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NUCLEAR ENERGY AGENCY
COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS

NEA/CSNI/R(2005)3
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CSNI/ INTEGRITY AND AGEING WORKING GROUP

Review of international developments and cooperation on Risk-Informed In-Service-Inspection (RI-ISI) and Non-destructive Testing (NDT) Qualification in OECD-NEA member countries- Responses to the questionnaire

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English text only

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), Korea (12th December 1996) and the Slovak Republic (14 December 2000). 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 the 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 consists of 28 OECD member countries: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Luxembourg, Mexico, the Netherlands, Norway, Portugal, Republic of Korea, the Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The Commission of the European Communities also takes part in the work of the Agency.

The mission of the NEA is:

- to assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes, as well as
- to provide authoritative assessments and to forge common understandings on key issues, as input to government decisions on nuclear energy policy and to broader OECD policy analyses in areas such as energy and sustainable development.

Specific areas of competence of the NEA include safety and regulation of nuclear activities, radioactive waste management, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information. The NEA Data Bank provides nuclear data and computer program services for participating countries.

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

COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS

The NEA Committee on the Safety of Nuclear Installations (CSNI) is an international committee made up of senior scientists and engineers, with broad responsibilities for safety technology and research programmes, and representatives from regulatory authorities. It was set up in 1973 to develop and co-ordinate the activities of the NEA concerning the technical aspects of the design, construction and operation of nuclear installations insofar as they affect the safety of such installations.

The committee's purpose is to foster international co-operation in nuclear safety amongst the OECD member countries. The CSNI's main tasks are to exchange technical information and to promote collaboration between research, development, engineering and regulatory organisations; to review operating experience and the state of knowledge on selected topics of nuclear safety technology and safety assessment; to initiate and conduct programmes to overcome discrepancies, develop improvements and research consensus on technical issues; to promote the coordination of work that serve maintaining competence in the nuclear safety matters, including the establishment of joint undertakings.

The committee shall focus primarily on existing power reactors and other nuclear installations; it shall also consider the safety implications of scientific and technical developments of new reactor designs.

In implementing its programme, the CSNI establishes co-operative mechanisms with NEA's Committee on Nuclear Regulatory Activities (CNRA) responsible for the program of the Agency concerning the regulation, licensing and inspection of nuclear installations with regard to safety. It also co-operates with NEA's Committee on Radiation Protection and Public Health (CRPPH), NEA's Radioactive Waste Management Committee (RWMC) and NEA's Nuclear Science Committee (NSC) on matters of common interest.

FOREWORD

In December 2000, the Committee on Nuclear Regulatory Activities (CNRA) and the Committee on the Safety of Nuclear Installations (CSNI) agreed to prepare a state-of-the art report addressing the present situation and regulatory aspects in NEA member countries on:

- Risk based/risk informed in-service inspections developments,
- Qualification of NDT system to be used for the inspections.

The CSNI gave mandate to the CSNI working group on the Integrity of Components and Structures (IAGE) to prepare the report.

In order to get a good basis for compiling the report with an overview on the present situation in OECD countries and regulatory aspects on the further developments of RI-ISI and NDT qualification approaches a questionnaire was prepared. This questionnaire was organised in two parts. The first part addressed used risk based/risk informed ISI approaches and regulatory aspects on the further developments. The second part addressed used NDT qualification approaches and other measures for getting reliable inspection results as well as regulatory aspects on the further developments of qualification approaches.

Some parts of the questionnaire addressed topics, which have been dealt with in other European or national programs. Available relevant information from these programs has been also collected.

The questionnaire was circulated in 2003 among NEA member countries organisations.
Appendix 1 contains the questionnaire.
Appendix 2 contains the compilation of responses to the questionnaire.

A workshop was organized to complement the questionnaire (NEA/CSNI/R(2004)9 Proceedings of the CSNI Workshop on "International developments and cooperation on Risk-Informed In-Service-Inspection (RI-ISI) and Non-destructive Testing (NDT) Qualification" held in Stockholm, Sweden on 13-14 April 2004 and hosted by SKI). In addition to regulators, licensees, manufacturers and researchers, this workshop gathered international organisations (i.e EC, IAEA) and the main organisations worldwide developing RI-ISI methodologies.

The synthesis report referenced NEA/CSNI/R(2005)9 “Review of International developments and cooperation on Risk-Informed In-Service-Inspection (RI-ISI) and Non-destructive Testing (NDT) Qualification in OECD-NEA member countries” compiles information from the questionnaire, the workshop and from discussions held at the IAGE WG meetings. It presents in a synthetic manner the state of the art on this topic and includes recommendations for activities to be further addressed.

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I CONSIDERATION ON RI-ISI AND NDE QUALIFICATIONS

In-service inspection (ISI) and testing are important means in the defence-in-depth concept to prevent incidents and accidents by detecting any degradation of components and equipment before it can affect the safety of the plant. Moreover, according to international guidance on defence-in-depth strategies[1] maintenance, in-service inspection and testing of structures, systems and components important to safety need to be of such a standard and frequency as to ensure that levels of reliability and effectiveness remain in accordance with the design assumptions and intent, and that the safety of the plant has not been compromised since beginning of operation.

The efficiency of applied ISI programmes, and thereby how well they can fulfil their role, depends on many factors such as strategies and procedures for

- identification and ranking of reactor system parts and components in which failure can have an impact on the safety level,
- identification of components which can be degraded by different kinds of operating conditions,
- determining the extent of inspections and inspection intervals,
- qualification by demonstration of the performance of the non-destructive testing (NDT) systems to be used during inspections.

The early ISI strategies, as well as many presently used, prescribe consequence ranking of components by safety classifications and the selection of specific areas to be inspected, more or less on the basis of design stresses. Many of these strategies also included prescriptive NDT rules with detailed description of equipment to be used and how it should be calibrated. However, during the late 1970s and early 1980s when component failures due to different types of cracking and other types of degradation were observed in several nuclear power plants the degradation problems were in many cases discovered by leakage, and not by in-service inspections. These observations led to concerns about the efficiency of the used in-service inspection strategies. Regulatory bodies therefore began to require additional inspections that were more focused on different types of degradation mechanisms.

Augmented inspection programmes were therefore successively developed for specific mechanisms such as intergranular stress corrosion cracking in piping, high-cycle thermal fatigue in piping and nozzles, erosion-corrosion in piping, etc. During the last five years regulatory bodies in many countries also have began to require more stringent demonstrations (qualifications) of the performance of the NDT systems that are to be used for inspection of safety related components which are susceptible to different kind of degradation mechanisms.

In the same time period the nuclear power generation industry have been facing an increasing economic pressure due to fierce competition in deregulated electricity markets. This has led to a pressure to cut operation and maintenance cost. In this situation many nuclear utilities have started to develop and implement risk-based or risk-informed inspection approaches to optimise the ISI programmes as far as possible.

[1] Defence In Depth in Nuclear Safety, INSAG 10. A report by the International Nuclear Safety Advisory Group. International Atomic Energy Agency, 1996.

However, the introduction of risk based/risk informed ISI strategies, particularly those based on quantitative methods, as well as NDT qualification requirements include both complex technical aspects and some more fundamental aspects. The further implementations and developments of risk based/risk informed inspection and NDT qualification approaches have therefore to be followed closely by the regulatory bodies and their technical support organisations.

Over the last years several guides and code cases have been developed to facilitate the practical implementation of risk informed in-service inspection (RI-ISI) programs. Examples of such documents are US NRC Regulatory Guide 1.178, ASME Code Cases N-577-1 and N-578-1, the EURIS-report and the NRWG-report EUR 19153. Guides and codes have also been published to facilitate the practical implementation of NDT qualification requirements. Examples of such documents are Appendix VIII to ASME Section XI, the NRWG-report EUR 16802 and the ENIQ-report EUR 17299.

The questionnaire is reproduced in Appendix 1. The responses provided by member countries are listed in appendix 2.

II QUESTIONNAIRE ON RI-ISI AND NDT QUALIFICATION DEVELOPMENTS

In order to get a good basis for compiling a report with an overview on the present situation in the OECD countries and regulatory aspects on the further developments of RI-ISI and NDT qualification approaches a questionnaire was prepared. This questionnaire was organised in two parts. The first part addressed used risk based/risk informed ISI approaches and regulatory aspects on the further developments. The second part addressed used NDT qualification approaches and other measures for getting reliable inspection results as well as regulatory aspects on the further developments of qualification approaches

Some parts of questionnaire addressed subjects, which have been dealt with in other European or national programs. Available information from these programs and that are relevant in this context, were included in the SOAR report.

The questionnaire had been circulated among organisations participating in the IAGE and responses had been received from most of the organisations.

Appendix 1 contains the questionnaire.

Appendix 2 contains the compilation of responses to the questionnaire.

III FURTHER WORK

At its meeting in December 2003 the CSNI decided to organise a workshop on RI-ISI and NDT qualification. The purpose of this workshop was to give complementary information for the SOAR by discussing and contrasting experience so far with different RI-ISI applications and NDT qualifications as well as important aspects to be considered in the further development.

The SOAR was finalised in March 2005. The report also included recommendations for further international co-operation in the area of RI-ISI and NDT Qualifications within IAGE and its subgroups.

APPENDIX 1: Questionnaire distributed to NEA member countries

Part 1- Risk based/risk informed ISI approaches

1.1 Describe briefly, or refer to published documents/papers with information on, used or planned risk based/risk informed strategies for identifying in-service inspection needs and extent for
a) piping systems
b) reactor pressure vessels and other passive components of safety importance.
c) reactor pressure vessel internals
d) steam generator tubes
e) reactor containment parts
in your country's nuclear power plants.

1.2 What has been or are the main incentive (optimisation, increasing safety, reducing inspection efforts, ALARA considerations, etc) for introduction of risk based/risk informed ISI strategies and practice.

1.3 Do you apply any prerequisite, such as US NRC in Reg. Guide 1.1.78[2] and discussed in the EURIS document, for the introduction of risk based/risk informed ISI strategies and practices?

1.4 Do your used or planned risk based/risk informed strategies in addition to identifying ISI needs and extent also include methods for determine inspection intervals and its relation to NDT performance (qualification/performance demonstration targets)? If not, what is the basis for inspection intervals?

1.5 What are or will be the strategy in your country to determine the extent of inspections in relation to different risk groups or risk ranking.

1.6 What are or will be the strategy in your country for high consequence components or regions but with low risks due to estimated low failure probability based on present knowledge of the degradation mechanism that can be active?

1.7 Do you have or plan to introduce any requirements on the quality (including level of detail, key assumptions, data sources, modelling approach and sensitivity/uncertainty analysis) of those Probabilistic Risk Analysis (PRA) that shall be used for developing risk informed ISI programs?

1.8 Do you have or plan to introduce any requirements on verification and/or validation of those Probabilistic Fracture Mechanics (PFM) codes/Structural Reliability Models (SRM) that shall be used for developing quantitative risk informed ISI programs?

1.9 What are the general experiences so far, from a regulatory point of view, of applied risk based/risk informed ISI strategies in your country? Do you foresee any changes in the near future?

1.10 What further actions and developments are needed from a regulatory point of view to improve applications of the risk based/risk informed strategies. Your response could for example include comments to the recommendations in the EURIS report.
Indicate also aspects that can be appropriate for further discussions in IAGE or its subgroups

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[2] e.g. demonstrating that the changes

- is consistent with the defence in depth philosophy
- maintains sufficient safety margins
- are risk neutral or result in a small risk increase

Part 2 – NDT qualification/performance demonstration approaches[3]

2.1 Have regulations, licence conditions or codes with requirements on the use of qualified NDT system for pre- and in-service inspections of reactor components been introduced in your country? Please describe briefly the requirements for qualification/performance demonstrations, and when the requirements have been introduced.

2.2 If NDT qualification requirements have not yet been introduced in your country please describe the future plans, or those other measures taken to secure reliable inspection results.

2.3 Are the qualification requirements in force or under a transition period?

2.4 Are the qualification requirements presently applicable to
a) all safety class/risk group components or just some of them?
b) all NDT methods or just NDT systems based on ultrasonic?
c) all components types?
d) both equipment, procedures and personnel?

2.5 What is the basis for derivation component specific qualification requirements, including qualification targets and the relationship, if any, between target size and inspection interval for different components?

2.6 Describe briefly, or refer to published documents/papers with information on, used qualification methodology (e.g i accordance with Appendix VIII to ASME Section XI, European approach as outlined in EUR 16802/17299, etc) in your country.

2.7 Describe how the qualification activities have been organised in your country. What organisations are responsible for:
a) Approval of the infra structure for qualification activities and assessment of the organisations involved?
b) Preparation and assessment of the qualification requirements, e.g. qualification targets, detection and sizing capabilities, for particular reactor components?
c) Preparation and assessment of the technical justifications of NDT procedures?
d) Witnessing, assessment and evaluation of practical trial demonstrations?
e) Issuing, withdrawal and cancellation of qualification certificates?

2.8 What actions are taken in your country to assure that the qualification defects are representative simulations of the defects/cracks that can occur in the plants?

2.9 What are the general experiences so far, from a regulatory point of view, of applied NDT qualification/performance demonstration approaches in your country? Do you foresee any changes in the near future?

2.10 What are the experiences so far of using qualified NDT systems for in-service inspection activities in the plants?

2.11 Discuss what further actions and developments that are needed to improve (from safety, cost-effective point of view, etc) the application of NDT qualification requirements? Indicate also aspects that can be

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[3] Some of these questions are a part of a more detailed questionnaire that presently is circulated among members of the European Nuclear Regulators Working Group (NRWG) Task Force on NDT qualifications. The questions are included here in order to also get information from other OECD/CSNI member countries on addressed subjects.

appropriate for further discussions in IAGE or its subgroups.

APPENDIX 2. Compilation of responses to the OECD/NEA questionnaire on developments of in-service inspections in nuclear power plants

Part 1- Risk based/risk informed ISI approaches

1.1 Describe briefly, or refer to published documents/papers with information on, used or planned risk based/risk informed strategies for identifying in-service inspection needs and extent for
f) piping systems
g) reactor pressure vessels and other passive components of safety importance.
h) reactor pressure vessel internals
i) steam generator tubes
j) reactor containment parts
in your country's nuclear power plants.

