C, seismic monitoring etc., and related needs for research.	3	2/2

Japan: In the first place, managing technological change in regard of safety is seen as a matter of quality assurance. There is no particular research planned in this regard. The Japan Electric Association is now working on revision of the related private sector standards, "Guidelines for the Application of Digital Computers to Safety Protection Systems" in order to update this standard. This Guideline summarises the requirements to assure that the functions necessary to secure safety protection are correctly realised in the processes of software design, fabrication and operation.	4	5/6
Mexico	3	2/3
Spain: The merits of introducing digital techniques have been evaluated.	3	2/2
Sweden: Here the verification and validation processes of the new technology are of interest. This is an area where co-operation between regulators to define common requirements could lead to substantial cost reduction for utilities and save work for regulators.		
The Netherlands	2	2/3
The UK: Perhaps less important area for ageing management because high standards can also be applied to new equipment for old reactors. Also, such equipment can often be fitted in a back-up, diverse, or supporting role and hence the existing proven hard-wire equipment will often remain in place (cf. 2.7).	3	6/7
The USA: In principle, the USNRC does not require the application of new technology for management of ageing. However, should a new technology be proposed by a licensee, it would be subject to verification and validation as established by the regulatory process.	2	2/2

2.6 Severe accident mitigation systems and severe accident management

	Relevance 1 Minor 2 Some 3 Definite 4 High	**Priority** n/N: ranked n among N levels
Canada: Severe accidents are not explicitly addressed in Canada, but some design basis events (dual failure analysis) are equivalent to other countries severe accidents (cf. 1.3.3).	2	3/3
Czech Republic: The study of the problems and phenomena of severe accidents was initiated in 1989. Methodology for severe accident studies for 440/213 NPPs was developed and implemented in the framework of the IAEA regional projects. The Nuclear Research Institute Rez participates in several international research programmes on severe accidents (CSARP, MCAP, ACE/MACE, etc.). Severe accident codes have been made available on the basis of co-operation and agreements with US NRC, IAEA and CEA/IPSN. Completed, current and planned projects cover detailed analysis of beyond DBA severe accidents, potential mitigatory measures for limiting radioactive releases in WWER 440/213 reactor severe accidents, severe accident management, PSA Level 2, and simulation of severe accident progression and consequences.	2	3/3
Finland:	3	4/7

Germany: A considerable number of severe accident mitigation and management systems have been implemented in German NPPs during the last decade and no major research issues remain unexplored for the time being.		
Hungary: There is a current strive to catch up on the severe accident issues, e.g. in terms of adopting state-of-the art analysis codes for source term calculations (InterRAS code) and for predicting severe accident progression (by obtaining the French SESAME code from ISPN). In addition there are efforts under way in order to enhance the monitoring and prediction capabilities of the systems used by the CERTA Centre for Emergency Response, including simulators for training and emergency exercises.	4	1/2
Japan: Example: MITI project “Reactor containment reliability demonstration test” for demonstration of integrity and reliability of the reactor containment under severe accidents.	4	6/6
Mexico	3	3/3
Spain: Spain takes part in the research projects PHEBUS FP, RASPLAV, MCAP, R5SCAP, OMEGA and STORM. The Spanish Authority will define a general policy on severe accidents depending mainly on results from PSA studies.	3	2/2
Sweden: New aspects of severe accident mitigation and management are being investigated. The experiences from TMI have indicated that there may be a possibility to keep the corium inside the reactor pressure vessel, at least under certain severe accident scenarios. Research in this area will be continued.	3	2/2
The Netherlands	3	1/3
The UK		7/7
The USA: All US utilities performed Individual Plant Examination (IPE) and Individual Plant External Event Examination (IPEEE) for internal and external severe accident scenarios.	2	2/2

2.7 Other

	Relevance 1 Minor 2 Some 3 Definite 4 High	**Priority** n/N: ranked n among N levels
Germany: Human factors (control room information system, hybrid control room, maintenance, competence conservation for decommissioning)		
The UK: Graphite moderator ageing	4	2/7

3. Driving forces in plant ageing management

Comments on the importance of various factors (13) with regard to effecting promotion of initiatives towards improved safety of the ageing reactors.

3.1 Regulatory initiatives (e.g. on the basis of research conducted on part of the safety authorities, regular inspections and safety reviews of, i.a., applications for re-licensing or plant modifications)

	Order of Importance n/N: ranked n among N levels
Canada: Reference made to generic action from 1990 entitled "Assurance of Continuing Nuclear Station Safety", requiring licensee assurance that safety performance will be maintained, through proper management practices and processes, throughout the life of their plants. A persisting regulatory pressure has evolved the position of the licensees.	2/3
Czech Republic: Regulatory initiatives are usually based on results of inspections, safety reviews, IAEA recommendations and on results of projects financed by the safety authority (the Government). Safety relevance and prioritisation of actions are usually discussed between the safety authority and the utility.	2/4
Finland	2/9
Germany: Play an important role, especially concerning the control that the licensing conditions are fully maintained, exchange and consideration of operating experience, and that appropriate measures are taken as required. In this regard the Reactor Safety Commission (RSK) recommendations are of high significance. Many incentives are derived from research financed by the Federal Government.	
Hungary: The PSR Guide of the HAEA (5.2 **Regulatory approaches to assessing ageing management**) was the first step in imposing regulatory requirements in regard of ageing management. The evaluation of the utility report initiated a series of additional requirements (Corrective Measures) to apply for the remaining nuclear plant units. In 1996 a new "Atom Act" has lead to issuing a new set of Nuclear Safety Regulations establishing the legal base for enforcement.	1/4
Japan: Reference made to the long-term maintenance plan according to the basic concept concerning ageing which was introduced by MITI in 1996 (cf. 4, General notes).	1/8
Mexico	1/3
Spain:	2/8
Sweden: The dialogue between the regulators and the utilities is probably the most important factor.	2/5
The Netherlands	1/4

[13]. "Factors" to be understood here as existing provisions or arrangements for promoting nuclear safety. The fact that certain ageing management *activity* is in place is not meant to constitute a "factor".

The UK: Regulatory initiatives are important and, in the UK, seen as complementary to the licensee's self assessment. Example: the nuclear licensing conditions requiring shutdown of reactors for maintenance and inspection etc. The regulator also takes initiative in co-ordinating some areas of research.	2/8
The USA: Recent regulatory initiatives included the issuance of the final rules on maintenance, license renewal, and containment surveillance as well as the establishment of the generic safety issues on metal fatigue and environmental qualification.	1/3

3.2 Utility initiatives on the basis of clear assignment of the ultimate responsibility for the safety to the utilities.

	Order of Importance n/N: ranked n among N levels
Canada: With persisting regulatory pressure, and increasing failures due to ageing, the position of the licensees evolved in regard of the corporate commitment to maintain plant safety performance, cf. 3.1.	1/3
Czech Republic: The fact that the utility, the Czech Electric Company (CEZ a.s.), has ultimate responsibility for safety of its NPPs constitutes the major driving force. The utilities perform self-assessment through internal audits, carried out by members of the utility staff supported by experts from research institutes, and external audits carried out by experts from US and West-European firms.	1/4
Finland: It is pointed out as important that the self-assessment are mad in a responsible way	1/9
Germany: The prime driving force is certainly the licensee's responsibility for the safety of the plant (together with the interest in maintaining plant availability). As the operating licences are not limited in time, many upgrading measures cannot be demanded obligatorily by the regulatory body, but are performed by the licensee in account of its responsibility for plant safety.	(prime)
Hungary: Up to the early '90s, there was not yet a legal basis established for specific requirements with regard to the control of ageing. Significant initiatives in this regard were then nevertheless taken on part of the utilities, mainly on account of their responsibility for the safety and their obvious interest in preserving the investments in the plant and lengthening the service life.	2/4
Japan: The implementation of the long term maintenance plan (cf. 4, General notes) by the utilities is not obliged by law but rather founded on the plan being respected by the utilities, feeling their responsibility.	3/8
Mexico	3/3
Spain: The Spanish safety system is based mainly on the responsibility of the licensees. CSN inspect and evaluates the licensee activities.	1/8
Sweden: The dialogue between the regulators and the utilities is probably the most important factor.	1/5
The Netherlands	2/4

The UK: "Self assessment" regarded as the most important factor listed as UK reactors are operated under a nuclear licensing regime which assigns ultimate responsibility for safety on the licensees who operate the reactors. The formal License Conditions require them to have adequate arrangements accordingly, including arrangements for production and self-assessment of safety cases and arrangements for their periodic review and reassessment.	1/8
The USA: US Utilities continue "self assessment" through industry organisations such as INPO, EPRI and NEI.	2/3

3.3 Common utility requirement standards as the EUR (in Europe) and the URD (in The USA).

	Order of Importance n/N: ranked n among N levels
Canada: Common utility requirement standards are presently not observed but are likely to become important in the future.	N/A
Czech Republic:	
Finland	9/9
Germany: International co-operation is generally considered to be an important factor in effecting development of plant ageing management.	
Hungary: Impact believed to be minor because of different technical background.	2/4
Japan: The Japan Electric Association Codes (JEAC) and the Japan Electric Association Guideline (JEAG) are the relevant national standards to be followed by all plants, also the aged ones. However, these standards do not specify details pertaining to ageing management, which are, therefore, specified by each utility. Work is underway to revise the JEAC Standard, "In-Service Inspection of Light Water Reactor Plant Components" towards shortening the inspection intervals for reactor coolant pressure boundary components that have served for 30 years or more.	5/8
Mexico	1/3
Spain: The EPRI methodology has been mainly used by the utilities in developing ageing management schemes. Other rules and standards, such IAEA and NEI 95-10 have been taken into account. These schemes are being subject to evaluation by the safety authority, CSN. Specific evaluations will be made at Garoña and Zorita in 1998-99	7/8
Sweden:	5/5
The Netherlands	-
The UK	7/8
The USA: NEI published the following ageing management guidelines: NEI Guideline 95-10 for license renewal, NEI Guideline 93-01 for maintenance and NEI Guideline 96-03 for monitoring the condition of structures.	2/3

3.4 International or internationally recognised national nuclear and conventional standards (e.g. the Nuclear Safety Convention, the IAEA Safety Standards etc.).