Belgium

Risk Based or Risk Informed methodologies have not yet been applied in Belgian NPPs. The present strategy is to remain informed about RI ISI developments in the USA and in Europe. A pilot study could be launched in the future to test the feasibility of this methodology. ISI is now organized according to the requirements of ASME XI code. Some Belgian adaptations to the code are implemented. These adaptations are usually justified taking into account risk information. There is however no plan for applying systematically RI ISI in the near future. Due to this situation, many of following questions are non applicable today.

Canada

In-service Inspection in Canadian nuclear power plant is guided by the CAN/CSA N285.4 "Periodic Inspection of CANDU Nuclear Power Plant Components". Some of Canadian utilities are considering risk based/ risk informed inspection methodologies, but they have not developed comprehensive RB/RI ISI strategies yet. The regulator and the utilities have been applying principles of risk informed decision making in identifying the scope of the in-service inspection program (including the population at risk, sampling size and inspection frequency) for certain components (steam generator tubes, pressure tubes, feeder pipes etc.) for several years.

Czech Republic

Piping systems

At present only risk informed strategies for identifying more general maintenance needs are applied (for example Phare project 1.07/97B). Specific risk informed strategy for identifying ISI needs is not used. Structural reliability models are applied for piping Risk informed strategy aspects are analysed within international co-operation in NURBIM project.

Reactor pressure vessels and other passive components of safety importance. PFM code for RPV probabilistic assessment will be developed, verified and used for VVER type RPVs during a national project and PROSIR RRT project, in which NRI Rez participates. Application of PFM RPV code will not be in near future available and suitable for identifying

RPV ISI needs.

Reactor pressure vessel internals

No application at present and near future.

Steam generator tubes

Application of PFM/SRM code for SG tubes assessment will not be available in near future and suitable for identifying ISI needs.

Reactor containment parts

No application at present and near future.

Finland

Finnish Radiation and Nuclear Safety Authority (STUK) has made a pilot study consisting of two systems in both plants (See “A pilot study on risk informed in-service inspection”, Presented at International Conference on Probabilistic Safety Assessment and Management - PSAM 5, Osaka, Japan, 2000). The results have not been implemented. The power company Fortum is interested in the application of RI-ISI and plans to start a pilot study about 2004. TVO is making a preliminary study on the application.

France

EdF has applied a "qualitative" risk informed approach since the beginning of plant operation (1977) for class 1 components (see C. Buchalet, J. Vauterin "A tentative approach to a more rational preparation of ISI programmes" AIEA document: SM 218/39, 1977). All the consequences at this time was considered has "high" and since reliable PRA not was available inspection were based on the potential degraded locations. For class 2 and 3 components a similar approach is used.

Recently six pilot risk inform studies have been conducted. The results are partially included in the ISI program for the six class 2 and 3 piping systems studied.

EdF have complete ISI-specific applications for steam generators.

Pilot studies are ongoing for RPV and Pressurizers

Germany

Hungary

The present in-service inspection programs for these components are not based on risk in Hungary. In-service inspection programs are based on original Soviet design prescriptions with consideration of recent ISI results and operational experience. It means the deterministic basis for class 1 and class 2 equipment can be modified if the inspection results indicate a declining condition of equipment or unexpected degradation mechanisms appear. Percentage of SG tube inspection was determined on basis of engineering judgement and experience of other WWER reactors. There are plans at the licensee to modify the ISI frequency of Class 1 components (from 4 years to 8 years) and they plan to use risk-informed strategies as well to support this major ISI change.

Japan

Some of the Japanese electric power companies are studying risk based/risk informed inspection methodologies. However, they have not yet introduced the methodologies and do not have any concrete plan for the introduction because of the unresolved issues such as construction of necessary data bases and establishment of the safety goal.

As for risk-informed ISI in Japan, the Japan Power Engineering and Inspection Corporation conducted a METI-sponsored study, "Study on Optimum Periodical Inspection Studying", in fiscal year 1995 through 2000. The study aimed at preparing a draft guideline for applying such methodologies through reviewing the risk-informed ISI methods in the United States and studying the applicability of probabilistic inspection management methods (risk-informed ISI methods) to the nuclear power plants in Japan. (Japan Power Engineering and Inspection Corporation's "Fiscal 2000 Project Report on the Development of the Advanced Safety Management Technologies for Light Water Reactors - Availability Improvement Technologies, etc.")

Korea

Korea is now establishing the framework of risk informed regulation (RIR) including risk informed ISI (RI-ISI). Some applications of risk information such as the change of AOT/STI in Tech. Spec. were approved as case-by-case basis. RI-ISI application will be regarded as one part of the RIR framework.

The current Korean regulatory guidance for ISI is based on ASME Code Sec. XI. Basically, RI-ISI will be applied only to piping systems in Korea. One Korean utility, KHNP, has just completed the pilot plant study on RI-ISI for one Korean Standard Nuclear Power Plant (PWR, 1000MWe) based on the WOG methodology. KHNP will submit the results of the pilot plant study to Korean regulatory body for review and approval in the near future.

Netherlands

Spain

For piping systems there is a Spanish guideline developed by the CSN and Spanish utilities (UNESA) with all the information. This guide follows the principles established in USNRC Regulatory Guides 1.174 and 1.178 and was issued after a pilot study conducted in Spain between the utilities and CSN to verify the feasibility of applying RI-ISI methodology (WOG approach, Code Case N-577).

Regarding the other components, in Spain there is nothing developed up to now.

As a brief summary, in Spain the RI-ISI programs are developed taking into account the safety principles included in the R.G. 1.174 and 1.178. All the RI-ISI programs combine probabilistic and deterministic information in order to identify the scope of the in-service inspection program and the inspection strategies (including the inspection method and the inspection frequency). All the programs have to demonstrate that although the scope is reduced the safety margins are maintained or increased. A small risk increase is allowed according to the Spanish guide, which takes the acceptance criteria from USNRC R.G. 1.174

Sweden

Piping systems

For piping and other components in the piping system a qualitative risk oriented approach is used. This approach was first introduced in 1987. It is based on the division of components and parts thereof into the control groups A–C. After a transition period of five years it became mandatory in 1992 for all components and parts thereof, except reactor pressure vessels and some steam generator parts. For the reactor pressure vessel and for steam generator tubes special rules still apply. (See further in the answer to question 1.1 b and c).

The division shall be such that it takes into account the risks for nuclear fuel damage, discharge of radioactive materials, unintentional chain reactions, and the degradation of the other safety levels as a result of cracking or other degradation process. In this respect, both the probabilities that such cracking or other degradation will occur in the specific component or component part must be taken into account, as well as the possible resultant consequences. Structural parts for which the resulting risks are assessed to be highest are assigned to control group A. Structural parts for which the risks are assessed to be lower than for group A are assigned to control group B. Structural parts for which the risks are assessed to be low are assigned to control group C.

For the practical application of this approach a qualitative system was developed where the division into the control groups is performed according to a risk matrix and assignment of a damage index and a consequence index to each component and parts thereof.

The consequence index gives a qualitative measure of the likelihood that a crack or other degradation process will result in nuclear fuel damage, damage to the reactor containment tightness, discharge of large amounts of radioactivity or other damage which could lead to ill health or an accident. In reactor plants the consequence index is determined mainly by the margin to such consequences as the result of a break or malfunction of the specific component or system part. Two aspects of importance when determining consequence index are:

- system technical margins, i.e. how many systems or system circuits that are essential in relation to how many are available, and
- thermal technical margins, i.e. how much the fuel can be heated up, in relation to the values which are considered to be acceptable.

The damage index gives a qualitative measure of the likelihood for crack formation or other degradation process occurring in the specific component, and it is determined by the probable loads and environment in relation to dimensions and material properties of the component. Components or parts which may be exposed to loads or other conditions which experience has shown can result in the occurrence of damage should be assigned damage index I. Components or parts which may be exposed to loads or other conditions which experience has shown are not expected to result in the occurrence of damage should be assigned damage index II. Components or parts, which are considered to be exposed to minimal loads or other benign operational conditions, should be assigned damage index III.

All components assigned to control group A should be inspected. For control group B an inspection sample of at least 10%, taken on random basis, is considered to be acceptable. For components and parts thereof assigned to control group C, and where the radiological the risks are assessed to be low, the inspection extent and interval should comply with the regulations of the Swedish Board of Occupational Safety and Health concerning inspections of boilers, and suchlike.

Inspection intervals are variable and depending on the detection capability of the qualified NDT systems used, damage tolerance of the component in question and the growth rate of the relevant degradation mechanism. However, with a maximum interval of 10 years. The NDT systems used for in-service inspection of component parts assigned to group A and B shall to be qualified in agreement with SKI's regulations and guidelines, which in this context are based on EUR 16802[4].

Reactor pressure vessels

No risk informed inspection approach is presently used for the main butt welds in reactor pressure vessels or for the safe-ends and inner radius in vessel nozzles. These welds and vessel reactor pressure parts shall be inspected at intervals not exceeding ten years. The more precise intervals, within the ten years limits, between reactor pressure vessels inspections are determined by the detection capability of the qualified NDT systems used, damage tolerance of the component in question and the growth rate of the relevant or postulated degradation mechanism.

Reactor pressure vessel internals

A simplified qualitative risk oriented approach is used for identification of inspection needs for other parts of reactor pressure vessels (e.g. instrument and control rod penetrations) as well as for reactor vessel internals. The approach includes accordingly both considerations of failure potentials and consequences of failure.

Steam generator tubes

No risk informed approach is presently used for in-service inspection of steam generator tubes. The practice for inspection of tubes in new steam generators and where no active degradation mechanism has been observed is such that all tubes are inspected in their full extension every 5-6 years. However, for the old steam generators in Swedish plants, which have stress corrosion susceptible tubes more frequent and extensive inspections, are performed. In these generators the identification of inspection needs is consequently based on failure potentials.

Reactor containment parts

No risk informed approach is presently used for in-service inspection and testing of reactor containment. Several licensees have however plans to use performance based inspection and testing approaches based on option B in US NRC 10CFR50, Appendix J.

<u>Switzerland</u>

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[4] Common position of European regulators on qualification of NDT systems for pre- and in-service inspection of light water reactor components. EUR16802. European Commission 1997.

Inservice Inspection in Swiss nuclear power plants is guided by the "SVTI Festlegung" NE-14. For class 2 components, NE-14 has pursued a simple qualitative risk-informed approach from the beginning (though it was not called "risk-informed"). The approach was revised in 1999, but still needs further development with regard to recent methodologies. The existing interest in risk-informed inservice inspection was recently strengthened by licensees desire to adopt the ASME/WOG and EPRI risk-informed methods to class 1 piping systems. Pilot projects have been carried through in two Swiss NPPs, and the HSK followed them as an observer. The HSK has launched an internal project to establish the prerequisites and appropriate guidance for the application of risk-informed methods to piping systems. The following answers to questions 1.2 to 1.10 will focus on the current and future developments.

United Kingdom

The NII assessment of nuclear safety cases is on the basis of risk analysis and engineering principles-see the NII Safety Assessment Principles (SAPs) http://www.hse.gov.uk/nsd/saps.htm -and the Health and Safety Executive (HSE) document "The Tolerability of Risks from Nuclear Power Stations" (TOR). TOR is only available as a paper copy. However the more general HSE framework for decision taking (Reducing Risks, Protecting People) is based on TOR and this is available as a pdf document at http://www.hse.gov.uk/dst/r2p2.pdf.

The NII SAPs recognise cases where it is difficult to quantify risk, for instance where failure rate data is not firmly based. Tenuous failure rate data (whether actuarial or synthesised) can undermine decisions based on estimates from complex calculations of either absolute risk or comparative risk between components.

NII has no formal requirements for risk based / risk informed approaches to In-Service Inspection (ISI). NII would assess the role, importance and contribution of ISI to a safety case on its merits, rather than consider ISI in isolation. Rather than concentrating exclusively on the methods by which an ISI plan was produced we would look closely at the outcome, to assess whether the plan made sense in deterministic engineering terms.

Engineering aspects we would consider include:

1. What importance does the structural integrity safety case of a component or set of components have for the nuclear safety case;

2. What is the structural integrity safety case for the components and what role does ISI play within this structural integrity safety case;

3. Is the proposal intended to modify a current general sampling coverage inspection;

4. Is the proposal intended to modify a current general 100% coverage inspection of defined regions – for instance welds (e.g inspections of parts of some components which come under the UK definition of Incredibility of Failure components or "No Break Zone" pipework);

5. Is inspection for specific active degradation mechanisms affected or are specific enhanced inspection programmes treated separately;

6. Do the consequences of component failure considered include the internal hazard aspects for adjacent systems (e.g pipewhip etc) as well as the functional capability of the system in

which the failure occurs (e.g inability to deliver fluid).

The NII SAPs state that a nuclear plant should be so designed that defence in depth against potentially significant faults or failures is achieved (Principle P65).

All UK industry, including nuclear installations, must comply with the requirements of the Health and Safety at Work etc Act 1974 (HSW Act). Sections 2 and 3 of the HSW Act require that measures necessary to avert risk must be taken until or unless the cost of those measures, whether in money, time or trouble, is grossly disproportionate to the risk which would thereby be averted. In short, risk must be reduced to a level which is as low as reasonably practicable (ALARP) - the ALARP principle. Information on ALARP is given in:

http://www.hse.gov.uk/dst/alarp1.htm
http://www.hse.gov.uk/dst/alarp2.htm
http://www.hse.gov.uk/dst/alarp3.htm

NII considers the ALARP principle in its assessments of safety cases for nuclear installations. Often this will be on the basis of judgement rather than precise quantification.

Considerations of tolerability of risk, defence in depth and ALARP would particularly feature in NII assessment of components / regions where the frequency of failure of the component / region is *required* to be low for the overall nuclear safety case. The role of ISI is just one element in the overall structural integrity safety case NII would expect to be produced by the Licensee to argue the requirement is achieved.

The concept of a limit of tolerability is translated in the NII SAPs into basic safety limits (BSLs). Each BSL is complemented by a basic safety objective (BSO). The BSOs define the point beyond which the NII assessor need not seek further safety improvements from the Licensee in the quest for ALARP. The Licensee is not given the option of stopping at the BSO. ALARP considerations may be such that the Licensee is justified in stopping before the BSO level is reached. But if it is reasonably practicable for the Licensee to provide a standard of safety better than the BSO, he is obliged to do so. When numerical estimates of risk are uncertain, the BSLs and BSOs provide a point of reference for engineering judgement.

If risk based / risk informed approaches to ISI mean methods which involve Probabilistic Safety Analysis (PSA) and Probabilistic Fracture Mechanics (PFM), then no use is currently made of these approaches for UK licensed nuclear installations. We are not aware of any definite plans to introduce such approaches. There are examples of more qualitative approaches being used in the UK.

United States of America

Present and planned risk informed in-service inspection applications are described in the following documents:

U.S. NRC Regulatory Guidance Documents:

1 Regulatory Guide 1.174
2 Regulatory Guide 1.178
3 Standard Review Plan 3.9.8

Industry Topical Reports:

a) Westinghouse Owners Group (WOG) Topical Report 14572, Revision 1-NP-A, Feb. 1999

b) Electric Power Research Institute (EPRI) Topical Report TR-112657, Revision B-A, Feb. 2000

ASME Code Activities:

Code Case N-560-2
Code Case N-577-1
Code Case N-578-1
Code Case N-658 (Under Preparation)
Code Case N-660 (Under Preparation)
Nonmandatory Appendix X
Some preliminary work on changing PWR reactor pressure vessel (RPV) inspection interval.

A Task Group has been established to formulate risk-Informed inservice inspection (RI-ISI) strategies for reactor containment structures and its components.

1.2 What has been or are the main incentive (optimisation, increasing safety, reducing inspection efforts, ALARA considerations, etc) for introduction of risk based/risk informed ISI strategies and practice.

Belgium

Main incentives would be optimization of ISI (concentrate efforts where the risk really is).

Canada

Increasing the safety and optimisation of inspection activities of aging nuclear power plants is the main incentive, for both, CNSC and Canadian licensees.

Czech Republic

For future activities: ISI needs - selection of sensitive inspection areas, ISI programme optimisation and potential reducing inspection efforts.

Finland

From the authorities point of view increasing safety by mapping places vulnerable for different ageing mechanisms and ALARA are important. Optimisation and reducing of inspection efforts gives the incentive to the power companies.

France

Sampling methods, as ASME XI, have never been used in French plants. However, optimisation of existing practices is needed to reduce and to focalise ISI on key locations

Germany

Hungary

Reducing inspection efforts without safety level decreasing.

Japan

The incentives of the "Study on Optimum Periodical Inspection Studying" were effective use of resources (human, facilities and financial) and streamlining of safety assuring activities for nuclear power stations.

Korea

Main incentives for RI-ISI would be ‘reducing inspection efforts’ and ‘ALARA consideration’ in Korea. Korean utility expects about 50~60% reduction of inspection points in piping.

Netherlands

Spain

The main incentive for introduction of RI-ISI programs is the optimisation of the in-service inspection (optimisation means reducing the inspections while maintaining or increasing safety), even though a small risk increase is allowed. The application of RI-ISI strategies is aimed to reduce inspection efforts which has a benefit from the ALARA point of view and would allow best allocation of resources.

Sweden

Optimisation of inspection efforts and increasing safety was the main incentive, for both SKI and the Swedish licensees, when the presently used qualitative risk oriented approach was introduced in the early 1990s. This will also be the most pronounced driving force for the further development of quantitative risk informed in-service inspection strategies in Sweden.

Switzerland

The HSK favours risk-informed inservice inspection, because it believes that the inclusion of service experience and PRA insights can provide a broader technical basis and make ISI more effective and efficient. Licensees stress economic reasons.

United Kingdom

(see answer to question 1.1)

United States of America

During the past several years, both the U.S. NRC and the nuclear industry have recognized that probabilistic risk assessment has evolved to the point that it can be used increasingly as a tool in regulatory Decision Making. In August 1995, the NRC published a policy statement that articulated the view that increased use of PRA technology would 1) enhance regulatory Decision Making, 2) allow for a more efficient use of agency resources, and 3) allow a reduction in unnecessary burden on licensees. In order for this change in regulatory approach to occur, guidance must be developed describing acceptable means for increasing the use of PRA information in the regulation of nuclear power reactors.

The NRC developed a PRA implementation plan that included development of RG 1.178 and SRP 3.9.8 for utilizing risk-informed methodologies in the areas of ISI. The RI-ISI RG and SRP provide guidance to nuclear power reactor licensees and NRC staff reviewers for utilizing risk information to support requests for changes in a plant's inservice inspection program for piping. The increased use of PRA information as described in the RI-ISI RG/SRP is voluntary.

In addition to the NRC activities, industry also developed methodologies for implementing RI-ISI of piping. These methodologies are sponsored by WOG and EPRI. As an integral part of the industry initiatives, ASME Section XI developed three Code Cases for implementing RI-ISI based on WOG and EPRI methodologies

Acceptance guidelines included in the RG 1.178 state that only small increases in overall risk are to be allowed under the risk-informed program. An improved prioritization of industry and NRC staff resources, such that the most important areas associated with plant safety receive increased attention, should result in a corresponding contributor to a reduction in risk.

It is believed that the changes in regulatory approach provided for in RG 1.178 and SRP 3.9.8 will result in significant improvement in the allocation of industry and NRC resources, and at the same time, the program can be implemented while maintaining an adequate level of safety at the plants that choose to implement risk-informed programs.

1.3 Do you apply any prerequisite, such as US NRC in Reg. Guide 1.1.78[5] and discussed in the EURIS document, for the introduction of risk based/risk informed ISI strategies and practices?

Belgium

Canada

No specific prerequisite has been formulated at the present time. However, it is expected that CNSC will develop such prerequisite in near future.

Czech republic

Risk based/risk informed ISI strategies are not introduced yet.

Finland

USNRC and EU documents on RI-ISI are used in the context of the pilot study. It is expected that the safety level is better if there are moderately less inspections. If the reduction of inspections is dramatic, the authorities would require more evidence on how to the maintaining of the safety level.

France

EdF have own practices presented in EURIS or RIBA project documents, or ENIQ future documents.

Germany

Hungary

Reg. Guide 1.178 is used as part of background material in elaboration of new regulations for maintenance effectiveness monitoring program. These regulations are expected to come into force in 2007.

Japan

In conducting the "Study on Optimum Periodical Inspection Studying", reference was made to US NRC Reg. Guide 1.178, ASME Code Case N-560, 577, 578, ASME Risk-Based Inspection – Development of Guidelines, etc.

Korea

The USNRC Reg. Guide 1.174 & 1.178 and SRP 3.9.8 will be used as technical bases for RI-ISI in Korea with some modifications and Limitations as follows; (1) Small increase of risk after the RI-ISI application given in Reg. Guide 1.174 will not be permitted in Korea. Korean

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[5] e.g. demonstrating that the changes

- is consistent with the defence in depth philosophy
- maintains sufficient safety margins
- are risk neutral or result in a small risk increase

pilot plant study shows that only 8 inspection points may be added to satisfy this requirement. (2) Qualification of UT shall be introduced prior to RI-ISI application to increase the reliability of UT. (3) Current augmented ISI program shall be excluded from the RI-ISI scope. (4) Adequate PRA quality on data, assumption, methods, and peer review shall be ensured for the purpose of RI-ISI application.

Netherlands

Spain

Yes, after the definition of the program the owner has to demonstrate that the application is risk neutral or the increase in risk is within the allowable limits (defined in RG 1.174 and RG 1.178). Additionally the application has to be consistent with the defence in depth philosophy and the safety margins must be maintained or increased.

Sweden

No prerequisite has been formulated so far. It is however expected that SKI will apply such prerequisite for the further optimisation of in-service inspection programmes by the use of quantitative risk informed strategies.

Switzerland

The HSK is on the way to define the prerequisites. All relevant information available will be considered.

United Kingdom

(See answer to question 1.1)

United States of America

The NRC applies RGs 1.174 and 1.178 as prerequisite for the overall implementation of RI-ISI in practice. In addition, the staff has reviewed and approved WOG and EPRI Topical Reports referenced in response to Question 1.1 for the detailed implementation of RI-ISI methodologies, and therefore, accepts plant specific RI-ISI submittals that comply with either of these two methodologies. The NRC staff is also working with the ASME Code personnel to develop a plan to revise and then approve the relevant ASME Code Cases, with conditions, if necessary.

1.4 Do your used or planned risk based/risk informed strategies in addition to identifying ISI needs and extent also include methods for determine inspection intervals and its relation to NDT performance (qualification/performance demonstration targets)? If not, what is the basis for inspection intervals?

Belgium

RI strategy will most probably consider all aspects of the inspection programme, including interval between inspections. Qualified performances of NDT methods will certainly be one of the information taken into account to assess the risk.

Canada

The basic requirements for the inspection intervals are defined by the CAN/CSA N285.4 but it is allowed to define different inspection intervals for different components and the areas at risk on a case by case fitness-for-service criteria. Inspection samples prescribed in CSA/CAN N285.4 are 100% of inspection program in first 5 years and then 100% of inspection program in lesser of 10 years or 1/3 of design lifetime. The inspection intervals for fitness-for-service are determined by the detection and sizing capability of the qualified NDE techniques, the growth rate of known degradation mechanism and the structural limit of specific components. The NDE methods and personnel must be federally qualified for site specific degradation mechanisms. It is expected that the inspection interval determination will be integral part of any future risk based/ risk informed ISI strategies.

Czech Republic

It would be desirable – both inspection intervals and relation to NDT performance. Current practice: Inspection interval, if it is not used a general 4 years interval, prescribed by the original Russian Code is derived using a deterministic enough conservative crack growth assessment, taking into account degradation of material properties, design/operational loadings, etc.

Finland

No plans. Normal inspection interval is 10 years according to ASME XI. Welds vulnerable to SCC are inspected every 3 or 5 years and high cycle thermal fatigue areas are inspected every 3 years.

France

ISI needs are connected to deterministic periodically updated studies of major degradation mechanisms (corrosion, fatigue, embrittlement…)

Germany

Hungary

In-service inspection intervals were originally determined by soviet design requirements. These are much shorter than intervals used in ASME BPV Section XI (4 years in the primary circuit and 8 years in the secondary circuit). A thorough analysis of material properties, original manufacturing QA-requirements and other special features is needed to extend these intervals. That's why is not easy for the regulator to allow the use of new ISI strategies.

Japan

The preliminary evaluation made in the "Study on Optimum Periodical Inspection Studying" was based on the guidelines described in the answer to the question 1.3. Since those references do not include the methods for determining the inspection intervals or NDT performance, the intervals were determined on the basis of the NPP operating experience in the past.

Korea

As answered in the 1.3 above, we will consider the NDT qualification prior to the RI-ISI application. However, we think it is not easy to quantify the risk insight for the inspection interval. We are now reviewing the effect of the inspection interval change on the plant risk.

Netherlands

Spain

The basis for the inspection intervals are the ASME XI inspection frequencies Code Cases but it is allowed to define different inspection intervals appropriate for the different areas taking into account the postulated mechanism, the inspection method and the final risk value. The NDT methods must be qualified for the specific failure mechanism, but this aspect is actually under development in Spain.

Sweden

According to the present practice inspection interval are determined by the detection capability of the qualified NDE systems used, damage tolerance of the component in question and the growth rate of the relevant or postulated degradation mechanism. It is expected that future strategies will include risk considerations also for inspection interval determination. Such approach has been demonstrated in one of the pilot studies performed in Sweden.

Switzerland

Yes. It is logical to include inspection intervals and NDT performance (qualification, performance demonstration) in the risk-informed scheme for in-service inspection.

United Kingdom

(See answer to question 1.1)

United States of America

Currently, for the implementation of RI-ISI for piping in the U.S., inspection intervals and periods are maintained as those currently specified in the ASME Section XI. However, since inspections are eliminated at some locations, inspection intervals for those locations, in essence, become infinite. There is some work underway by ASME to change the inspection interval for PWR RPV inspections.

The RI-ISI methodologies are based on targeted examination volumes (typically associated with welds) and methods of examination based on the type(s) of degradation expected. The implementation of these RI-ISI examinations guidelines should result in improved detection of service-related degradations over those currently required by exiting codes.

1.5 What is or will be the strategy in your country for determine extent of inspections in relation to different risk groups or risk ranking.

Belgium

Canada

The strategy for risk based determination of the extent of inspections is still under consideration. Traditional engineering analysis combined with probabilistic calculations is used on case by case in scoping inspection plans for certain components (steam generator tubing). Inspection standard is based on accident analyses from safety report which is part of licensing basis.

Czech Republic

Common European approach to RI-ISI is expected to be developed as in the past the NDT qualification methodology by ENIQ. Such an approach would be understood as a guide for a national strategy development and further practical implementation.

Finland

The strategy is not chosen. A new revision of Finnish Regulatory Guide YVL 3.8 "Nuclear Power Plant Pressure Equipment. Inservice Inspections" is in the course of preparation. The references in the Guide are ENIQ Report nr. 21 EUR 19742, USNRC Regulatory Guide 1.178, ASME Code Cases N-560, N-577 and N-578.

France

EdF apply a step by step process that include to:

- rank the locations with potentiality of degradation
- define performance and periodicity through deterministic analysis

Perhaps in the future use the safety consequences of degradation on CDF or LERF can be used, however it cannot be accepted by French safety authority in a short term period.

Germany

Hungary

The risk ranking strategy has not been elaborated yet.

Japan

The preliminary evaluation made in the "Study on Optimum Periodical Inspection Studying" used the PSA results and adjusted the opinions at the expert panel.