	Order of Importance n/N: ranked n among N levels
Canada: The IAEA safety standards are used for guidance in the current efforts aimed at managing ageing at the utilities and in establishing regulatory requirements	2/3
Czech Republic: The Safety Authority and the utilities use the IAEA Safety Standards and similar documents as a base for determination of basic requirements that must be satisfied to ensure adequate safety for particular activities or applications.	1/4
Finland	7/9
Germany: International co-operation in general is considered to be an important factor in effecting development of plant ageing management.	
Hungary: A main source of information and guidance.	1/4
Japan: Japan's national and civil technical standards are based on the Code & Standard of the ASME. The civil standards for quality assurance are based on the safety standard by IAEA.	2/8
Mexico	2/3
Spain:	4/8
Sweden: Traditionally the US standards and regulations have had a large influence on safety considerations, because they were available when the plants were designed and built. During the current work with requirements for plants in operation on the 21st century, more use is made of the internationally recognised standards such as the IAEA documents.	5/5
The Netherlands	2/4
The UK: A key aim is the comparison against modern standards. Both the licensees and NII set their own standards but against a background of best international. International initiatives are therefore viewed as important.	4/8
The USA: The USNRC continues to support the participation of its staff experts in developing IAEA standards and /or other international co-operation in the field of nuclear safety.	3/3

3.5 International co-operation in the field of nuclear safety (except 3.6) as organised by EU, IAEA, NEA etc. in reviewing feed-back of operating experience and the general state-of-the-art of current safety practices, and working out recommendations

	Order of Importance n/N: ranked n among N levels
Canada: There is certain co-operation with the IAEA on ageing and Canada participates in a NEA group for management of ageing.	3/3
Czech Republic: International co-operation organised by IAEA is referred to as having contributed extensively to the development of current safety practices in the Czech Republic, e.g., in regard of criteria for the reporting of safety significant events to the safety authority, root cause analysis of occurrences, quality assurance etc. The value of the IAEA services in performing various types of missions, e.g. ASSET missions, is emphasised.	1/4
Finland	5/9
Germany: International co-operation on feedback of information is emphasised as particularly important.	
Hungary: Even more important than international standards because it could be applied to identified needs.	1/4
Japan	6/8
Mexico	2/3
Spain:	6/8
Sweden	3/5
The Netherlands	3/4
The UK	5/8
The USA: Experts made available to participate in international working groups.	2/3

3.6 International research co-operation in the field of nuclear safety

	Order of Importance n/N: ranked n among N levels
Canada: Not aware of any international research co-operation on ageing. Co-operation at the level of component experts is highly desirable.	2/3
Czech Republic: Czech experts participated and participate mainly on activities organised by IAEA (e.g. ”Pilot studies on management of ageing” and ”Assuring of structure integrity of reactor pressure vessels”).	4/4
Finland: Very important especially for small countries	6/9
Germany: International co-operation in general is considered to be an important factor in effecting development of plant ageing management.	
Hungary: Participation limited for economic reasons. Maintaining presence on the international research scene important for the future.	2/4
Japan: Not engaged in international R&D relating to plant ageing management	8/8
Mexico	2/3
Spain:	5/8

Sweden: On the regulatory side the international co-operation provides information and serves as a benchmarking activity. Both affect the regulatory requirements and hence indirectly the level of safety.	3/5
The Netherlands	4/4
The UK	5/8
The USA: Experts made available to participate in international working groups	2/3

3.7 Utility co-operation (e.g. owner's working groups, user consortia for research and development, feed back of experience etc.).

	Order of Importance n/N: ranked n among N levels
Canada: The CANDU Owners Group (COG) have several R&D issues in the area of ageing.	2/3
Czech Republic: Utilities are members of WANO and have an access to International Nuclear Network. There are meetings organised by the "Club of WWER users" where direct information exchange is taking place.	3/4
Finland: Very important especially for small countries	3/9
Germany: The German utilities co-operate on the national and international level. On the international level, exchange of operational experiences via INPO/WANO is important. On the national level, VGB (Technische Vereinigung der Großkraftwerk-betreiber E.V.) has prepared a document describing the status of the plants and the measures planned that are specifically related to ageing.	
Hungary: Paks NPP stands alone in Hungary. Present contacts in the WWER club, PLEX conferences, WANO, and bilateral contacts, are valuable but contribute little to the forces driving the development of ageing management.	3/4
Japan: Research is in partly carried out jointly by utilities.	4/8
Mexico	1/3
Spain:	3/8
Sweden: The Owners Groups are important sources of operating experience for the utilities. In particular the PWR plants of Westinghouse type, where a large number exists world-wide. However, possibly due to increased competition between utilities on the open national electricity market, the co-operation seems to become less intensive nationally.	4/5
The Netherlands	3/4
The UK: Operator co-operation is important, e.g. in the area of feed-back of operating experience providing essential learning opportunity. Industry working groups also aid the management of research and development programmes.	3/8
The USA: US utilities have many owners groups in an effort to collectively consider safety issues generic to the industry, such as the BWR and Westinghouse Owners Group (WOG) on reactor internals.	3/3

3.8 Proclaimed advanced safety concepts for new reactors - suggesting possible applications in the operating reactors as well as suggesting to the public the idea that the operating reactors may not be safe enough (e.g. various APWR's and ABWR's with "passive" features etc.)

	Order of Importance n/N: ranked n among N levels
Canada: Cost aspects in many cases prevents gaining benefits from adopting advanced safety concepts.	3/3
Czech Republic:	**-**
Finland	8/8
Germany: In Periodic Safety Review, the safety of all operating plants is assessed in the light of modern requirements.	
Hungary: Likely to be minor.	4/4
Japan: Although Japan has two ABWR plants there is no movement for reflecting the ABWR design into an aged plant. The advancing technology is, however, receiving attention in the periodic safety reviews.	7/8
Mexico	3/3
Spain:	8/8
Sweden: The current tendency can be described as evolutionary rather than revolutionary. Hence the fact that advanced concepts with for instance passive safety features have been proposed, does not seem to have influenced the thinking, neither at regulators nor at utilities.	5/5
The Netherlands	4/4
The UK	8/8
The USA: The regulatory process aims at providing all required assurance that the licensing bases of all currently operating plants provides and maintains an acceptable level of safety.	3/3

4. Current agenda in plant ageing management

General

Germany: The utilities have prepared a document describing the status of their plants and measures planned related to ageing. Following topics are covered: conceptual and technological ageing, ageing of materials, mechanical structures and components (wear), building structures, lubricants, diesel engine fuel, staff, documentation and software.

Japan: A long-term plan for integrity evaluation of structures and components, which are safety significant and not easily reparable or replaceable, was established by MITI in April 1996 together with a summary of basic concepts for measures accordingly seen to be required. Applying to the oldest LWRs, the plan extends to 60 years following start of operation of the plant and is to be completed within 30 years from start of operation of a plant. The plan will be gradually expanded to other plants. – The plan is based on enhancing the periodic inspections performed by MITI on shutting down the plants once every 13 months as well as the regular inspections conducted by the utilities.

The UK: Ranking is difficult because many aspects are covered. However the basis of ageing management is one of continuous review of the plant and its safety case. The emphasis is on maintaining the original design intent and then comparing it against modern standards and introducing improvements where appropriate. The objective is to maintain defence-in-depth an avoid accidents. – The issues in the bottom part of the priority ranking list are continuously being developed and are not regarded as low priority.

4.1 Enhanced feed-back of experience

	Order of Priority n/N: ranked n among N levels
Canada: Emphasis has thus far been placed on general management approaches to plant ageing. It remains to address some important components like the feed-back of experience.	2/3
Czech Republic: The feedback of experience with regard to ageing from similar foreign plants is low and is planned to be improved. The utility has started rewriting the original operational procedures supplied by the vendor. New symptom-oriented Emergency Operating Procedures are being developed according to Westinghouse methodology and solution strategy.	1/4
Finland: Note that it is important to enhance the feedback of experience from other similar plants, particularly related to ageing mechanisms.	1/12
Germany: No need for enhancing the feedback of experience in regard of the event reporting systems already in place. Ageing effects are covered by the reporting system but there is no enhanced reporting in this respect.	
Hungary: Enhanced condition monitoring and a data recording system to serve as a basis for life management are on the agenda	1/4
Japan: Important to accumulate ageing data for structures and components acquired during periodic inspections	2/6

Mexico: The applicability of reported international events is being investigated in the programme “Implementation of external and internal operating experience”.	1/4
Spain: The Provisional Operation Permit (PEP) requires yearly reporting of analysis of operating experience, both domestic and foreign.	1/12
Sweden: Experience feedback together with careful analysis is probably one of the most valuable sources of information for consideration of safety and degradation due to ageing. The experience gained over many years of operation can provide insight in how good the assumptions made in the design phase were.	1/3
The Netherlands	1/5
The UK	9/12
The USA: The US NRCs regulation and regulatory guidance documents are continuously being enhanced by the feedback of operating experience. Examples are Standard Review Plan revisions, the amended license renewal rule, issuance of the maintenance rule and establishment and resolution of generic safety issues.	2/3

4.2 General or partial update of the safety studies of the plants (e.g. transient analyses, severe accident analyses, PSA etc. in regard of recent developments).