Korea

Because Korean utility uses the WOG methodology for RI-ISI in Korea, they also use the WOG strategy for the determining the extent of inspection. We think the WOG strategy may be acceptable if they agree with some limitations and modifications described in the answer of 1.3 above.

Netherlands

Spain

In Spain we follow the strategy established in Code Case N-577 (quantitative methodology). That's to say: for High Safety Significant (HSS) segments with High Failure Potential (HFP) all areas (welds) are included in the inspection program. For HSS segments with Low Failure Potential (LFP) a sample is selected for inspection. For Low Safety Significant (LSS) segments with HFP an owner defined program is used and for the LSS and LFP only pressure test and the companion VT-2 exam are required. The categorization of the segments is established by an experts' panel in different areas.

Sweden

In the present qualitative system used in Sweden for piping systems the inspection extent required for high-risk components (control group A) are 100%. For medium and low risk components sampling is acceptable. For these, a fixed percentage of e.g. 10% can be appropriate. However, in some situations statistical models and sensitivity analysis are necessary for determining the appropriate sample sizes.

Switzerland

The strategy for determining the extent of inspections in relation to risk ranking is still under consideration. The existing schemes are studied.

United Kingdom

United States of America

RG 1.178 and SRP Chapter 3.9.8 guidelines describe an integrated approach that should be utilized to determine the acceptability of the proposed RI-ISI program by considering in concert the traditional engineering analysis, risk evaluation, and the implementation and performance monitoring of piping under the program. In the U.S., two methodologies, by WOG and EPRI, have been utilized for the detailed implementation of RI-ISI programs at more than 45 plants.

For the WOG methodology, Sections 3.7.1 and 3.7.2 of WCAP-14572 address the criteria used to determine the number of structural elements selected for examination, consistent with the safety significance and failure potential of the given pipe segment. The RI-ISI program includes examinations of high safety-significant (HSS) elements contained in Regions 1 and 2 of the element selection matrix (high safety-significant and high failure importance). By the WCAP-14572 selection process, 100% of the susceptible locations (Region 1A) are examined. Elements in Regions 1B and 2 are generally subject to a statistical evaluation process. This process is intended to be used on highly reliable piping to establish a statistically relevant sample size and verify the condition of the piping. In cases where an active degradation mechanism exists, particularly where there is an ongoing augmented program, it is inappropriate to use the statistical model for element selection. In these cases, the expert panel must apply other rationales for selecting the number of elements to examine. Additional guidance is provided in Section 3.7 of WCAP-14572 to address sample size selection in cases where the statistical model could not be applied to state that “additional rationale must be developed when a statistical model cannot be applied to determine the minimum number of examination locations for a given segment.” In conclusion, in the WOG methodology, all HSS segments with known degradation mechanisms will be subject to 100% examination, HSS segments with no known degradation mechanism will be sampled for examination on a sound statistical basis to ensure that a specified target leak frequency is not exceeded at the pre-specified confidence level of 95%, LSS segments with known degradation mechanisms will be subject to examination in accordance with the licensees defined program, and the final scope of examination will result in a change in risk consistent with RG 1.174 guidelines.

The EPRI methodology guidelines specify that the number of locations to be volumetrically examined as part of the RI-ISI program is as follows: For piping segments that are in Risk Category 1, 2, or 3 (High risk), the number of inspection locations in each risk category should be 25 percent of the total number of elements in each risk category. For Risk Categories 4 and 5 (Medium risk), the number of inspection locations in each category should be 10 percent of the total number of elements in each risk category. Volumetric examinations are not required for those segments determined to be in Risk Category 6 or 7 (Low risk). However, all elements, regardless of the risk category, are to be subjected to pressure-/leak-testing requirements under the ASME XI Code. For ASME Code Case N-578 applications that include Class 1 piping, the EPRI methodology recommends reviewing any resulting Class 1 inspection populations that are less than 10 percent of the Class 1 piping population. The EPRI methodology also discusses special treatment for those segments not included in the existing plant augmented inspection programs, such as flow accelerated corrosion (FAC) and intergrannular stress corrosion cracking (IGSCC) inspection programs.

For systems that are subject to localized corrosion, for example, service water systems, the degradation mechanisms for MIC, pitting, and flow-induced erosion-cavitation are expected to dominate. For such systems, the examination selection guidance is not practical in that localized corrosive attack can occur within substantially large portions of the piping and is not necessarily associated with a discontinuity such as a weld. Section 3.6.7 of EPRI TR-112657, includes a detailed process description and guidance for licensees to conduct “finer screening” evaluations for these systems. The method recognizes that there is variation in the severity of these degradation mechanisms (e.g., areas close to biocide injection may experience degradation greater than predicted from nominal biocide concentrations) and variation due to geometrical properties (e.g., enhanced deposition at the bottom of long vertical runs). A preliminary element selection is based on the identification of worst case areas and a selection of typical areas. The final element selection includes a sampling of High consequence segments not captured by the preliminary selection and the substitution of higher consequence elements for lower consequence elements of the same or similar susceptibility. This degradation susceptibility review process, augmented by the selection of higher risk locations, is a systematic and reasonable method for considering engineering and risk insights in establishing a program to assess service-induced degradation due to variable, localized corrosion.

1.6 What are or will be the strategy in your country for high consequence components or regions but with low risks due to estimated low failure probability based on present knowledge of the degradation mechanism that can be active?

Belgium

In the past, when ISI programme has been optimized (Belgian adaptation to ASME XI), inspection has been maintained on high consequence components. This approach will probably be maintained if RI approach is systematically used.

Canada

The longstanding CNSC position has been that in-service inspections should ensure:

- a low probability of spontaneous component failure, in terms of occurrence per plant year, under normal operating conditions;
- a very low probability of component failure under accident conditions, in terms of the probability of occurrence of a design basis accident and consequential failures;
- limiting primary to secondary leakage during normal operation and during postulated accidents within regulatory dose limits.

According to current strategy, high consequence components are subject to examinations, regardless of whether the probability of failure is low or high.

Czech Republic

Current approach is conservative as for high consequence components or regions but with low risks due to estimated low failure probability. The scope of ISI for these regions will be maximum and performance required with qualified NDT methods will be required. We wait for verified European best RI-ISI practices.

Finland

The reactor pressure vessels and maybe primary loops in PWRs will be inspected about in the same extent as now regardless of low risk values.

France

Low failure probability connected to no active degradation mechanism = no inspection, independently of safety consequences.

Germany

Hungary

These measures have not been defined yet.

Japan

See the answer to the question 1.5.

Korea

The expert panel would analyze these components and regions.

Netherlands

Spain

These areas area analysed by the experts' panel and the panel decides what to do. Additionally, at least one area in each group of similar High consequences segments is examined.

Sweden

According to SKI's view in-service inspections have two similar but slightly different roles:

- to ensure that the probability of failure of safety significant components is low or negligible by detecting any degradation of components and equipment before it can affect the safety, and
- to provide confidence that the probability of failure of such components is low or negligible.

To fulfil these roles in-service inspection programmes have to include both components identified by risk ranking and an appropriate sample of such high consequence components or regions with low risk due to estimated low failure probability based on current knowledge. The present qualitative risk oriented approach used in Sweden for piping systems address such high consequence components.

Switzerland

High consequence components or regions with low risk due to estimated low failure probability based on present knowledge deserve adequate inservice inspection. What has to be regarded as adequate within a risk-informed scheme is still under consideration.

United Kingdom

(See answer to question 1.1)

United States of America

In the WOG methodology, HSS segments are subject to examinations, regardless of whether the failure potential is low or high. If the failure potential is high, and the segment is subject to a known degradation mechanism, 100% of elements in the segment are examined. If the failure potential is high but there is no known degradation mechanism, or the failure potential is low, a statistical examination sample is chosen with the objective of keeping the leak rates below those that have been found in the past. In the EPRI methodology, high consequence segments with low potential of pipe rupture are classified as Medium risk, for which 10% of elements are selected for examination. Further details are provided in response to Question 1.5, and in the WOG and EPRI Topical Reports referenced in response to Question 1.1.

1.7 Do you have or plan to introduce any requirements on the quality (including level of detail, key assumptions, data sources, modelling approach and sensitivity/uncertainty analysis) of those Probabilistic Risk Analysis (PRA) that shall be used for developing risk informed ISI programs?

Belgium

For every tools, method, technique, etc. that are used to specify and/or implement the ISI programme, it is a normal practice in Belgium to have requirements on the quality and to verify the conformity to these requirements.

Canada

A new CNSC Regulatory Standard S-294 “Probabilistic Safety/ Risk Assessment (PSA/PRA) for Nuclear Reactors” deals with the PSA/PRA and specify requirements on the quality of PRA.

Czech Republic

Requirements on quality are introduced for PRA generally, not introduced for developing risk informed ISI programs.

Finland

The Finnish Regulatory Guide YVL 2.8 (Probabilistic safety analyses, PSA) deals with the PRA and gives more detailed requirements on the quality of PRA.

France

No specific development or sensitivity studies for RI-ISI/IST,
only review of initiator frequency with experience feedback and ageing

Germany

Hungary

There are no quality criteria for the PRA accepted by the regulator yet.

Japan

The preliminary evaluation made in the "Study on Optimum Periodical Inspection Studying" assumed that the current PSA was a right one. However, the draft guideline for applying the risk-informed in-service tests (RI-IST) methods which was prepared in the study describes the appropriateness of PSA models as follows.

- PSA methodologies should be those specified in appropriate PSA guides. In addition, handling of uncertainties in the analysis models/parameters and common cause failures and failures due to human errors should be clearly shown.
- Highly reliable values should be used for the component failure rate data, etc.
- The basis of engineering judgment should be clearly shown where applicable.
- Handling of external events should be clearly shown.

Korea

As answered in 1.3, adequate PRA quality on data, assumption, methods, and peer review shall be ensured for the purpose of RI-ISI application.

Netherlands

Spain

Spanish utilities have already developed PRAs of enough quality to allow them to initiate Risk Informed applications. All PRAs are evaluated and accepted by CSN. In any case, all applications are also evaluated and authorised by CSN before they are implemented, and CSN can introduce specific requirements, if deemed necessary.

Sweden

According to SKI's general guidelines, in SKIFS 2000:2, for in-service inspections all analysis models used should be validated and input data should be quality-assured. Furthermore, the possibilities and limitations of the models should be documented with respect to the capability of predicting degradation and consequences in adequate detail. Also the effects of uncertainties in models and input data should be studied through sensitivity analyses. This applies to both Probabilistic Risk Analysis (PRA) models and Probabilistic Fracture Mechanics (PFM) codes/Structural Reliability Models (SRM).

Switzerland

Yes. Requirements on the quality of PRA analyses used to develop risk-informed ISI programs will be established.

United Kingdom

(See answer to question 1.1)

United States of America

The scope, level of detail, and quality of a PRA and the general methodology for using PRA in regulatory applications is discussed in RG 1.174. RG 1.178 provides guidance that is more specific to ISI.

The PRA results characterize the specific attributes at the plant in a manner that can support and confirm the basic assumptions of the general methodology and the RI-ISI methodologies include systematic consideration of initiating events and operating states outside the scope of the licensee's PRA such as external events and refueling operation. Plant-specific PRA results are used to support placing pipe segments into broad risk-significant categories and to support risk evaluations in order to investigate the potential change in risk as a result of the proposed change in the ISI program. The NRC staff notes that in support of all risk-informed applications, the licensee is responsible for developing, and retaining on site for potential NRC audits, justification that the PRA is of sufficient quality and that there is reasonable assurance that the general results and conclusions of the proposed program change are valid.

1.8 Do you have or plan to introduce any requirements on verification and/or validation of those Probabilistic Fracture Mechanics (PFM) codes/Structural Reliability Models (SRM) that shall be used for developing quantitative risk informed ISI programs?

Belgium

For every PFM code or SRM, it is a normal practice in Belgium to have requirements on verification and/or validation.

Canada

The CNSC Regulatory Guide G-149 “Computer Programs Used in Design and Safety Analyses of Nuclear Power Plants and Research Reactors” provides general guidance to licensees on the development, maintenance and use, including verification, of computer programs used in the design and safety analysis of nuclear power plants.

Czech republic

Requirements on verification and/or validation of PFM/SRM codes are included in the future plans. PFM code for RPV probabilistic assessment will be verified within a national project and simultaneously during PROSIR RRT project through benchmark tests. Other first of all SRM codes will be verified on benchmarks and testing within NURBIM project, where NRI participates. PRAISE code due to worldwide application has been used without additional special requirements on verification.

Finland

The power company decides on the approach. If they apply PFM-method, STUK will ask on verification and/or validation.

France

EdF are reviewing set of probabilistic code for RPV integrity, rupture of components, fatigue, corrosion, corrosion-erosion, and a SG code. A new one is under development for fatigue and for LBB.

Germany

Hungary

There are no V/V requirements on PFM models yet.

Japan

The preliminary evaluation made in the "Study on Optimum Periodical Inspection Studying" did not require the verification/validation. We do not yet have a plan to introduce any requirements on verification and/or validation.

Korea

The Probabilistic Fracture Mechanics (PFM) codes/Structural Reliability Models (SRM) used in RI-ISI application shall be verified by use of the other code.

Netherlands

Spain

During the development of the Spanish guide mentioned above two PFM codes were analysed, cross compared and used in two different pilot studies with acceptable results. Nevertheless, one conclusion arisen from the Spanish guide recommends to perform uncertainty and/or sensibility analysis and verify PFM code internal coherence.

Sweden

See the answer to question 1.7.

Switzerland

Yes. Computer Codes utilised to determine failure probabilities must be validated. Requirements should be established.

United Kingdom

(See answer to question 1.1).