	Order of Priority n/N: ranked n among N levels
Canada: It is a licensing requirement that the safety report be updated every 3 years. However, there is a need for reviewing the assumed performance of critical components in regard of the actual performance level, accounting for ageing effects.	2/3
Czech Republic: Update of safety studies is usually performed within periodic safety review if necessary. Important impetus for update is research and development. After ten years of operation PSA for WWER 440/213 was completely reworked. The Level 1 and 2 PSAs including internal and external initiating events will be periodically updated as part of Living PSA programmes (operational modes – full power and shut-down).	1/4
Finland: Order of priority rated low since the issue is already taken care of in the ongoing plant upgrading programmes.	6/12
Germany: No major updates are under way. Within the Periodic Safety Review a comprehensive review of safety studies is performed, including new analyses when necessary.	
Hungary There may be needs to reopen the issue of thermal transients for providing improved basis for PTS assessments and RPV life span considerations. New opportunities to pursue severe accident analyses should be utilised.(1.3.6 **with regard to severe accident phenomena and consequences**).	1/4
Japan: The safety studies are revised every fiscal year under Japan’s budget system.	4/6
Mexico: A study is made on the response of the Laguna Verde Units 1&2 to Station Blackout.	3/4

Spain: The Safety Studies (FSAR) in Spain have to be revised six months after each outage.	2/12
Sweden: An updated analysis considering up-to-date knowledge and modern analysis methods can certainly give valuable information regarding ageing phenomena. In Sweden the utilities are reviewing their Final Safety Analysis Reports in depth after the experience with clogged strainers in the Emergency Core Cooling System.	1/3
The Netherlands	1/5
The UK: Ranked highest, assuming that this covers all safety studies such as would be addressed in a PSR.	1/12
The USA: As a matter of regulatory process, all affected US utilities are requested to perform safety assessment of their plants in response to US NRC's Bulletins and Generic Letters (GL) related to ageing if issued. Recent examples are GL 94-03, "Intergranular Stress Corrosion Cracking of Core Shrouds in Boiling Water Reactors" and GL 97-05, "Steam Generator Tube Inspection Techniques." License renewal applicants are required to assess ageing effects on long-lived, passive structures and components, and propose ageing management programs for staff review and approval.	3/3

4.3 Strengthened basis of ageing management in PSA (e.g., extended use of PSA in planning in-service inspections, prioritising plant up-grading measures, directing related research efforts etc.).

	Order of Priority n/N: ranked n among N levels
Canada: Some but not all of the licensees have or are developing PSAs. The value of PSA in the context is recognised, but also the limitations, e.g., i regard of CCF, which is important in the context of component ageing.	2/3
Czech Republic: The safety authority has supported several activities related to the application of PSA techniques to operational safety issues and to improve the quality of existing technical specifications for the WWER 440/213 units and development of the Safety Advisory System (SAS) - a real time risk monitoring system. Currently the SAS is being used to analyse actual operational data at each of the four WWER 440/213 units. The safety authority is also using SAS as a tool to evaluate utility request for extended outage times of safety equipment The results of PSA are also used for deciding on prioritisation of safety measures, e.g. modernisation, upgrades, safety research projects etc.	2/4
Finland: Note that the use of "living PSA" to govern inspections and R&D is recognised.	5/12
Germany: PSA can be used to the degree that the ageing issues are really modelled. PSA is used in the assessment of plant upgrades. All plants have performed or will have performed PSA at level 1 in the near future.	
Hungary: There is a definite need to be met.	1/4
Japan: MITI consigns the Japan Power Engineering and Inspection Corporation to study application of probabilistic and risk informed methods to inspections.	4/6
Mexico	2/4

Spain: The CSN PSA program recently reviewed the PSA applications to licensing. Applying "Risk Informed and Performance Based" approach in the integrated safety programme, based on the use of PSA, is emphasised. Part is taken in the projects HALDEN, CABRI, and FALSIRE on risk based inspections techniques.	3/12
Sweden: PSA is a useful tool to identify systems, which are risk significant. A separate study is required to identify whether ageing phenomena are active, and the rate of ageing.	1/3
The Netherlands	2/5
The UK: No doubt that more extensive PSA is valuable. Important element of UK PSRs tending mainly to be used for examining the overall balance of risk and help to identify most effective plant modifications	8/12
The USA: "Risk informed" approach continues to be the top priority of the Commission.	1/3

4.4 Augmented in-service inspections making use of the advancing technology with qualification of applied methodologies

	Order of Priority n/N: ranked n among N levels
Canada: Examples given : Development of improved inspection techniques for pressure tubes and steam generators.	2/3
Czech Republic: Improved inspections of rector pressure vessels (RPV) have been developed by Czech manufacturer of RPVs. Augmented in-service inspection programmes of high-energy fluid system piping are being developed on the basis of, *i.a.*, the Leak Before Break concept and an ISI qualification project. The work on implementation of a qualification system for the in-service inspections of WWER reactor pressure vessels, piping and other components started in 1995. The qualification system for non-destructive examinations is based on ENIQ (European Network for Inspection Qualification) and IAEA methodologies.	1/4
Finland:	4/12
Germany: An important, comprehensive preventive maintenance concept, including especially in-service inspections is being applied to assure safe NPP operation.	
Hungary: Not presently on the agenda as running activities provide for current needs.	3/4
Japan: Technical development to clearly detect the ageing degree is vital.	3/6
Mexico: Programme on ISI and IST placing particular emphasis on detecting defects in piping, pressure vessels and supports, and on the operability of pumps and valves; Augmented and enhanced visual inspection for IGSCC in core shroud and other reactor internals.	1/4
Spain: New techniques on In-service Inspection (Risk Based Inspection, Risk Based Test, etc) are developed and evaluated by the licensees, the inspection companies as well as by the safety authority.	5/12

Sweden: In Sweden in-service inspection is considered the main tool to verify that piping components are capable of performing their safety functions. Experiences from research (e.g. PISC) and experience has demonstrated that in order to have any credibility the ISI systems must be qualified for the intended purpose. Such qualification is required from 1998. The components to be inspected are selected on a risk-informed basis, considering factors affecting the probability of failure and consequence of failure.	1/3
The Netherlands	5/5
The UK: An area receiving attention with appropriate developments being introduced as technology or experience allow.	7/12
The USA: Wherever necessary, license renewal applicants will be required to perform augmented in-service inspections for structures and components.	2/3

4.5 Enhanced maintenance development programmes

	Order of **Priority** n/N: ranked n among N levels
Canada: Reliability centred maintenance (RCM) programmes adopted by some licensees. A limitation of RCM is seen in its reliance on failure rate statistics, as being insufficient for reliability predictions for some components.	2/3
Czech Republic: Most of the major safety related components are covered by preventive maintenance. The scope and timing of maintenance of major components is based mainly on rules, experience and manufacturers' recommendations. The concept includes scheduled in-service inspections and application of condition monitoring and failure trending techniques for major mechanical components and for selected rotating electromechanical components.	1/4
Finland: Both Finnish utilities have developed and are still partly in the process of developing systems for ageing management. The systems enable organised collection and handling of all important data of systems and components.	9/12
Germany: In applying the comprehensive preventive maintenance concept (4.4 **Augmented in-service inspections making use of the advancing technology with qualification of applied methodologies**), reliability is taken into account with growing emphasis to optimise preventive maintenance and inspection programmes and to concentrate efforts on significant issues.	
Hungary: The development programmes for maintenance includes follow-up of the Periodic Safety Reviews by training in maintenance. A training centre has been established for the purpose and the approach is being developed in a project called "Systematic Approach to Training".	
Japan: The application of risk informed approach is under study, cf. 4.3	5/6
Mexico: Adopting the Maintenance Rule (10 CFR 50.65) using risk informed maintenance.	2/4
Spain: Pilot programs are implemented in Spain (Vandellós 2 and Garoña) following the lines of US "Maintenance Rule" with a view to implement them for all Spanish plants.	

Sweden: Currently not on the agenda.	3/3
The Netherlands	4/5
The UK: Note: Reliability centred maintenance is not viewed by the regulator as essential to ageing management.	12/12
The USA: A new maintenance rule took effect in 1996.	3/3

4.6 Design modifications for improved safety through improved working conditions of the staff at the plants (e.g. in regard of needs for automation, operator aids in the control rooms, reducing occupational radiation dose commitments, and other aspects of occupational safety.).

	Order of Priority n/N: ranked n among N levels
Canada: The CANDU plants are already highly automated. Some automated tools have been developed for minimising radiation doses to workers, especially in the area of inspections.	2/3
Czech Republic: Certain criteria applied for assessing human engineering aspects of control room facilities are referred to.	4/4
Finland:	8/12
Germany: According to the defence-in-depth concept, the original design of the German NPPs already provide for a high degree of automation, especially for the control of incidents (30 minutes rule) and a well developed design of the man-machine interfaces. Nevertheless, design modifications to improve operational conditions have been performed in a number of cases. For example, automation of inspection tasks critical to exposure has been introduced successfully. Further improvements of the man-machine interface utilising modern I&T devices are installed case by case (6.1 **Examples of major programmes under way aimed at assessing and improving the safety of the operating reactors**). In most modern plants an extremely low occupational exposure has been achieved by the replacement of cobalt in certain components.	
Hungary: No actions at present	3/4
Japan: Working conditions are improved as required by the utilities according to laws and regulations Control boards in the main control rooms of all existing plants are being improved by adding mimic design and electronic displays. For ABWR plants, in particular, improvements have been made to enhance the operator's comprehension of alarms and major plant status parameters. Developing and introducing automatic inspection equipment and new systems for work management has reduced the radiation dose committed in inspections and maintenance.	6/6
Mexico: Introduction of a safety parameter display system; Reduction of insignificant alarms in the main control room in the programme "Human factors and Cleaning of Alarms"; Reduction of occupational dose by means of enhanced water chemistry and replacement of cobalt containing components in the primary system.	2/4

Spain: The working conditions are evaluated from various aspects, including ALARA, for possible improvements.	10/12
Sweden: A number of the items indicated are currently on the agenda in Sweden. A modernisation of the control rooms is under way. The radiation dose to the personnel has increased considerably over recent years, depending partly on large modernisation activities. To reduce radiation from cobalt 60, Stellite valve seats are being substituted.	2/3
The Netherlands	4/5
The UK: Important because of the pivotal role the operator plays. Human factors review undertaken, as part of UK PSRs, often result in improvements to lighting, labelling and information displays.	6/12
The USA: The established regulatory process is used to determine whether or not a design modification should be required. Included in this regulatory process are USNRC rules, Orders, Bulletins, Generic Letters, among others.	3/3

4.7 Design modifications for improved prevention of initiating events (e.g. measures for limiting losses of coolant upon pipe breaks below upper core level, improved inspectability, reduced environmental strains (corrosion, radiation, mechanical fatigue), use of more resistant structural materials (e.g. replacement of nickel based alloys in primary piping for enhanced cracking resistance) etc.).

	Order of Priority n/N: ranked n among N levels
Canada: Examples given in the area of reducing fatigue due to vibrations.	2/3
Czech Republic: A significant number of safety improvements are being or have been incorporated, e.g. an erosion-corrosion monitoring program, improved materials for heat exchangers in the ECCS/RHR systems (reactor heat removal), supplementary surveillance programmes, implementation of the LBB concept, new methods for NDT, etc.	1/4
Finland:	2/12
Germany: See answer to question 6.2 **Examples of major plant upgrading projects**.	
Hungary:	2/4
Japan: Example: Core shroud material in some BWRs replaced by 316L SS to improve SCC resistance	1/6
Mexico	1/4
Spain:	6/12
Sweden: Substantial design modifications have been performed in the on-going modernisation of the plants. Examples are: the introduction of an extra containment isolation valve in systems which connect below core level; replacement of weld deposit material of nickel-base alloys which are sensitive to IGSCC by less sensitive (possibly insensitive) materials in the main recirculation loops of a BWR plant; damping of vibrations in main recirculation loops of BWR plants to prevent rapid crack growth from a synergetic effect of IGSCC initiation and high cycle fatigue crack propagation; substitution of reactor internal emergency core cooling components due to IGSCC sensitivity. Similar modifications are planned for the future modernisation programmes.	2/3

The Netherlands	2/5
The UK:	2/12
The USA: cf. 4.6.	3/3

4.8 Improved fire alarm and fire fighting systems

	Order of Priority n/N: ranked n among N levels
Canada: The Canadian nuclear standard on fire protection was revised in 1995. Reviews according to the new standards are under way.	2/3
Czech Republic: Fire alarms and fire fighting systems were improved on the basis of results from deterministic and probabilistic analyses of fire risk and fire effects and in accordance with IAEA recommendations. The special state supervisory authority checks all implemented measures for conformity with national laws, regulations and standards.	3/4
Finland: Fires have been found to contribute most to the total core damage frequency in the Finnish plants. Measures include modernising the fire detection systems and substituting the halon extinguisher systems.	3/12
Germany: Fire protection has already been improved in all German NPPs. According to the guidelines on PSR, a fire PSA is required. This will lead to new insights on fire risk.	
Hungary: Contained in the PSR follow-up.	2/4
Japan: The fire alarms and fire control systems are reviewed in the periodical safety review which is conducted by the electric utility companies about every 10 years.	6/6
Mexico	4/4
Spain: The older Spanish plants are updated as required (10 CFR 50 App. R)	10/12
Sweden:	2/3
The Netherlands	4/5
The UK: Note: Should be considered a logical subset of 4.7, 4.9 and 4.10.	5/12
The USA: The USNRC issued a fire protection rule (10 CFR50.48) which set forth the requirements for a fire protection plan that must describe the overall fire protection program for the facility.	3/3

4.9 Design modifications for improved protection of the safety systems from consequent failures caused by initiating events (e.g. improved piping supports, improved separation and other measures in regard of fires and flooding, pipe whips, jet impingement and missiles upon pipe breaks, as well as ensuring adequate relief paths for expelled steam and water, environmental qualification of safety related components, seismic qualification etc.).

	Order of Priority n/N: ranked n among N levels
Canada: Seismic peer reviews have identified possible threats to safety related systems and several modifications have resulted. The issue of equipment qualification for accident conditions is being addressed.	2/3
Czech Republic: Systematic hazard analyses to identify weak points in the buildings with regard to pipe whips, medium jet impingement or missiles have started. Leak Before Break analyses have been performed but it remains to provide the required leak detection systems. Several design modifications are considered (e.g. removing of some pipelines to another place, possible installations of the pipe whip restraints and shields against water jet etc.) in WWER 440/213 NPP. Equipment qualification is in progress.	3/4
Finland: The poor layout of the Loviisa plant necessitated many modifications to protect the safety systems. Recently updated PSAs covering fires and shutdowns may indicate when fully assessed, needs for further measures.	7/12
Germany: In the older plans there have been a number of design modifications especially with regard to pipe whip or improved protection against external impacts (example: bunkered emergency systems). Another example is the provision of measures for preventing clogging of strainers in emergency cooling systems. In the frame of PSR no major additional improvements have been identified in this area.	
Hungary:	2/4
Japan: Modifications aimed at gaining benefit from advancing technology may be made in the future, e.g. based on results of periodic safety reviews.	6/6
Mexico	2/4
Spain:	8/12
Sweden: The current regulatory position is that physical protection from adverse effects of pipe failures on safety systems is preferred to a demonstration that the break probability is negligible (the LBB concept). As to environmental qualification of safety relevant components Sweden uses a system of "ongoing qualification" where components taken out of service are subjected to accelerated ageing and then tested under accident environmental conditions to demonstrate the possibility to use similar components for some limited time.	2/3
The Netherlands	4/5
The UK	4/12
The USA: cf. 4.6.	3/3

4.10 Design modifications (except 4.11) for improved functional reliability of the safety systems (e.g. by improved process control, increased redundancy and diversity, and enhanced autonomy14 of the safety systems).

	Order of Priority n/N: ranked n among N levels
Canada: Example given of enhancing the reliability of the shutdown systems at the older 4 units station, Pickering, by providing for the two separate trains in each system to be fully independent, as presently required (Shut Down System Enhancement, SDSE).	1/3
Czech Republic:	3/4
Finland:	12/12
Germany: For example, in a BWR plant an additional and diverse system for decay heat removal has been back-fitted triggered by insights from plant specific PSA. Redundant and diverse on- and off-site power supply has been augmented in all plants.	
Hungary: Some modifications and complementary systems under way. As an example, thorough modernisation of I&C has been initiated (4.10). (Example: cf. 1.3.2)	3/3
Japan: Modifications aimed at gaining benefit from advancing technology may be made in the future, e.g. based on results of periodic safety reviews.	6/6
Mexico	2/4
Spain:	11/12
Sweden: This type of design modifications will be required in the on-going modernisation programmes for the early generations of the Swedish reactors.	2/3
The Netherlands	3/5
The UK	3/12
The USA: cf. 4.6.	3/3

4.11 Design modifications for improved mitigation of severe accidents

	Order of Priority n/N: ranked n among N levels
Canada: Not known.	3/3
Czech Republic: Possible weaknesses in the existing preventative and mitigatory measures are studied (cf. 2.6.)	3/4
Finland: Measures for improved severe accident mitigation have been carried out in all Finnish plants. Further analyses may lead to some additional modifications.	10/12
Germany: For example, systems for filtered containment venting have been installed in most plants (6.2) Presently, catalytic recombiners to prevent critical hydrogen concentrations are implemented in PWRs.	
Hungary: Some modifications and added features are under way, e.g. in the Seismic Upgrade Project.	