United States of America

The WOG methodology for RI-ISI of piping is based on industry experience and the Structural Reliability and Risk Assessment (SRRA) computer code to determine the failure probabilities of piping segments. The staff believes that the purpose of the piping failure probability estimation is to provide a relative estimate of the piping failure potential in order to differentiate the piping segments based on potential failure mechanism and postulated consequences. The relative failure probabilities of piping segments provide insights for use by the expert panel in defining the scope of inspection for the RI-ISI program. The NRC staff had a peer review performed with regard to using structural reliability and risk assessment computer codes to estimate the probability of a piping failure. The peer review, performed by Battelle-Columbus, and concluded that the SRRA computer code is technically sound and within the state-of-the-art, and that its application can facilitate risk-informed regulatory decision-making in the area of ISI. While ASME-Research and the WOG developed methods to perform RI-ISI programs for piping, the NRC staff held public meetings with both groups to develop guidelines for acceptable uses of probabilistic fracture mechanics computer codes. In addition, with the assistance of Pacific Northwest National Laboratory (PNNL), the staff performed independent audit calculations to validate the results of the SRRA computer code.

The EPRI methodology for RI-ISI of piping is based on the relative failure potential of piping segments insights for defining the scope of inspection for the RI-ISI program. Determination of piping failure potential is discussed in Section 3.4 of EPRI TR-112657, Rev. B. The basis for this assessment includes evaluating the degradation mechanisms for each pipe segment using the attributes and evaluation criteria presented in that section of the Topical Report, followed by categorizing the potential for a large pipe failure according to the degradation category. Table 3-14 of EPRI TR-112657, Rev. B, provides guidance and criteria for assessing the degradation mechanism. In the EPRI methodology, although the consequences of piping failures are evaluated assuming a large break, the pipe break failure potential rankings are based upon specific degradation mechanisms to which the pipe segment is postulated to be susceptible. Only a pipe segment that is susceptible to FAC receives a high pipe failure potential, unless that segment is susceptible to a degradation mechanism other than FAC and also has the potential for water hammer. EPRI TR-112657 describes how insights from service experience formed the technical basis for the pipe failure degradation categories. EPRI analyses of piping service experience have been performed relating to recent developments in the area of piping service data and reliability assessment techniques, and further insights from those studies have been documented in Section 2.2.2 of the EPRI TR. As noted in Section 3.4.2.2 of EPRI TR-112657, Rev. B, plant service history as well as industry experience are important considerations in the EPRI methodology for evaluating degradation mechanisms to ensure completeness and to validate the existence of any identified mechanisms. Actual operating experience at the plant performing the evaluation is used to define the portion of the pipe segment (elements) in which the potential degradation mechanism has been identified. The ultimate determination of the potential degradation mechanism for a specific piping segment is primarily based on actual operating conditions at the plant. The EPRI risk matrix is based on the premise that, in light of uncertainties associated with any attempt to quantify risk levels associated with passive components, it is appropriate to place pipe segments into broad categories of pipe rupture potential and consequence. That is, the method should lead to consistent rankings of pipe segments since these categories include conservative, broad ranges that should ensure reproducible results between various analysts. The NRC staff expects that an in-depth review of plant and industry databases and plant documents will be required to characterize each plant's operating experience with respect to piping degradation. Plant service experience provides confirmation of appropriate assignment of damage mechanisms to piping segments. This information is also utilized in the element selection process.

As new probabilistic Fracture Mechanics (PFM) codes/Structural Reliability Models (SRM) are developed and implemented for new applications, such as RI-ISI of structural components and change in inspection frequency of RPV, the NRC will undertake verification and validation efforts of those PFM codes.

1.9 What are the general experiences so far, from a regulatory point of view, of applied risk based/risk informed ISI strategies in your country? Do you foresee any changes in the near future?

Belgium

Canada

No experience in actual application of the risk-based/ risk-informed regulation. We have some positive experience with use of qualitative approach for inspection of steam generator tubing.

Czech republic

No experience from a regulatory point of view. Common European approach to RI-ISI is expected to be developed in the near future.

Finland

No experiences other than the pilot study on RI-ISI.

France

No official position for the moment.

Germany

Hungary

There are no experiences of applied risk based ISI strategies in Hungary yet.

There are plans to apply risk informed methods as well in the course of elaboration of new regulations for maintenance effectiveness monitoring program.

Japan

We have no experience in actual application of the risk-based/risk-informed regulation, though we have studied the methods used in foreign countries and preliminarily checked their applicability to the domestic plants.

Korea

We expect the RI-ISI may be applied to all Korean Plants by the end of 2008.

Netherlands

Spain

In late 2001 one PWR unit was authorized to follow a RI-ISI program for Class 1 (ASME Code) piping systems. The reduction in the amount of areas to be inspected is around 80% and there is a reduction in risk because new areas are included in the program. CSN recommends to extend the application to class 2, class 3 and non-class systems. Other licensees have also presented applications for piping systems which are being evaluated in

CSN.

Sweden

Experience of the used qualitative approach for piping systems is from an overall point of view positive so far. The system is transparent, as well as easy to understand and manage. It works relatively well and the degradation of components appears to be detected before the required safety level is affected. However, opportunities for improvement exist. The use of more quantitative risk oriented strategies is one way for such improvements. Several pilot studies of quantitative strategies have been conducted during the last years. At least one of the Swedish licensees will in a near future apply for changes of their in-service inspection program and base them on more quantitative risk informed approaches. This licensee will use the approach developed by Westinghouse. Other licensee may use similar approaches developed in Sweden.

SKI's regulations and guidelines, in SKIFS 2000:2, for in-service inspection has recently (April 2000) been changed to cover both qualitative quantitative risk informed approaches.

Switzerland

Experiences with the application of modern risk-informed ISI methodologies do not yet exist in our country. Changes in the future are foreseen, as outlined in the answer to question 1.1.

United Kingdom

(See answer to question 1.1).

United States of America

Development of risk-informed inservice inspection (RI-ISI) methodology was one of the pilot activities in the NRC Probabilistic Risk Assessment implementation plan. The activities in this area have included development of the Standard Review Plan 3.9.8, Regulatory Guide 1.178, review and approval of generic industry methodologies from EPRI and WOG, approval of three pilot plant RI-ISI programs, and staff participation in the development of ASME Code Cases related to RI-ISI of piping. The staff also developed Information Notice 98-44 as part of the pilot RI-ISI activities to inform addressees that for those licensees that intend to implement a RI-ISI program, the staff will consider authorizing a delay of up to two years in implementing the next 10-year ISI program in order for the licensee to develop and obtain approval for the RI-ISI program. RI-ISI has been one of the most successful applications of the risk-informed concept. Approximately 100 plants are expected to have implemented RI-ISI in the next two years. Of these, the RI-ISI programs for 25 plants have been approved by the staff. Approximately 20 programs are currently being reviewed.

In the near future, the staff expects that the concept of risk-informed strategies will be extended to RI-ISI of structures and structural components, increase in inspection frequency of PWR RPV welds, and activities related to repair and replacement. In addition, the NRC staff has evaluated and undertaken various options for risk-informing the NRC Regulation. Some details of these options are discussed in response to question 1.10.

1.10 What further actions and developments are needed from a regulatory point of view to improve applications of the risk based/risk informed strategies. Your response could for example include comments to the recommendations in the EURIS report.

Indicate also aspects that can be appropriate for further discussions in IAGE or its subgroups

Belgium

Canada

Exchange of experience from pilot studies should be beneficial. We believe the IAGE could provide an excellent forum for such exchange and discussion.

Czech republic

Without developed common European approach supported by NRWG with high level consensus to RI-ISI smaller central Europe countries like Czech and Slovak Republic, Hungary, Bulgaria and Slovenia are in difficult position as the future trends in Europe are not clear and foreseeable.

IAGE or its subgroups could support first of all the idea of common European approach to RI-ISI and discuss ways of support for the development of the approach based on current best practices acceptable both for utilities, engineering companies and regulators. The work on the common European approach to RI-ISI was started within ENIQ TG R devoted to RI-ISI.

Finland

An expert panel should be part of every approach.

France

Aspects that can be appropriate for further discussions in IAGE or its subgroups are

- degradation mechanism knowledge with uncertainties
- flaw distribution of different components
- POD of defect for different techniques and different materials

Germany

Hungary

There is a need in

- comparison of ASME BPV Sections II, III, V, IX and XI with similar Soviet or Russian regulations used at the time of manufacturing, commissioning and beginning of operation,
- a detailed analysis of failure modes and their consequences for equipment and pipes concerned,
- a risk ranking of equipment and pipes,
- reliable qualification of ISI methods used,
- improvement of criteria for action levels when using risk informed decision making

Japan

We have not yet adopted the risk-based/risk-informed ISI.

Korea

Followings are needed to improve the application of RI-ISI;
- Improvements in the PRA Quality
- Improvements in the reliability of Probabilistic Fracture Mechanics (PFM) codes
- Investigation the piping failure events to use in the determination of pipe segments
- Feedback from the field experience to RI-ISI program
- Information exchange the lessons learned from the RI-ISI application.

Netherlands

Spain

There are several aspects to be considered in order to improve risk-informed applications, as RI-ISI. One important point is to share world wide experiences coming from pilot projects or real applications. As a consequence, an international guide should be developed, giving general acceptance criteria for regulatory use, when the subject would be considered as a mature item.

Sweden

SKI agree with the recommendation given in the EURIS report that further work is needed to establish how well PRA models primarily directed at active component failures can be adapted via the surrogate concept, to handle the failure of passive elements. SKI also agree with the recommendation that a mechanistic understanding of degradation mechanisms lies at the centre of all risk assessment, and that the development, verification and validation of structural reliability modelling (SRM) are therefore an important area of development.

Establishment of a common approach to the verification/validation of structural risk assessment (SRM) models could be one aspect for further discussions in IAGE or its subgroups. Another aspect could be strategies for dealing with components where failures having very high consequences are not acceptable, even if their probability of occurrence is very low.

Switzerland

Experiences gained from pilot studies should be exchanged. The European regulators should develop common views on key issues, such as addressed by the questions 1.3 through 1.8 of this questionnaire.

United Kingdom

United States of America

The NRC staff has undertaken a high level approach for incorporating risk-informed attributes into the Part 50 regulations. The primary objectives of this effort are to develop a risk-informed regulatory framework that will enhance safety as well as reducing unnecessary staff and licensee burden. The NRC staff is proceeding with three options for modifying regulations in 10 CFR Part 50 to make them risk-informed. These options are:

Continue with ongoing rulemakings, but make no additional changes to Part 50. This option would terminate staff action to develop comprehensive risk-informed changes to the current Part 50. Risk-informed approaches specified in RG 1.174, and associated application-specific RGs would continue to be implemented subject to existing regulatory limitations.

Make changes to the overall scope of systems, structures, and components (SSCs) covered by those sections of Part 50 requiring special treatment (such as quality assurance, technical specifications, environmental qualification, and 50.59 by formulating new definitions of safety-related and important-to-safety SSCs). As the primary part of this option, risk-informed definitions of "safety-related" and "important to safety" are being developed. This would lead to changes in the scope of what receives special operational and qualification treatment.

Make changes to specific requirements in the body of regulations, including general design criteria (GDCs). Under this option, changes would be made to the body of the Part 50 regulations to include risk-informed attributes in the requirements. Approaches to revising the body of the regulations could include the following:

- adding provisions to Part 50 allowing the staff to approve risk-informed alternatives to current regulations,

- revising specific requirements to reflect risk-informed considerations,

- deleting unnecessary or ineffective regulations.

The NRC staff is proceeding with the current rulemaking in Option 1 and implementing Option 2. The staff is also proceeding with a study of Option 3.The NRC would be interested in exploring the experiences of IAGE members or its subgroups in implementing RI-ISI for various SSCs. In particular, the NRC would be interested in research and data related to applying RI-ISI methodologies to structures and structural components. A Task Group has been established to formulate RI-ISI strategies for reactor containment structures and its components. In order to develop methodologies for RI-ISI of structures, the NRC staff will need data on degradation mechanisms for structures and structural components, consequences of failures of these components (using PRA), appropriate NDE/NDT methods for potential degradation mechanisms, and concepts on how to come up with "risk-classifications" for structural components. Recently, ASME XI has formulated a Task Group whose task is to develop a Code Case for RI-ISI for structures and structural components by extending the concept that has been applied to RI-ISI of piping and repair and replacement. The NRC would be interested in developing information exchange with IAGE group members to see what has been done and what is available. This may lead to sharing information and, possibly, cooperative research as we move forward in this area.

Part 2 – NDT qualification/performance demonstration approaches[6]

2.1 Have regulations, licence conditions or codes with requirements on the use of qualified NDT system for pre- and in-service inspections of reactor components been introduced in your country? Please describe briefly the requirements for qualification/performance demonstrations, and when the requirements have been introduced.

Belgium

Belgian nuclear power plants are operated in accordance with American regulations (10 CFR on Energy) and USNRC rules. For the mechanical components, this means that the ASME Code, and in particular Section XI, becomes regulatory requirement, together with the "Transposition to Belgium of the Regulatory Aspects of Section XI, Division 1" of the ASME Code.

The Belgian licensee is required to reassess the safety of its installations every ten years: this is a condition of its license. The current status of a unit must be compared, in terms of rules, standards and practices, to the most recent rules and practices existing in the USA and in the European Union. In this frame, the decision has been taken to meet the inservice inspection requirements of the 92 edition of Section XI of the ASME Code for the ongoing ten-year intervals, which started in 1994 for Doel 3 and Tihange 2, and in 1996 for the five other units.

It was recognised that:

- on one hand, the strict application of a qualification process in accordance with the Appendix VIII alone would lead to some inconsistencies in terms of feasibility or efficiency;
- on the other hand, the approach from the European Network for Inspection Qualification (ENIQ), which recognizes that the qualification needs may depend on the actual safety case, is of interest.

Therefore, it was decided to apply in Belgium a pragmatic and flexible approach i.e. a combination of the European Methodology developed by ENIQ and of the Performance Demonstration as described in Appendix VIII of ASME XI; such an approach was thought to be the most adequate answer to be given to the question of qualification of a complete NDT system (procedure, equipment, personnel).

Canada

Uniform federal certification of inspection personnel – levels 1, 2 and 3.

Czech republic

[6] Some of these questions are a part of a more detailed questionnaire that presently is circulated among members of the European Nuclear Regulators Working Group (NRWG) Task Force on NDT qualifications. The questions are included here in order to also get information from other OECD/CSNI member countries on addressed subjects.