[14]. System autonomy: quality in regard of absence of dependencies on other systems and common supplies

Japan: MITI demands that complete measures to cope with severe accidents be established by the utilities in all nuclear power plants by the year 2000.	6/6
Mexico	3/4
Spain:	7/12
Sweden: As all Swedish NPPs were equipped with severe accident mitigation systems in the eighties, the protection of the environment in case of a severe accident is rated at a high level. Continued attention is paid to the issue, however, in regard of the remaining uncertainties and current research and development in the field is followed closely.	2/3
The Netherlands	2/5
The UK	11/12
The USA: cf. 4.6.	3/3

4.12 Extended or intensified training relating to ageing management.

	Order of Priority n/N: ranked n among N levels
Canada: Not known.	2/3
Czech Republic: Requirements on the training of personnel to some extent including also ageing management are addressed in numerous lower QA documents for particular activities.	4/4
Finland:	11/12
Germany: Measures to assure the required degree of training of the plant personnel are in place, including what is required in regard of ageing management. A long-term concern is the potential loss of know-how by personnel fluctuation and how this is to be compensated.	
Hungary: The follow-up measures of PSR include the “Systematic Approach to Training” programme aimed at maintenance training.	3/3
Japan: Appropriateness of training programs is evaluated in the periodical safety review.	6/6
Mexico: Most important areas: Structural Integrity, Water Chemistry, Environmental Qualification	1/4
Spain:	12/12
Sweden: No specific training related to ageing management has been discussed	3/3
The Netherlands	5/5
The UK	10/12
The USA: The training will be focused on maintaining the current licensing basis for all structures and components within the scope of license renewal	2/3

5. Strategies for plant ageing management

General

Belgium: Basic aims are 1) to confirm that the plant is as safe as originally intended; 2) to establish the exact plant status with emphasis on those structures, systems and components susceptible to ageing; and 3) to justify the current level of safety of the plant by comparison with current safety standards and practices, and identify areas where improvements would be beneficial and risks reduced at justifiable expenses.

Germany: The basic philosophy of the German approach to ageing relies on Quality Assurance (QA). Although many measures in QA have the effect of preventing and mitigating ageing, they are, however, not seen as specific ageing programmes. – Upgrading and backfitting of safety measures is an ongoing process to ensure comparable safety level of nuclear power plants of different age.

Mexico: The regulator places special emphasis on the ageing management activities at the plants in regard of the importance of maintaining the defence-in-depth system at top condition.

Sweden: The general view is that ageing should not be allowed to affect the safety.

USA: The regulatory process includes a generic issues prioritisation program, which ensures the timely and efficient allocation of resources to those safety issues that have a high potential for reducing risk and in decisions to remove from further consideration of issues that have little safety significance and hold little promise of worthwhile safety enhancement. When needed, immediate action on issues of high gravity may be taken in the form of a Bulletin or Order. Details of this program are contained in NUREG-0933, entitled “A Prioritisation of Generic Safety Issues”.

5.1 Comments on the regulatory use of safety goals (and on the guidance provided to allow the safety of the ageing reactors to be assessed as remaining acceptable).

	Relevance 1 Minor 2 Some 3 Definite 4 High	**Priority** n/N: ranked n among N levels
Canada: Standard on “Maintaining Nuclear Power Plant Safety Performance” currently being drafted.	4	1/4
Czech Republic: The safety authority policy is mainly based on the deterministic approach; quantitative safety goals are defined in safety regulations and in safety documents approved by the safety authority.	4	1/4
Finland	2	8/8

Germany: A comprehensive set of rules and guides derived from the Atomic Energy Act is in place describing the obligation of the licensee to maintain the quality of the plant and the qualification of the personnel. Corresponding conditions in the license are imposed and monitored in the frame of regulatory supervision. Recurrent testing and operational experience assessment are important measures. An additional measure to counteract ageing is the Periodic Safety Review. This comprehensive scheme of criteria and conditions contains a great variety of „safety goals“ that can not be described here in detail.		
Hungary: A most important step was taken the PSR Guide of 1995 in which safety goals are set and guidance is given. In 1996 a new “Atom Act” has lead to issuing a new set of Nuclear Safety Regulations establishing the legal base for enforcement.	4	1/4
Japan: cf. 4, General notes	4	3/3
Mexico: Safety goals are set in various related terms (leak tightness, number of scrams and trips etc) to minimise the number and severity of possible events. Reference is made to guidance provided by the USNRC and guidance in particular ageing management particular matters such as BWR internals, concrete structures and fracture mechanics provided in documents from IAEA and NEA.	3	1/4
Spain: Until now, Spain has not defined safety goals.	2	2/2
Sweden: In regard of safety goals, the regulatory emphasis is on avoiding radiological accidents, or any incidents indicating weaknesses in the defence in depth. Furthermore, the regulatory policy is to maintain and increase the level of safety. The possibilities to increase safety should thus always be considered, e.g. when plant modifications are planned. Probabilistic safety goals are not emphasised but probabilistic targets are required to be set according to established international practices as necessary for demonstrating validity of the safety case. While there are established rules for the licensing of a new reactor there is a need to further develop the methods for assessing the safety of an ageing reactor as remaining acceptable, and to establish criteria for additional safety requirements. An investigation is thus under way at the regulatory body to establish the regulatory requirements on plants to be used during the 21st century. In this process the most modern plants are considered, as well as the proposed future plants. A similar activity is under way on the utility side.	3	2/3
The Netherlands	4	1/5
The UK: The basic philosophy is that of “goals setting” rather than using a prescriptive approach. Regulatory use of safety goals and guidance in the UK is applied through the use of “The Tolerability of Risk from Nuclear Power Stations” and NII’s “Safety Assessment Principles for Nuclear Plants”. These provide a framework against which NII judge the acceptability of UK nuclear plants, including ageing reactors. Licensees tend to use this guidance a basis for producing their own safety goals.	4	2/8

The USA: The regulatory process aims at providing all required assurance that the licensing bases of all currently operating plants provide and maintain an acceptable level of safety.	4	1/2

5.2 Regulatory approaches to assessing ageing management (Comments were asked for in particular in regard of conceived relative merits of a) complete re-licensing of the plants to be required at intervals (e.g. 10 years), b) periodic safety reviews (PSR) of the entire safety case (e.g. every 10 years), c) ad hoc (international) peer safety reviews, and d) the safety authority performing in any case, on regular basis, inspections and topical safety reviews).

	Relevance 1 Minor 2 Some 3 Definite 4 High	**Priority** n/N: ranked n among N levels
Belgium: b) Operating licences, by Royal Decree of Authorisation, require as a condition that a safety reassessment must be made every ten years		
Canada: a) Relicensing issued for 2 years in average; b) No PSRs; c) Some peer reviews, i.a., OSART etc at different stations. – Indications of need for more systematic approach to plant ageing.	4	2/4
Czech Republic: An operating licence for reactor unit is issued for four years and it can be renewed only after thorough safety review up to now. The safety review must include assessment of ageing. An assessment of the ageing matters is required on a yearly basis (the assessment should include also topics mentioned in the document IAEA/INSAG – 8). Cf. 3.1 and 3.5. At present safety authority prepares new rules for licensing processes.	4	1/4
Finland: The approach is a combination of all items, especially b) and d). Renewal of the license, required about every 10 years, is based on periodic safety review (PSR) of the plant. In addition there is a yearly inspection programme including items relating to plant ageing management.	3	4/8
Germany: a) Licenses for NPPs are not limited in time; b) The German Reactor Safety Commission (RSK) recommended in 1988 to make every nuclear power plant subject to PSR about every 10 years. The PSR is considered a supplementary means of regulatory surveillance and there is no statutory obligation for a PSR. PSRs are nevertheless carried out at all plants on a voluntary basis. The scope is set down in a BMU-guideline to ensure uniform application; c) To item c): International peer safety reviews (OSART) have been conducted for some of the stations. d) The plants are under regulatory supervision comprising both regular and topical inspections.		
Hungary: b) PSRs were first made, according to the Guide to Periodic Safety Review of Unit 1 and 2 of NPP Paks 1995, over a 12-year interval. The evaluation of the utility report initiated a series of additional requirements (Corrective Measures) to apply for the remaining nuclear plant units. Recent prescriptions reduced the interval to 10 years. Performing the PSR is a condition for maintaining the license. The PSR does not, however, correspond to a complete re-licensing.	4	1/4

Japan: a) Not applicable; b) PSR conducted at 10 year intervals; c) Not applicable; d) applied as periodic inspections or in maintenance management research.	4	1/3
Mexico: a) Not applicable; Licenses are limited to 30 years, however; b) PSR conducted at 5 year intervals according as a condition of the license; c) OSARTs and ONPO audits have been conducted.	3	2/4
Spain: The Periodic Operation Permits for the plants, constituting the licensing basis, are presently subject to renewal in 3-4 year intervals. As a condition for these Permits the licensees are required, since 1995, to submit yearly reports on the ageing management activities at the plants to CSN and the Ministry of Industry. PSRs are conducted at 10 year intervals	2	1/2
Sweden: Ageing degradation is monitored by in-service inspections and in-service testing to verify that the systems and components have the at least the capability set forth in the license. Monitoring of operation is also a means of keeping track of ageing effects. Research findings and operational experience from other plants provide information about possible ageing effects that should be considered. It is requested that the utilities do an annual update of these matters and report to the regulatory body and propose modification in their in-service inspection program they find motivated. Comments to the listed approaches: a) Relicensing at time intervals is not used; b) PSRs are obligatory and are conducted about every 8 years since the early eighties. The PSRs, conducted by the utilities, reviewed by the regulator and reported to the Government, are considered as forming part of the regulatory inspection and assessment programme. The scope is broad, covering also analyses of operating experience including plant modifications and evaluation of organisational aspects. The PSRs are considered highly valuable; c) OSARTs and ASSETs have been conducted and valued.		
The Netherlands	4	1/5
The UK: Major PSRs, starting in 1980 on the Magnox reactors, are undertaken to review all aspects of the safety case. PSRs are now a requirement of the standard nuclear license. The agreed period between each review is 10 years. The safety assessment principles are primarily for a new plant. Compliance with modern safety standards is not viewed as absolutely necessary, however, provided it can be demonstrated that an acceptable case exists. Views taken on the various ageing management options: a) Complete re-licensing offers no substantial benefits over a properly conducted periodic safety review but has a greater administrative burden; b) Experience shows that effective improvements do result from PSR. For success, it is necessary to have a regulatory regime which effectively makes such reviews mandatory. It is necessary to agree an appropriate scope and the acceptance standards from the outset; c) International ad hoc reviews can be useful but are usually of limited scope and can lead to problems of ownership of the conclusions and recommendations; d) NII use a process of continuous safety review and site inspection. The work, viewed as essential, is done by one site inspector, using around 30% of his time at the site, and other inspectors on an ad hoc basis.	4	1/8

The USA: The regulatory process does not include complete safety re-evaluations during the licensing term which was fixed at 40 years for the US plants. For a renewed license beyond the 40 years term, an ageing management review of the plant structures and components in accordance with the licensing renewal rule is required. This rule requires that structures and components within the scope of the rule and the applicable ageing effects be identified and that the effectiveness of the ageing management programs be demonstrated in license renewal applications.	4	1/3

5.3 Balancing, on part of the safety authority, inspecting and assessing the <u>utility processes</u> used in ageing management vs. inspecting the <u>current state of the plant</u>

	Relevance 1 Minor 2 Some 3 Definite 4 High	**Priority** n/N: ranked n among N levels
Canada: The licensees have responded to the regulatory action "Assurance of Continuing Nuclear Station Safety" by referring to programmes or processes claimed to provide the required assurance. The regulator has not yet approved these however, and continues keeping pressure on the licensees to come up with more soundly based approach.	4	2/4
Czech Republic: The most important activities are supervised by the safety authority inspectors or by the third party organisations.	3	3/4
Finland: The inspection activities have thus far been concentrated on the actual state of the plant. The policy of the authority is to give increased emphasis to the inspections of the utility processes.	4	1/8
Germany: The approach followed is a combination of both strategies. The QA procedures and other procedures relevant to ageing management are laid down in specific documents, mainly in the Testing manual (Prüfhandbuch), subject to continuous updating. The Testing manual is subject to supervision by the nuclear safety authorities and approval of any changes.		
Hungary:	3	2/4
Japan: In Japan, the periodical inspection system is regarded as the key element, and most of the activities of this system consist of inspections of the current condition of a plant.	4	1/3
Mexico: The regulatory body place special emphasis on ageing management activities at the plant in order to avoid events, incidents and accidents.	3	2/4
Spain: The CSN approach is focused on inspecting and assessing the utility processes used in ageing management. The Spanish safety system is based mainly on the responsibility of the licensees. CSN inspects and evaluates the licensee activities.	3	2/2
Sweden: There has been a shift during the recent years towards increased emphasis on inspecting and assessing the utility processes relative to checking or verifying results obtained in the utility's own inspections and assessments. A proper balance between the two approaches is needed to emphasise the different responsibilities of the regulator and the utility while ensuring required verification.	4	1/3

The Netherlands	3	2/5
The UK: In the UK, the majority of regulatory effort goes into ensuring that the licensees have adequate arrangements for managing nuclear safety and that these arrangements are being applied efficiently. The results of the licensee inspections results are also examined to ensure that NII agree with their interpretation.	3	3/12
The USA: As part of the license renewal process, an inspection programme is being developed to focus on inspection of ageing effects identified and the associated ageing management programmes for structures and components in plants applying for license renewal.	3	2/2

5.4 Publicly communicated utility policies and safety goals in regard of ageing management and upgrading of the plants with regard to safety

	Relevance 1 Minor 2 Some 3 Definite 4 High	**Priority** n/N: ranked n among N levels
Canada: Not known**.**	2	4/4
Czech Republic: The utility aims at providing safe operation up to and including the planned end of the plant lifetime, possibly to be extended. There is a published document by the CEZ a.s. (owner of NPPs) ”The Statement of Safety Policy”. The Communication Section of CEZ a.s publishes the utility policy and goals in different public documents, journals, newspaper etc. General information is also given to the public through information (visitors) centres at the NPPs.	2	4/4
Finland: In public the utilities have expressed that their policy is to keep the plants in a condition to always have a remaining lifetime of 40 years.	2	7/8
Germany As the degradation of components and structures is well under control due to the measures in place, the ageing issues did not play a major part in the public discussion. However, the fact that the older plants do not feature the most advanced safety concepts has been an issue both in the political debate and, consequently, in the public discussion. Presently, the Atomic Energy Act is being revised including a legal clarification on the required degree of backfitting of older plants.		
Hungary: In the utility reports from the completed Periodic Safety Reviews, which according to law are available to the public, summaries are presented which relate back to the relevant safety goals.	2	3/4
Japan: The ageing management only is published in the periodical safety review report. Guidance, as far as ageing management is concerned, is provided for in the long-term maintenance plan (section 4, General notes).	4	1/3
Mexico: There are no such utility policies.	1	4/4
Spain: The reports from the Periodic Safety Reviews are publicly available.	2	2/2
Sweden: The utilities state openly their safety goals, in probabilistic as well as general terms. The latter include maintaining safety culture and ensuring at all times safety, as a first priority, together with continuous strive for increasing the safety.	3	2/3

The Netherlands	4	4/5
The UK: The UK operators are responsible for communicating their policies to the public. One forum for this is via local community liaison committees which meet regularly at each site. However, the information communicated to the public tends to be rather general. The regulator takes a more active role in publishing ageing management policies by publishing the findings of PSRs in reports.	3	5/12
The USA: License renewal applications and associated supporting documents submitted by US utilities are publicly accessible in the USNRC Public Document Room, Any discussion regarding ageing effects, ageing management programs and/or technical bases for the conclusions contained in the application are held publicly.	3	2/2

5.5 Views in regard of pursuing, in practice, safety goals beyond current licensing conditions for the operating reactors

	Relevance 1 Minor 2 Some 3 Definite 4 High	**Priority** n/N: ranked n among N levels
Canada: In a situation where utilities do not accept to implement a change, or follow a new standard, the Board of the AECB can impose shutdown of any station. However, the Board is likely to consider the cost/benefit of a proposed back-fitting.	3	3/4
Czech Republic: Technical basis and prioritisation of actions are usually discussed between the safety authority and the NPPs.	3	3/4
Finland: The operating licenses do not include technical requirements. The requirements are given in general safety regulations by the Council of State and in guides (YVL) issued by STUK. The general regulations require the safety to be enhanced when needed as indicated by research or technical advances. Safety modifications aimed at meeting enhanced safety requirements have in several cases been carried out, usually in good mutual co-operation between the utility and the authority.	3	3/8
Germany: As the operating licences are not limited in time, many upgrading measures cannot be demanded obligatorily by the regulatory body, but are performed by the licensee in account of its responsibility for plant safety. Questions of this type are resolved in the dialogue between regulator on the basis of understanding of the responsibilities on both sides and a commitment to highest standards of nuclear safety. In this process the German Reactor Safety Commission (RSK) plays an important role.		
Hungary: As an example, the “Corrective Measures” to the PSR Guide (cf. 5.2 **Regulatory approaches to assessing ageing management**) had to be strongly enforced by the authority. In order to enforce safety measures beyond the current licensing conditions, if needed, the regulatory authority might initiate a public administration process and prescribe de measures under sanction of suspension of license or fine.	4	2/4

Japan: The electric utility companies endeavour to reflect the latest technical knowledge, considered in particular depth in the periodical safety reviews. The regulatory authorities encourage such efforts.	4	2/3
Mexico	4	1/4
Spain: Any possible additional safety requirement to the current licensing basis is technically discussed between the licensees and the CSN. The new safety requirements would be added to future PEP revisions.	2	1/2
Sweden: Swedish nuclear regulation is primarily concerned with safety objectives and safety cases, rather than with matters of compliance, and the safety authority is required by law to impose any requirements required in regard of safety. As, furthermore, an efficient dialogue has been developed between the authority and the licensees, questions in regard of what can reasonably be required to ensure safety are usually not difficult to resolve in full mutual understanding.	4	1/3
The Netherlands	1	5/5
The UK: UK nuclear licenses are wide-ranging and they are goal setting in approach rather than stipulating acceptable standards. The benefits of safety improvements are judged against the principle of reasonable practicability. Those that are demonstrated to be worthwhile are implemented.		
The USA: Any additional requirements which go beyond the current licensing basis in support of current operation or licensing renewal are publicly discussed between utilities and the USNRC staff. These additional requirements will eventually be documented in an appropriate regulatory document. For example, the maintenance rule and the Generic Letters on IPE and IPEEE were issued after extensive public discussion.	4	1/2