The regulations to perform NDT qualification for selected inspection areas and conduct qualified NDT examinations have been issued by the Safety Authority (State Office for Nuclear Safety abbreviated SONS). These requirements are from the legal point of view indirectly based on the requirements of the so called “Atomic law” (the Law No. 18/1997, in force since July 1, 1997) and the Decree of the SONS No. 214/1997. Due to the fact that the Law and the Decree are in force since 1997, when the Second Issue of ENIQ methodology was just published, there is no precise wording about “NDT qualification”. However, the sense of it is the same. It is required to establish qualification criteria for special processes (including NDT examination), verify applied equipment, to save records on meeting the qualification criteria, verify capabilities of the special processes, etc.

Finland

A new revision of Finnish Regulatory Guide YVL 3.8 "Nuclear Power Plant Pressure Equipment. Inservice Inspections" is in the course of preparation. Requirements for inspection qualification have been drafted on the base of Common position of European regulators on qualification of NDT systems for pre- and in-service inspection of light water reactor components, EUR 16802 EN as well as The European methodology for qualification of non-destructive testing, EUR 17299 EN with Recommended practices. The content of requirements for inspection qualification has been taken quite directly from the documents mentioned above. STUK has given in 1996 decision, that Common position document of European regulators shall be followed.

France

Yes, by French law on November 1999 on primary and secondary main systems**.**

Germany

Hungary

The qualification requirements for NDT systems have not been introduced yet in Hungary. There is only a statement in the Guideline for ISI the regulator can require - if necessary – the qualification of method used, equipment and/or personnel for in-service inspection. But it is not a common practice yet.

Japan

We have no regulation, licence condition or code for Performance Demonstration Approaches. An industry code JEAC4205 includes the requirements on the use of NDT methods for in-service inspections. The code requires that:
- UT should be conducted in accordance with JEAG4207, and ET in accordance with JEAG4208.
- it is desirable that non-destructive tests are conducted and evaluated by personnel with JSNDI qualification. (JSNDI: Japanese Society for Non-Destructive Inspection)

Korea

The current ISI and NDT requirements in Korea are based on ASME Code Sec. XI. As the requirement in Appendix VIII in ASME Code Sec. XI, Korean regulatory body and utility have been prepared to NDT qualification from several years ago. The NDT qualification will be introduced from 2004 in Korea. Korean utility has prepared their NDT qualification system with EPRI. The Korean NDT qualification system focuses on piping and stud bolt. The facility including the piping test specimens was almost completed in Korea. The NDT qualification on reactor vessel may be delayed up to 2005. The ECT qualification for steam generator tube will be introduced from 2004.

Netherlands

Spain

No regulations, nor NPPs license conditions or codes requiring the use of qualified NDT systems are actually in place in Spain. There is only a CSN regulatory guide (nº. GSN 10.10, issued 23/02/00) related to "Qualification and certification of NDT personnel", which requires, in case of NDT of structural components related with safety of NPPs, that personnel performing these NDT be examined over the standard requisites of EN-473-93, in order to demonstrate their capabilities for defects detection, discrimination and characterisation by means of blind testing.

Sweden

The requirements on qualification of NDT systems, to be used for in-service inspections of the safety significant mechanical components, were introduced in Sweden 1994, by the SKI's regulation of mechanical components SKIFS 1994:1. The qualification requirements became effective 1996 after a transition period. The requirements are now transferred to the new regulations, SKIFS 2000:2.

In accordance with the regulation, the NDT qualifications should be supervised and assessed by an independent qualification body – the Swedish Qualification Centre SQC. The SKI has approved SQC for operation and also regulates the SQC's activities.

Switzerland

Inservice Inspection in Swiss nuclear power plants is guided by the "SVTI Festlegung" NE-14. In 1988, the requirement was introduced that ultrasonic examination "techniques" dedicated to the inspection of austenitic steel, Ni alloy, and dissimilar metal welds shall be qualified using test blocks representative of the component to be examined. In March 1996, the HSK notified by letter the licensees of the Consensus Document of European regulators (EUR 16802 EN) as basis for the development of qualification programs for Swiss NPPs. Moreover, qualifications were required by the HSK in particular cases.

United Kingdom

No regulations, licence conditions or codes have been introduced in the UK with requirements for use of qualified NDT systems for pre- and in-service inspections for reactor components. However the Nuclear Installation Inspectorate's Safety Assessment Principles (SAPs) define our general expectations. In particular Principle 163 states:

"Inspection techniques for structures and components should be sufficiently redundant and diverse. Personnel and equipment performance and procedures should be validated (for validation read qualification). The safety categorisation (see paragraph 131) should be taken into account when determining the appropriate level of these measures."

(current edition of the NII SAPs published in 1992, text available at:

http://www.hse.gov.uk/nsd/saps.htm)

United States of America

Yes, there are regulations with requirements on the use of qualified NDT systems for inservice inspection (ISI) of specific reactor components in the US. In September 22, 1999, the US Nuclear Regulatory Commission (NRC) issued a final rule, 10CFR50.59, that requires licensees to implement Appendix VIII of ASME Section XI. Appendix VIII states mandatory requirements for the performance demonstration of ultrasonic (UT) procedures, equipment and personnel when examining piping, bolts and certain regions of the reactor pressure vessel. The requirements in Appendix VIII will replace requirements of the NRC IGSCC program.

2.2 If NDT qualification requirements have not yet been introduced in your country please describe the future plans, or those other measures taken to secure reliable inspection results.

Belgium

As mentioned above, NDT qualification requirements are introduced in Belgium.

Canada

Active since 1970's

Czech republic

Finland

See the answer 2.1 above.

France

Germany

Hungary

Preparation for qualification started 2 years ago. A trial qualification process is underway for ultrasonic inspection of ligament region of steam generators primary collector (there is horizontal S-Gs in Hungary). This process is intended to be finished in August 2002.04. The qualification board consists of Licensees' experts, independent inspection companies and international support (AEA Technologies)
Current activities:

- approval of the QA system
- elaboration of qualification procedure
- elaboration and acceptance (including regulatory body) of failure criteria
- elaboration of inspection technology

Next activity: technical justification and practical examination.
Qualification is established in accordance with IAEA-EBR-WWER-11 and ENIQ EUR 17299.

Japan

We have no future plan to introduce NDT qualification requirements nor other measures to be taken to secure reliable inspection results.

Korea

See the answer in 2.1.

Netherlands

Spain

During the period 1999-2002 a NDT (mainly Ultrasonics) qualification pilot exercise (called VENDE) is being carried out jointly by Spanish utilities, Spanish NDT vendors and CSN, in order to demonstrate the validity of the Spanish approach on NDT qualification process established in the document CEX-120 and developed in several technical practices, issued in early 1999 by the Spanish utilities group (UNESA). One basic piece in this study is the development of NDT systems qualification requirements, both technical and organisational. It is expected to have a final CSN rule on the subject by the end of 2002.

Sweden

See the answer to question 2.1.

Switzerland

A general HSK guideline on NDT qualification is in preparation. It is intended to be put in force by the end of the year 2002.

United Kingdom

Due to the general non-prescriptive nature of regulation in the UK, such specific regulations or licence conditions are not expected to be introduced.

United States of America

Not applicable as there are NDT qualification requirements in place in the US.

2.3 Are the qualification requirements in force or under a transition period?

Belgium

The qualification requirements depend on the actual safety case; they become mandatory (in force) when accepted by the authorised organisations together with the safety case; this is true in particular for the RPV inspection for which specific qualification requirements have been developed by the licensee and accepted by the authorised organisations.

Canada

Active since 1970's

Czech republic

The Qualification requirements are in force for both VVER 440 (Dukovany) and VVER 1000 (Temelín) type NPP, however for selected components only. They have been issued by the Safety Authority as plant specific regulations for selected inspection areas of safety relevant components (like RPV butt welds, RPV nozzle inner radius, RPV safe-end dissimilar weld, etc). For other especially VVER 1000 type components, including a part of safety significant ones, the qualification requirements are under a transition period.

Finland

The qualification requirements are under a transition period.

France

The qualification requirements are in force

Germany

Hungary

The qualification requirements are not in force yet.

Japan

No answer because the question is not applicable to our country.

Korea

The qualification requirements based on Appendix VIII in ASME Code Sec. XI with some modifications and limitations are in force. EPRI NP6201 is considered as the qualification requirement for the steam generator tube.

Netherlands

Spain

NDT qualification requirements are under a transition period as explained in the answer to question 2.2.

Sweden

The qualification requirements are in force, see the answer to question 2.1.

Switzerland

The qualification requirements are under a transition period as described above (questions 2.1 and 2.2). Qualification activities in the spirit of the European methodology have been initiated as early as 1992. All qualification projects carried through up to now have also been used as pilot studies to promote the necessary change in mind and to explore an appropriate way to regular implementation.

United Kingdom

See the answer to question 2.1 and 2.2.

United States of America

The final rule 10CFR 50.59 required a gradual implementation period for the various supplements of Appendix VIII. Specific information on the supplements is included

Supplement Number	Area of Qualification Requirements	Implementation
1	Evaluating Electronic Characteristics of UT Systems	
2	Wrought Austenitic Piping Welds	5/00
3	Ferritic Piping Welds	5/00
4	Clad/Base Metal Interface of Reactor Vessel	11/00
5	Nozzle Inside Radius Section	11/02
6	Reactor Vessel Welds other Clad/Base Metal Interface	11/00
7	Nozzle to Vessel Welds	11/02
8	Bolts and Studs	5/00
9	Cast Austenitic Piping Welds	Pending
10	Dissimilar Metal Piping Welds	11/02
11	Full Structural Overlaid Wrought Austenitic Piping Welds	11/22/2001

2.4 Are the qualification requirements presently applicable to

e) all safety class/risk group components or just some of them?

f) all NDT methods or just NDT systems based on ultrasonic?

g) all components types?

h) both equipment, procedures and personnel?

Belgium

a, c.) Qualification is applied to all safety related components for which a qualification is required by the ASME Code (Appendices I & VIII) and to those for which a qualification is required by the authorised organisations or the licensee himself (steam generator tubes, RV head penetrations,…).

b.) Qualification is applied to both ultrasonic (UT) and eddy current (ECT) techniques.

d.) Qualification requirements are applicable to procedure, equipment and personnel.

Canada

Are the qualification requirements presently applicable to

- all safety class/risk group components or just some of them?
  All
- all NDT methods or just NDT systems based on ultrasonic?
  RT, UT, MT, LT, VT
- all components types?
  Yes
- both equipment, procedures and personnel?
  Performance demonstration for procedures and personnel and equipment for non-ASME Section V techniques

Czech republic

A qualification methodology issued by the SONS, following ENIQ methodology, is applicable to all safety class/risk group components, all NDT methods, all components types, both equipment, procedures and personnel. The qualification requirements issued as the regulations of the SONS are not applicable in such a scope.

a.) Some safety classes
b.) At present only NDT systems based on UT and ET methods.
c.) At present only some components types
d.) The qualification of applied equipment and UT/ET inspection procedures is being performed. Additional qualification of personnel is planned after conducted qualifications of appropriate inspection procedures. The qualification of personnel can be limited due to the relative lack of test blocks for blind trials.

Finland

a.) To all components classified into safety classes 1 and 2 and which are included in the inservice inspection program based on ASME Code, Section XI added with some components classified into lower safety classes, but included in the same program for other safety reasons.

b.) Normally for ultrasonic and eddy current testing. The qualification requirements could be also applied to other NDT methods, when needed.
c.) See the answer 2.4 a) above.
d.) To both equipment, procedures and personnel

France

a) only for primary and secondary systems- case by case on class 2 systems
b) all NDT techniques
c) all inspected locations
d) equipment, procedure on one hand with recommandation for personnel training,in the over hand the personnel is certified by Cofrend according to the general rules or by the nuclear sub-sector

Germany

Hungary

The qualification requirements are not in force yet.

Japan

No answer because the question is not applicable to our country.

Korea

a) all safety class/risk group components
b) just NDT systems based on ultrasonic and ECT
c) Piping, stud bolt, and steam generator tube from 2004 and reactor vessel from 2007
d) both equipment, procedures and personnel

Netherlands

Spain

a) NDT qualification requirements will be applied to all structural components related with safety of NPPs, and specifically to:

- Pressure vessel weldments including heads, nozzle to vessel welds, nozzle internal radii areas and base metal/cladding interfaces, for component thickness $t \geq 50$ mm.
- Bolting and other attachments of internal structures.
- Weldments in ferritic and austenitic steel piping and dissimilar welds.
- Steam Generator tubing.

Spanish methodology will be a mix of ASME XI and ENIQ. The scope will be that of Appendix VIII of ASME XI and ENIQ philosophy will be followed for the qualification process.

b) NDT qualification requirements will be established for volumetric methods, especially for ultrasonic and eddy current techniques. At this moment are not intended for superficial testing.

c) all components types as specified in a) above
d) Yes, both equipment, procedures and personnel. The Spanish methodology CEX-120 follows closely ENIQ philosophy, separating procedure and equipment qualification from personnel qualification.

Sweden

a) NDT system used for in-service inspection of reactor pressure vessels, steam generator tubes, and piping and components that have been assigned control group A and B shall be qualified. (See the answer to question 1.1)
b) The requirements apply to all NDT methods

c) The requirements apply to all types of components according to question 2.4 a).

d) The requirements apply to all parts of the NDT system.

Switzerland

Qualification is at present effectively required

a) for specific class 1 components
b) for specific ultrasonic and eddy current examination systems
c) for specific pressure vessels, mechanical and piping parts
d) mostly for equipment and procedures, in specific cases also for personnel.

United Kingdom

a) As part of its assessment process, NII considers the appropriate level of qualification of inspections which are claimed as part of a safety case. NII would expect the licensee to have considered the level of qualification before making the safety case submission.
b) Currently NDT qualification is generally applied to ultrasonic and some surface inspection procedures. There are also examples of qualification processes being applied to eddy current inspection of tubing.
c) There is no list of components where qualification of inspection needs to be applied. Qualification requirements depend on: the overall importance of the safety case, the safety significance of the integrity of the component as part of the safety case, the importance of inspection results in supporting the safety case.
d) Qualification would be expected to be applied to the NDT procedures, equipment and personnel.

United States of America

The qualification requirements are applicable to

a) class I piping, bolting and the RPV shell and shell welds.
b) ultrasonic testing (UT)
c) piping, bolting and the RPV shell, shell welds and nozzle welds
d) to equipment, procedures and personnel

2.5 What is the basis for derivation component specific qualification requirements, including qualification targets and the relationship, if any, between target size and inspection interval for different components?

Belgium

The Belgian policy proposes a general scheme to cover the qualification of every type of UT inspection on a case by case basis; the pursued objective is to optimise the qualification procedure taking into consideration safety goals and economical aspects; in order to achieve this, it is necessary, for each component to be qualified, to develop specific qualification requirements.

Canada

Based on ASME V -6dB drop method for UT
ASME V for RT, MT,LT, VT

Czech republic

The basis for derivation component specific qualification requirements are at least a technical specification, stress analysis report and critical defect sizes assessment reports for target defect size determination. Inspection interval, if it is not used a general 4 years interval, prescribed by the original Russian Code is derived using a deterministic conservative enough crack growth assessment, taking into account degradation of material properties, design/operational loadings, etc.

Finland

The qualification flaw size is based on the allowable flaw size according to ASME Code, Section XI, IWB-3600. In some cases shorter inspection interval is used, like thermal mixing areas, where loading is not well known.

France

The objectives of performance demonstration are defined by analytical studies.
The frequency is generally derived from same studies

Germany

Hungary

The qualification requirements are not in force yet.

Japan

No answer because the question is not applicable to our country.

Korea

The bases are the impact on plant safety, the degradation mechanism, and the UT technique

Netherlands

Spain

Main basis for component specific qualification requirements is defect category and morphology as type, size, location, orientation, etc.

Sweden

Qualification requirements are derived from relevant plant documentation, such as safety analysis reports, structural integrity assessment reports, risk/control group classifications, etc. Considerations are taken to relevant degradation mechanisms, and thereby the type, position, orientation, geometry and size of defects that have to be detected and sentenced with required reliability and accuracy.

For most components the inspection intervals are variable and depending on the detection capability of the qualified NDT systems used, damage tolerance of the component in question and the growth rate of the relevant degradation mechanism. However, with a maximum interval of 10 years.

The licensee can consequently thereby apply a longer inspection interval if it is demonstrated that the NDT system with reasonable reliability can detect and size small defects (small detection targets). On the other hand can a larger detection target be chosen if the licensee is prepared to apply shorter inspection interval for the component in question.

Switzerland

The component specific qualification requirements are based in principle on the degradation mechanisms expected, fracture mechanics analyses, safety margins, and the state of the art in NDT technology. The state of the art and flaw size unacceptable due to analysis have been used as bounding criteria. Inspection intervals shorter than 10 years would be considered if necessary.

United Kingdom

The concept is used of matching the qualification process to the importance of the inspection results in the overall safety case and the novelty of the inspection procedure employed.

The starting point for an inspection qualification is expected to be a specification of what the inspection is supposed to achieve. For crack-like defects, this specification would be in terms of parameters such as type of defect, size (depth through-wall and length along wall), location, roughness, orientation and skew.

The target size would normally be derived from a fracture mechanics analysis to determine limiting sizes of cracks. The fracture analysis would be expected to use conservative assumptions and materials properties. The degree of conservatism would be expected to be greater for frequent event loadings than for infrequent event loadings. It would be expected there would be some margin on size between the estimated limiting crack sizes and the capability of the inspection method to detect and size cracks.

United States of America

10CFR50.55a states inspection requirements for inservice inspection to include Appendix VIII of ASME Section XI. Appendix VIII was completed in 1989 to be a performance-based qualification criteria with detailed requirements for UT inspections. The detailed requirements include statistically based acceptance criteria to detect and size flaws.

2.6 Describe briefly, or refer to published documents/papers with information on, used qualification methodology (e.g i accordance with Appendix VIII to ASME Section XI, European approach as outlined in EUR 16802/17299, etc) in your country.

Belgium

The qualification can be strictly in conformity with Appendix VIII to ASME Section XI (performance demonstration), can be in conformity with the ENIQ approach (EUR 16802 and EUR 17299) or can be carried out according to an alternative methodology to be defined and accepted by the authorised organisations.

Canada

ASME XI LEFM

Czech republic

ENIQ (EUR 17299) and IAEA (IAEA-EBP-WWER-11) methodologies are followed. A specific methodology document "A qualification methodology for in-service inspections of main VVER type primary circuit components" was issued by the SONS in December 1998.

Finland

We refer to the European approach as outlined in EUR 16802/17299.

France

See Joseph SAMMAN - La qualification des applications d'Examen Non Destructif en France - RGN n° 3 Mai-Juin 2000

Germany

Hungary

Qualification methodology is being implemented in accordance with IAEA-EBR-WWER-11 and ENIQ EUR 17299.

Japan

No answer because the question is not applicable to our country.

Korea

Accordance with Appendix VIII to ASME Section XI for UT and EPRI NP6201 for ECT

Netherlands

Spain

As stated above, Spanish methodology will be a mix of Appendix VIII to ASME XI and ENIQ philosophy. The scope, that's to say, the components that will be required to be inspected with qualified NDT are those of Supplements 2 to 11 of Appendix VIII; however, the qualification process will follow ENIQ methodology.

Sweden

The NDT qualifications shall be in agreement with SKI's regulations and guidelines (SKIFS 2000:2), which in this context are based on Eurpean regulators common position document, EUR 16802.

Switzerland

Qualifications are performed in accordance with the European qualification methodology (EN 16802/17299). Performance Demonstrations in accordance with App. VIII/PDI are accepted.

United Kingdom

United States of America

The NDT/NDE qualification methodology applied is described in following documents:

Topical Letter Report: NDE Performance (POD) Curves for Fatigue Cracks in Piping Based on Industry Performance Demonstration Data. Gosselin, SR, PG Heasler, SR Doctor, FA Simonen, FL Becker. 2001 Pacific Northwest National Laboratory, Richland, WA prepared for the US Department of Energy.

Performance Demonstration 25 years of Progress Becker, L. 2001, 3rd International Conference on NDE in Relation to Structural Integrity for Nuclear and Pressurized Components, Seville, Spain.

Summary of Experience with the Qualifications of RPV Procedures to ASME Section XI, Appendix VIII, Supplements 4 and 6 Becker, L. 2001, 3rd International Conference on NDE in Relation to Structural Integrity for Nuclear and Pressurized Components, Seville, Spain.

U.S. Nuclear Regulatory Commission on Performance Demonstration of UT System E.J. Sullivan, R.A. Hermann, D. Terao, D. G. Naujock

2.7 Describe how the qualification activities have been organised in your country. What organisations are responsible for:

f) Approval of the infra structure for qualification activities and assessment of the organisations involved?
g) Preparation and assessment of the qualification requirements, e.g. qualification targets, detection and sizing capabilities, for particular reactor components?
h) Preparation and assessment of the technical justifications of NDT procedures?
i) Witnessing, assessment and evaluation of practical trial demonstrations?
j) Issuing, withdrawal and cancellation of qualification certificates?

Belgium

a) In order to deal with all matters related to inspection qualification of NDT systems, a Working Group was created in 1992 with representatives of the licensee (Electrabel), the architect/engineer (Tractebel) and both authorised organisations :

- AVN as regulatory organisation and technical support to the Safety Authorities;
- AV as Authorised Nuclear Inservice Inspector (ANII) and inspection specialist.

b) Preparation of specific qualification requirements and qualification procedures (including both practical trials and technical justifications) is carried out by the licensee in accordance with the requirements of either the Appendix VIII or the ENIQ methodology, while the qualification of the whole NDT system (procedure, equipment, personnel) is carried out by the vendor.

The criteria needed to pronounce the qualification are proposed by the licensee and discussed in the Working Group. If they are not strictly in conformity with Appendix VIII, the equivalence of the alternatives must be demonstrated to the satisfaction of the authorised organisations, before approval.

c) For procedure qualification, in most cases, the qualification is based on a balance between experience, technical justifications, modelling and practical trials. In all cases, the qualification programme is submitted by the vendor to the approval of the licensee and of the authorised organisations. The qualification processes show that the successful development of a technical justification depends a lot on the technical competence of the vendor and on its internal quality assurance.

Technical justifications have several advantages:

- allow the reduction of the number of practical trials;
- assess the validity of the practical trials;
- complete or extend the qualification;
- optimise the economical aspects of the qualification process.

Modelling is useful to support aspects of the technical justifications, in particular to establish predictions regarding the different site conditions and configurations.

d) The ANII is in charge of undertaking audits and periodic reviews to verify compliance of NDT systems qualification with the requirements.

Practical trials are usually performed under non blind conditions on mockups representative of the geometry of the component and containing real or realistic flaws; it is only for personnel qualification that some practical trials are performed under blind conditions. When practical trials are performed, the ANII witnesses the tests progress on an ad hoc basis.

e) There are no so-called “qualification certificates” but the qualification shall be demonstrated to the satisfaction of the authorised organisations.

Canada

- Approval of the infra structure for qualification activities and assessment of the organisations involved?

Federal HRDC

- Preparation and assessment of the qualification requirements, e.g. qualification targets, detection and sizing capabilities, for particular reactor components?

Federal Regulator

- Preparation and assessment of the technical justifications of NDT procedures?

Federal Regulator

- Witnessing, assessment and evaluation of practical trial demonstrations?

Federal Regulator

- Issuing, withdrawal and cancellation of qualification certificates?

Federal HRDC

Czech republic

a) Qualification Body consists of: Steering Committee at Utilities Headquarters (CEZ) with members from nuclear industry leaders. Two Executive Qualification Bodies both for Dukovany NPP (VVER 440 type) and Temelín NPP (VVER 1000 type) are independent parts of utilities with specific QA manuals integrated into QA manuals of utilities. The infrastructure approved by CEZ headquarters.
b) Preparation: Utility and/or an engineering organisation ordered by the utility Assessment: utility.
c) Preparation: Utility (input data, technical specification), the rest by ISI vendor Assessment: Executive Qualification Body
d) Witnessing: Executive Qualification Body (EQB), assessment: EQB and/or independent experts hired by EQB, evaluation: EQB.
e) A proposal to issue, withdraw or cancel the certificate is submitted by the Executive Qualification Body to the responsible person of the NPP Headquarters for certificate issuing, withdrawal or cancellation in compliance with the QA manual

Finland

a) The regulatory body
b) The utilities are responsible for preparation and the regulatory body is responsible for assessment and final approval.
c) The vendor together with the utility are responsible for preparation and the qualification body is responsible for assessment.
d) The qualification body is responsible.
e) The qualification body is responsible for issuing and the steering committee of

qualification is responsible for withdrawal and cancellation.

Additional remarks: On the base of assessment reports prepared by the qualification bodies, the regulatory body gives final approvals for all the activities mentioned above.

France

a) all EDF organisation is based on ISO9001 / versus 2000 underway, the qualification body is type B according to ENIQ practice n°7, and is accredited according to EN 45004 type B by Cofrac, and recognized by the regulator
b) Nuclear Operator reprsentativ writes the requirements
c) A NDE engineering department(help by vendors) does the job
d) By the same people, witnessing by the IQB
e) The IQB issues the certificate after reviewing the qualification dossier, the NOP has to check the on field feedback experience and to report to the IQB in case of lack or gap with the previous objective

It's always the NOP who is responsible on the use of a qualified procedure and of the results of the inspection

Germany

Hungary

An independent third party was selected for performing of the qualification process. Regulatory body has to issue two permissions: one for the acceptance of quality criteria and another one for approval of the qualification certificate. Other organisational measures described in 2.2.

Japan

No answer because the question is not applicable to our country.

Korea

a) The Regulatory Body MOST(Ministry of Science and Technology) and KINS(Korea Institute of Nuclear Safety)
b) The Qualification Body: In principle, any organization including utility, vendor, and inspection company may be the qualification body if they verify the requirement for the NDT qualification system. KEPRI (Korea Electric Power Research Institute) is the only current qualification body in Korea.
c) The Qualification Body
d) The Qualification Body
e) The Qualification Body

Netherlands

Spain

Note: Spanish methodology is under development, so the following answers are an estimation of what will be in the future.

a) Inside the nuclear industry, each NPP owner or owner's group (licensees) shall be responsible for the establishment and approval of their internal qualification system. However CSN will approve, or not, the proposal of the whole qualification system that licensees must submit when the pilot project VENDE be finished. The main point under discussion is the type of organisation that licensees are going to choose for the Qualification Body. It seems that it will be an EN 45004 type B organisational structure, but this could change in the future to an EN 45004 type A, if deemed necessary by CSN.
b) Each NPP owner or owner's group (licensees) shall be responsible for defining all qualification requisites. The independent Qualification Body will be responsible for reviewing all these aspects.
c) Preparation of the technical justifications as well as NDT procedures are the responsibility of the NDT vendor, following all qualification requisites established by the NPP owner or owner's group (licensees) for the case. Assessment of the technical justifications as well as NDT procedures and related NDT qualification documents shall be a standard duty of the Qualification Body.
d) Witnessing, assessment and evaluation of practical trial (open and blind) demonstrations shall be also a standard duty of the Qualification Body.
e) Issuing, withdrawal and cancellation of qualification certificates shall be also a standard duty of the Qualification Body.