5.6 Balancing safety requirements and correspondingly required commitments in terms of occupational radiation dose

	Relevance 1 Minor 2 Some 3 Definite 4 High	**Priority** n/N: ranked n among N levels
Canada: the Board of the AECB has the authority to consider this judicious balancing. Guidelines are not known to exist.	3	3/4
Czech Republic: The radiation protection practises require minimising radiation dose in accordance with the ALARA principles and in accordance with requirements described in mandatory ”regulation on requirements on radiation protection (ICRP-60 recommendations) ”.	3	3/4
Finland: The benefit of in-service inspections vs. received radiation dose is often subject to consideration.	2	6/8
Germany: The occupational exposure of a project for safety improvements is carefully assessed and evaluated		

Hungary: From ’96 on, the new Atom Act refers to the ALARA principle. The authority is currently in the process of implementing the principle in the nuclear safety regulations. Current practice is that the utility is required by the authority to account for any associated commitment of radiation dose when proposing measures to be taken in the plant for safety reasons. The obedience to radiation dose limitations is checked and supervised by a separate service at the Ministry of Welfare (responsible for public health).	2	4/4
Japan: Electric utility companies define the dose equivalent target in the periodical plant shutdown works, and such target is defined according to ALARA principle.	4	2/3
Mexico: The subject has not been studied.	1	4/4
Spain: The need for safety requirements is evaluated from a technical point of view. Additionally, ALARA principle is always applied. Until now, there are not in CSN guides or committees for evaluating such balance.	2	1/2
Sweden: Potential dose commitments are carefully assessed and reviewed before attempted modification or replacement projects.	3	2/3
The Netherlands	1	5/5
The UK: There is a current drive in the UK to reduce dose to workers. The matter is subject to judgement on a case-by-case basis against reasonable practicability.	2	7/12
The USA: Benefits of any additional requirements for inspections and/or modifications are assessed and weighed against potential exposure to additional radiation.	4	1/2

5.7 Policies and practices aimed at disclosing and sharing, within the nuclear community, all documented information about relevant operating experience and failures (in order to avoid undesirable restrictions for commercial and proprietary reasons).

	Relevance 1 Minor 2 Some 3 Definite 4 High	**Priority** n/N: ranked n among N levels
Canada	3	3/4
Czech Republic: Practically all information (or documents) are available except manufacturer’s ”know how” and details concerning physical protection of NPPs and transport of nuclear materials.	4	3/4
Finland: The information is submitted very openly and quickly within the nuclear community, strongly encouraged by the authority while at the same time duly respecting the proprietary aspects.	4	2/8
Germany: Incident reporting from the licensee to the authorities is required in the Ordinance on the Nuclear Safety Officer and Reporting of Incidents. Germany participates in the established international exchange of operational experience.		
Hungary: In practice, all information, which is available to the authority and needed for handling the safety issues, is shared.	4	3/4
Japan: Every effort is made to release safety relevant information openly	4	1/3

Mexico: Mexico participates in the INES system and events required. The regulatory body and the utility have to respect obligations to protect some proprietary information form suppliers.	4	1/4
Spain: No particular problems have been encountered.	3	2/2
Sweden: Any document possessed by the regulatory body is, by law, available to any Swedish citizen unless the document is restricted due to commercial interest. There is an expressed agreement between the utilities that the competitive situation shall not prevent sharing vital, safety related information.	3	1/3
The Netherlands	3	3/5
The UK: The UK licensees are required, by a Condition of their licenses, to operate a system to record, investigate and report events at their sites. Licensees share their experience within the UK and participate in the WANO and the IAEA/NEA IRS systems. In general, the confidentiality of information supplied to the NII is protected unless there is a public interest in its release.	1	8/8
The USA: A nuclear plant owner is required to submit Licensee Event Report (LER) addressing the details of the event and the corrective actions taken or to be taken after every reportable plant event. The LERs are public documents.	4	1/2

5.8 Practices for ensuring that documentation, procedures and safety analyses are updated and maintained current.

	Relevance 1 Minor 2 Some 3 Definite 4 High	**Priority** n/N: ranked n among N levels
Canada: While the documentation of procedures (operating manuals etc.) is properly maintained there is room for improving the maintenance of other documents, such as system design information. Furthermore, the plant ageing management documentation needs to be made part of a document structure which makes QA audits possible.	4	2/4
Czech Republic: All rules and procedures for updating and maintaining documentation are described in QA programmes in accordance with mandatory regulation on ”QA of classified items”. The safety authority performs inspections of practices used at the NPPs. The NPPs perform internal audits.	4	1/4
Finland: The practices are subject to part of the annual inspection programme by the authority (cf. 5.2).	2	5/8
Germany: A number of requirements are in place to assure that an adequate documentation is prepared and maintained current. The outdating of analytical techniques relevant to the safety case is counteracted by the PSR.		
Hungary: Relevant rules for quality assurance is covered in the PSR Guide and the amended Corrective Measures (5.2 **Regulatory approaches to assessing ageing management**). However, current practice needs to be improved.	3	3/4
Japan: The Quality Assurance Guideline for Nuclear Power Plants by the Japan Electric Association is followed by the utilities. MITI audits the utility activities accordingly.	4	2/3
Mexico: The US quality assurance criteria apply. The regulator is about to start a QA programme, which will cover technical documentation among others.	3	2/4

Spain: All Spanish plant have fully implemented quality assurance, evaluated and audited by CSN, following the requirements of 10 CFR50 App. A and IAEA Safety Guides.	4	1/2
Sweden: The issue is obviously covered in the QA systems and followed up by corporate auditing and regulatory inspections. Nevertheless, experience indicates needs to pay attention to the matter (cf. 1.3 **The gap seen on viewing the current safety case and safety defence-in-depth system in the light of current state-of-the-art**).	3	1/3
The Netherlands	3	3/5
The UK: Arrangements and quality assurance are required to be in place to ensure that a fully documented safety case exists and is maintained up-to-date. Additionally, steps are now being taken to ensure that the safety cases are presented in a clearer and more user-friendly format.	3	6/8
The USA: The plant's Safety Analysis Report is required to be updated annually by the USNRC regulation. USNRC also has a rigorous inspection programme which specifies periodic on-site inspections.	4	1/2

6. Related programmes and achievements

6.1 Examples of major programmes under way aimed at assessing and improving the safety of the operating reactors

Note: No complete account of the national responses. Examples also given in answers to questions 1-5.
Canada: *Maintaining Nuclear Plant Safety Performance*: a standard is being drafted containing requirements to provide assurance that the safety of a nuclear power plant is maintained throughout the licensed life of the station. The requirements will be explained in a guide. The requirements include identification of critical components, establishing the performance requirements and ensuring that adequate activities be in place for maintaining the safety performance of the plant. The requirements aim at forcing the organisation to fill a number of major gaps identified to date in taking a new, comprehensive and systematic approach to implementing proper management processes.

Czech Republic: Principally all safety issues identified in IAEA publication ”Safety issues and their ranking for WWER 440 model 213 NPPs - IAEA-EBP-WWER-O3” were/are resolved (e.g. issues category 3 – which are of high safety concern): Qualification of equipment, Non-destructive testing, ECCS sump screen blocking, Feedwater supply vulnerability and Internal hazards due to high energy pipe breaks.

Finland: The programme for providing improved mitigation of severe accidents, both at the Olkiluoto (BWR) and the Loviisa plants (WWER), is still in progress. A number of features have already been implemented, e.g., filtered venting of the containment in Olkiluoto and external spray cooling of the Loviisa containment for pressure control. Issues currently addressed include, e.g. pH-control in the containment and vent filter efficiency in Olkiluoto, and external pressure vessel cooling and catalytic hydrogen burning in the Loviisa plant. – Major modernisations for power up-rating together with improvements on safety and process systems, including I&C are under way.
Germany: The introduction of preventive and mitigatory accident management (AM) measures shall be mentioned as a still ongoing major programme to improve plant safety. Measures already implemented are described below 6.2 **Examples of major plant upgrading projects**). Currently, accident management measures to prevent hydrogen explosions by the use of catalytic recombiners are under development.
To enhance the safety of operation and accident control by improved staff education a programme for the construction of plant specific full-scope simulators has been initiated which is near completion.

Hungary: Earthquake safety re-assessment and upgrade. Replacement of old I&C systems with up-to-date digital process control systems. Auxiliary emergency feedwater system and enhanced systems for emergency cooling. Additional provisions for accident management (e.g. catalytic hydrogen burners).

Japan: MITI summarised the evaluation of the long-term integrity of components and structures the Tsuruga Unit-1 BWR, the Mihama Unit-1 PWR, and the Fukushima-Daiichi Unit-1 BWR in April 1996. These plants are Japan’s oldest LWRs. The basic concept regarding measures for ageing nuclear power plants was then also summarised (cf. 4, General notes).

Spain: Integrated PSA programme, Periodic Safety Reviews, implementation of the Maintenance Rule, systematic performance evaluation of the nuclear stations (ESFUC), feed-back of operational experience (AEOS), improvement of Technical Specifications.

Sweden: BOKA, REDA, RAK, BOKA, and DART are major utility programs (special design basis reviews, cf. 1.3) for re-evaluation of the Final Safety Analysis Reports in light of modern knowledge and past operating experience. Comparison is made with requirements from the time of the license, and with what is termed as modern standards. If deviations are found from initial requirements, modifications should be carried out as soon as possible. If deviations from modern standards are found, the deviations are judged, often based on probabilistic arguments. To meet these activities the regulatory body has initiated the above mentioned investigation to define is requirements on plants operating in the 21st century.
Modernisation and upgrade programs are FENIX, SPRINT, TRIM. FENIX has finished the first part, SPRINT is finished and TRIM is being planned. All these programs refer to BWR plants with external recirculation loops.

The UK: A first complete round of periodic safety reviews of Magnox reactors have been notable in achieving safety improvements. PSRs on AGRs are well under way.

The USA: Examples are: steam generator generic letter development, maintenance rule follow-up inspections and the final rule on containment in-service inspections.

6.2 Examples of major plant upgrading projects

Note: No complete account of the national responses. Examples also given in answers to questions 1-5.

Canada: Coating the inside of the reactor building of the 600 MWe with a new liner. The old liner would crack because of ageing, resulting in increasing leak rate. The design change required complete re-qualification of the liner. – Pressure tube replacements in some stations (380-480 tubes per station). The replacement aimed at avoiding that the tendency of the ageing pressure tubes to sag will cause contact with the calandria tube resulting in hydride blisters and cracking. – There is a cable ageing issue which is underway but not yet completed.

Czech Republic: Examples :
1. Qualification of equipment (WWER 440/213). Qualification programme for selected equipment important to safety started in 1995 and includes environmental and seismic qualification of selected electrical, I&C and mechanical equipment, encompassing rooms and buildings in which these equipment is placed. Insufficient qualification of safety related systems with respect to harsh environmental or seismic conditions would seriously affect levels 1 to 3 of protection of defence in depth and the safety functions would be questionable for scenarios within design basis envelope.
2. Surveillance programme. Supplementary surveillance programme was realised in 1997 (lead factor <3). Insufficient accuracy and reliability of reactor pressure vessel monitoring affects levels 1 to 3 of protection of de-fence in depth. A PTS in an embrittled RPV could lead to its failure.

Finland: A number of major, safety significant upgrading are mentioned, including anneal of the core zone weld in the Loviisa (WWER) RPV, fire separation, replacement of feed water lines for improved resistance to erosion, replacement of piping in RHRS for improved resistance to SSC etc.

Germany: 1) Backfitting of BWR ferritic steel piping in the first half of the eighties for improved manufacturing (weld) quality and improved testability using ultrasonics. - 2) Measures for improved corrosion protection of PWR steel containment. - 3) Implementation of a considerable number of accident management measures for preventing core damage, or mitigating the consequences of core damage, in case of failure of safety systems for control of design basis accidents. The measures included filtered air supply to the control room, additional sources for coolant injection to RPV of BWR and containment venting with vent filtration for removal of aerosol and iodine, and inerting all containments of the BWR-69 design.

Hungary

Japan: For the prevention from SCC, the type 304 core shroud of Fukushima-Daiichi Unit-3 (BWR) is currently being replaced with a type 316L shroud. It is planned to implement such replacement at 5 more BWR plants.
The severe accident management procedure will be completed for all plants by the year 2000.

Mexico: As the Mexican plant is only 7 years, no major upgradings have been made. However, for example, SS 304 was replaced with SS 304 in the recirculation system, together with applying improved heat treatment for stress improvement of weld joints.

Spain: Steam generators replacements, reactor pressure vessel head replacements (Zorita and Almaraz), BWR recirculation system replacement (Garoña), installations of tie rods in BWR core barrel (Garoña), Leak Before Break methodology, Nuclear Instrumentation System (NIS).

Sweden: The renovation project FENIX at Oskarshamn 1, completed in 1995. Piping components with IGSCC potential were replaced, additional cabling was provided in the containment to form formed separated trains, rooms were separated to avoid flooding problems, etc. In the on-going modernisation programme the Emergency Core Cooling Spray distributor will be replaced.
Project SPRINT at Ringhals 1 was completed during 1997. It was a replacement of IGSCC sensitive weld deposit materials in the main re-circulation loops with less sensitive materials. The intention was to reduce the probability of large LOCA in the BWR with external recirculation loops.

The Netherlands

The UK: One example of significant reactor upgrade arose from the early Magnox safety reviews and was taken forward in the Magnox reactor “Generic Issues” programme. This has resulted in a number of major safety improvements being successfully implemented on all the Magnox reactors. These have included diverse lines of reactor shut-down protection; provisions of a divers post-trip cooling system; provisions of emergency indication centres; and improved protection against a number of hazards including fire, releases of hot reactor gas and seismic events. - Similar improvements are being considered for the AGRs.

6.3 Examples of other notable achievements in regard of ageing management

Czech Republic: Example: A DIALIFE System is being implemented at WWER 440/213 NPP. The system has the following basic features:
- It enables on-line assessment of material degradation and makes possible to determine a remaining lifetime and prepare recommendations for controlled ageing of plant components in operational conditions

- it helps preparing supporting documents to a licence renewal request as a prerequisite to continue plant operation also beyond the time assumed by the plant designer
- it helps monitoring actual remaining lifetime in order to optimise component operation and control component ageing.

The UK: The UK took the initiative to undertake PSRs in the early 1980s. Early results led to identification of the generic issues programme (6.2). One of the lessons learnt was that firm regulatory milestones were needed if the complex PSR process was not to overrun original timescales. A series of regulatory milestones have thus been agreed between the NII and the licensees to ensure that the programme for future PSR is completed to schedule. The system has proved itself, during a number of years, to ensure timely control of ageing management.

7. Communication of related information to the public

The questions asked relate to the view that it is essential that the public perception of the safety can be based on complete, relevant and correct information on the risks, the uncertainties and the measures taken to ensure safety.

7.1 Authority and utility policies and practices

	Relevance 1 Minor 2 Some 3 Definite 4 High	**Priority** n/N: ranked n among N levels
Canada: The AECB, as a government agency, has the responsibility of informing the public about its operations. Any significant topic will be released to the public in a publication entitled the Reporter. The AECB Office of Public manages all AECB press releases.	1	low
Czech Republic: The safety authority provides information to the public and to the government through an official document "SUJB Annual Report". The NPPs established information centres for the public.	4	-
Finland: The authority as well as the utilities are striving for a frank and open attitude in informing the public. Both sides allocate currently more resources for this purpose and look for improved approaches to communicating with the media.	2	2/2
Germany: The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) keeps the public informed about decision taken and the corresponding safety background. The channels include press releases, conferences, brochures and answering letters as well as regular publications. An overview of events reported is published regularly. The utilities provide information to the general public as well, e.g. through information centres established at most plant sites.		
Hungary: The regulatory body is in the process of establishing its PR activities. Documents issued by now are aimed mainly more for a rather educated audience. The Paks NPP has established an information centre at the site.	2	-
Japan: MITI and the utilities believe that it is important to inform the public on ageing related safety measures. The relevant information will be released officially as soon as it is compiled (cf. section 1.4 **Declining confidence in the safety of the ageing plants on part of the public**)	4	1/2
Mexico: There are no such policies.	1	-
The Netherlands		low
Sweden: SKI provides information on the safety performance of the nuclear plants in an official publication issued four times a year and in a yearly report to the Government which is also available to the public. Press releases are issued as appropriate.		

The UK: The UK Government has a policy of openness and therefore NII publish a number of reports on related subject which are freely available to the public. Some reports are re-enforced by launching them at press conferences. NII has a commitment to answer all letter from members of the public. Press releases are issued for significant issues. NII believe that all this helps to reassure the public that reactors are not allowed to continue operation without appropriate safety standards being met. – The UK operators also recognise the benefits of openness and public understanding of nuclear power and there are, e.g., visitor centres and plant tours at each station. (cf. 5.4).	4	2/2
The USA: It is the policy of USNRC that the public is informed of all risks and safety measures related to the safety of the nuclear plants. This includes the considerations of plant ageing.	4	-

7.2 The interplay between the safety authority and the utilities in communicating information to the public

	Relevance 1 Minor 2 Some 3 Definite 4 High	**Priority** n/N: ranked n among N levels
Canada: cf. 7.1	1	low
Czech Republic: The safety authority is a neutral and independent organisation.	1	-
Finland: The authority strives to maintain a neutral and independent image.	3	1/2
Germany		
Hungary	2	-
Japan: The regulatory authorities supply information independently from utilities, who also supply information by co-ordinating with the information supplied by regulators.	3	2/2
Mexico: The Ministry of Energy has set up an organisation, “Social Communication”, with responsibility for informing the public in the event of serious event. The utility has an Information Centre at the plant kept open for the public.	1	-
The Netherlands	1	low
Sweden: The utilities are expected to inform the public about notable events in their plants. If such information would not be released in an appropriate manner, the authority would itself release the information.		
The UK	4	1/2
The USA: USNRC makes safety decisions based on the docketed information submitted by the utilities. All such information is made available and accessible to the public.	4	-