Sweden

a) The infrastructure for NDT of nuclear components is set up and approved by the SKI. The Swedish Qualification Body is under supervision of SKI. Independent third party inspection bodies who assess the inspection programs as well as those inspection companies who conduct the NDT activities have to be accredited by the Swedish Accreditation Board (SWEDAC).

b) Specification of the inspection / qualification targets is the responsibility of the licensee. An independent third party inspection body has to assess that these targets are in agreement with the inspection interval that are used in the in-service inspection programmes.

c) Preparation of the technical justification is the responsibility of the licensee. The licensee may order the work on preparation of technical justification from a NDT vendor or a consulting company. The qualification body may not be involved in the preparation of the technical justification because of its third part position. The qualification body's role is assessment of technical justifications.

d) Witnessing, assessment and evaluation of practical trials is the responsibility of the qualification body.

e) Issuing, withdrawal and cancellation of qualification certificates is the responsibility of the qualification body.

Switzerland

a) Qualifications are under the supervision of the HSK.
b) The a. m. qualification requirements are prepared by the licensee, assessed by the qualification body, and finally approved by the HSK.
c) Technical Justification of NDT procedures to provide supporting evidence was rarely used, as reliance was mostly on practical demonstrations.

d) Witnessing, assessment and evaluation of practical demonstrations is the responsibility of the Qualification Body.
e) Because of the transient character of the situation, no formal mode of certification is in force yet. This will be established in the guideline being in preparation.

United Kingdom

a) There is no single body in the UK to approve the infrastructure for qualification activities and assessment of the organisations involved. NII would expect qualification bodies to use well-known quality assurance methods. Qualification bodies vary in size, nature and duration. In general the activities of a qualification body can be seen to be similar to any other commercial, technical service. NII would expect licensees through their own QA processes to ensure that anyone employed as part of a qualification body (whether their own employees or contractors) would be Suitably Qualified and Experienced Persons (SQEP) for the work. Depending on the importance of the inspection, NII might choose to test the licensees' arrangements in this regard.

b) Preparation of Technical Justifications (TJs) could be done by a number of parties, the licensee, the inspection vendor or a third party. However the Technical Justification needs to be written to combine the theoretical and experimental body of knowledge of the inspection with the practicalities of the inspection, that is how it will actually be done. So a degree of co-operation may be needed in producing the Technical Justification.

c) Assessment of the Technical Justification is the responsibility of the qualification body.

d) The three activities of witnessing, assessment and evaluation of practical trial demonstrations is the responsibility of the qualification body. Depending on the importance and novelty of the inspection, NII might choose to witness some trials and might consider a sample assessment and evaluation of its own.

e) Issuing, withdrawing and cancelling qualification certificates is the role of the qualification body. Note that for some inspections a qualification body might be constituted to do the first qualification and then disbanded. Then years later if a change occurs requiring some modification of the certificate, a new qualification body might be established.

United States of America

The US nuclear industry created the Performance Demonstration Initiative (PDI) in 1991 to manage implementation of the performance demonstration criteria of Appendix VIII. The PDI is comprised of members from all US nuclear utilities and three foreign countries. The PDI is responsible for all decisions concerning the location, quantity and types of flaws in each test specimen. All of PDI's program decisions are documented in technical basis documents

2.8 What actions are taken in your country to assure that the qualification defects are representative simulations of the defects/cracks that can occur in the plants?

Belgium

Because the test blocks are not destructively examined, it is difficult to assume that the defects are exactly known in location and size; however, as no practical trials are performed to demonstrate the performance on all possible defects at all locations due to the lack of fully representative mockups, modelling and technical justifications are extensively used in the process of qualification, therefore the uncertainty of the defects location and size in the blocks has a small influence on the qualification results.

Canada

We rely on the latest technologies and techniques in preparing artificial flaws in the test blocks. CANDU Owners Group is sponsoring research and development projects to address the issue of performance demonstration.

Czech republic

Qualification defects types are a result of consensus made by participating Parties. How realistic/ representative the defects/cracks are depends also on the qualification level/rigour assigned to the qualification case. For this reason are used both artificial defect simulations (various types of notches, PISC type A semi-elliptical defects), realistic simulations as implanted mechanically cycled fatigue cracks, SCC type defects.
Actions taken:

- development of manufacturing technologies for real/realistic representative simulations of defects/cracks (examples: ODSCC type defects and pitting in steam generator tubes by NRI Rez) with verification of manufacturing technology and provided evidence
- analyses of degradation mechanisms, application of microstructure analyses, destructive examinations of real operation induced defects/cracks
- international co-operation in projects – SPIQNAR (comparison of UT responses of real operation induced cracks and different types of defect simulations, etc.).

Finland

Some research work has been done in order to compare NDT results of simulations with the results of real defects.

France

The IQB has to valid the mock-ups referring with the inspections requirements, and according to the qualification management (engineer reasoning, modelisation, open trials,..)

Germany

Hungary

This issue is not solved yet.

Japan

No answer because the question is not applicable to our country.

Korea

Regulatory body reviews the crack morphology used in the test specimen if the crack reflects the plant experience. Usually thermal fatigue crack, mechanical fatigue crack and mechanical notch are acceptable in PWR. Although SCC type cracks have been reported in PWR, the SCC type crack is not considered in Korea yet.

Netherlands

Spain

There is no simple answer to this question, because the only way to determine the representation in type, location and size of a simulated defect is to section the block and make destructive testing.
In pilot study VENDE there are not provisions for such verification by means of destructive testing. Only internationally known methods used to implant defects in the trial mock-ups can give a relative assurance of the quality of these defects.
A defect manufacturing validation dossier must be required to the test specimen manufacturer for each defect case.

Sweden

The representation of defects in the qualification test blocks is a key point in any performance demonstration and practical assessment. The response of the defects used, with respect to the actual NDT system, must adequately represent the response of the expected or observed real defects. The assessment of the qualification defect's representation can however not be performed within a particular qualification project. This must be a subject for research and development efforts. The Swedish qualification body is conducting such research and development projects.

The awareness of these important aspects has increased after the evaluation of uncertainties in the result from inspections of Ringhals 3 and 4 safe-ends during 2000 and 2001 were complex inter dendritic stress corrosion cracking were observed.

Switzerland

Concerning the representative nature of simulated defects we have to rely on the state-of-the-art in artificial flaw manufacturing techniques, and use what can be obtained in time and at reasonable cost. We are aware of the existing shortcomings. The question of how representative flaws can be simulated cannot be answered in the framework of a qualification project. It should be an issue for research programs.

United Kingdom

Validity of test blocks in terms of type, location and size of defects is of course the major issue for the practical trials aspects of qualification. There are no simple answers to this question. The only way to assess the location and size of defects in test blocks is by using a combination of NDT techniques with a knowledge of how the defects were manufactured. The only way to determine the ‘true’ location and size is to section a test block and so in the process destroy it. So test blocks can only be sectioned once they have finished being used for qualification purposes. In the UK several internationally-known methods have been used to implant defects in trial blocks. This process seems very much at the empirical level at present, with differing results achieved using apparently the same nominal technique.

United States of America

The PDI reactor pressure vessel specimens are full size “mock ups” of the actual component. The test specimens are fabricated from material salvaged from cancelled nuclear power plants. Flaw types and sizes specified by ASME have been introduced with each test specimen. Exhaustive investigations on the quality of the material and test specimen manufacturing capabilities are completed to make certain that all test specimens are of the highest quality. Technical basis documents were developed for flaw types used and to ensure that reliability and repeatability of flaw manufacturing methods could be verified. These technical basis documents include comparison where possible with the test flaws to flaws detected during ISI

2.9 What are the general experiences so far, from a regulatory point of view, of applied NDT qualification/performance demonstration approaches in your country? Do you foresee any changes in the near future?

Belgium

Stricto sensu, there is no qualification body in Belgium, but the Working Group is actually playing the role of a qualification body; for instance the approval of all qualification activities is in the scope of the Working Group.

Belgium is not such a large country that many people are working on NDT in nuclear industry. In order to pool the knowledge and be efficient, it has been considered wise that the licensee, the architect/engineer and the authorised organisations are members of the same Working Group in charge of NDT system qualification. Further, regular meetings take place between NDT experts of Belgian and foreign Safety Authorities, in particular BCCN from France, in order to exchange views on the approaches followed in both countries.

The experience gained during the qualification activities in relation with RPV inspection has shown some benefit to the approach followed for organising these activities: the authorised organisations are involved in the full process of qualification and, if some confrontations arise, they take place during the development phase of the qualification process, and not only at the end, allowing a better proactivity.
Therefore, no changes are foreseen in the near future. Moreover, in order to avoid a loss of critical sense by being too much involved in the qualification activities, the work is divided as follows: a follow up of every step by the inspection specialists of the ANII and only a review by AVN, keeping in mind the safety objectives of the inspection.

There are some experiences of the use of qualifications from foreign countries, mainly because the vendors are foreign companies. In particular, for UT inspection qualification of RPV, the results of practical trials performed in France, by EDF, on mockups are used: the mockups are representative of the geometry of one of the Belgian vessel and contain real or artificial defects; these results are complemented by modelling and technical justification; the integrated qualification programme was submitted by the vendor for approval to the licensee and to the authorised organisations.

Canada

Very favourable. VT to be addresses soon.

Czech republic

Due to the NDT qualifications performed in a systematic way according to national, ENIQ and IAEA methodologies there is a brief review of achievements:
- better understanding and trust in NDT techniques applied (participation of Safety Authority, Qualification Body and utility personnel at practical trials)
- verified NDT techniques capabilities including application of advanced techniques
- given evidence to meet ISI/qualification quantitative objectives determined based on knowledge of critical sizes of defects and damage mechanisms
- transparent, optimised and clearly written inspection procedures.

Finland

The licensees have generally referenced the European qualification methodology and the ENIQ recommended practices as a basis for qualification activities, but a lot of discussions against the details of those documents have arisen among the licensees.

The utilities have often started the qualification projects too late and timetables of inspection vendors have lengthened. Therefore, there may be period of waiting due to the lack of personnel resources at the qualification body. Qualification projects may take several years before final results.

Actions planned to be taken in our country to improve the effectiveness of qualifications are under discussion. A new revision of Finnish Regulatory Guide YVL 3.8 "Nuclear Power Plant Pressure Equipment. Inservice Inspections" is in the course of preparation.

France

No changes, go on

Germany

Hungary

Changes are under way as it is described in 2.2 and 2.8. Formally from regulatory point of view there will be an addition to “Safety requirements for operation of NPPs Ch. 9: In-service inspection requirements” and a new edition of Guideline 4.1: “In-service inspection of NPPs’ equipment” will be issued.

Japan

No answer because the question is not applicable to our country.

Korea

We performed some round robin tests for the NDT qualification using piping and studs and bolt specimen. The results showed that the training is very important in the NDT qualification and the new UT techniques are needed for the cast stainless steel and bi-material piping. We will enhance the requirement on the training with the specimen.

Netherlands

Spain

So far, we have not applied qualified NDT in Spain in the terms established in ENIQ methodology or in Appendix VIII. We follow ASME XI and ASME V as references. When pilot study VENDE will be finished, then the licensees must begin the qualification of NDT applied in their in-service inspection activities. See 2.10 below.

Sweden

The establishment of the infrastructure for qualification and the introduction of qualification requirements in Sweden have been very resource demanding and costly. The use of technical justifications, e.g. as a mean to reduce the number of practical trials needed, have not been as frequent as intended with the European qualification approach. There are also several other technical problems to be solved before the established qualification scheme and infrastructure fully will produce effective NDT system and reliable inspections in cost-effective manner. However, as experiences have been gained the qualification activities have become more and more effective.

The change from previous prescriptive NDT regulation to a strategy where the purpose of the inspection direct the NDT effectiveness needed is a complex issue which also have affected both the licensee and their inspection companies in many areas.

Switzerland

The general experiences from a regulatory view are:
Qualification is useful and necessary. The workload is high. It is a difficult task to bring together a qualification body that has the necessary ability and the required independence.

United Kingdom

United States of America

The early and accurate detection of flaws in plants is important for maintaining structural integrity and ensuring the safety function of safety-related systems and components. Appendix VIII is an improvement over previous ISI requirements, and NRC staff finds that Appendix VIII criteria, as implemented by the PDI program, provides UT results that are generally superior to those of the 1989 (and earlier) Edition of Section XI of the ASME Code.

There may be possible changes in the future with the recent events of control rod drive mechanism (CRDM) cracking. Conclusions regarding the most recent event at Davis Besse is raising a concern that there may need to be further review of the present inspection process for certain components of the plant

2.10 What are the experiences so far of using qualified NDT systems for in-service inspection activities in the plants?

Belgium

The most important qualification project under way is the project for inspection qualification of RPV welds; it is a huge project, which started in 1998 and should end in 2002; it is obvious that, in the, the long term licensee will benefit from the results of the project: the amount of inspections (mainly reinspections of indications) carried out will certainly decrease due to the improved efficiency and effectiveness of the methods used, leading to a better knowledge of the indications.

A follow up of every step of the inspection procedures and of their application on site during ISI is performed by the inspection specialists of the ANII.
Qualifications are completed for the following components :

- reactor pressure vessels : nozzle welds, flange to shell welds, safe ends, circular shell welds, nozzle inside radii
- ferritic and wrought austenitic piping welds
- cast austenitic stainless steel : primary piping circular welds
- steam generator and pressuriser safe ends
- thick ferritic welds (for instance of the steam generator shell)
- all bolting, including RPV studs

A lot of experience has been gained with ECT inspection of old steam generators; NDT methods were adapted in function of results of destructive examinations of extracted tubes; due to SG replacement in 5 of the 7 units, this remains applicable only to the oldest units of Doel 1 and 2.

Canada

Generally good. Licensees are oriented toward broader use of remote inspection technologies.

Czech republic

In majority only inspection procedures for mechanised UT examinations known as "inspection procedures qualified within simulations of qualification as parts of PHARE projects" are used at present for in-service inspections. These inspection procedures are applied on site at Dukovany NPP with success on austenitic primary piping (complex geometries including T- pieces) and dissimilar welds. Advantages appreciated: transparent inspection procedures, very good results of geometrical indications analysis, substantial improvement of defect sizing capabilities. UT/ET qualification of other inspection procedures will be completed in the period 2002-2003 and applied on site.

Finland

We haven't experiences so far of using qualified NDT systems for in-service inspection activities in the plants.

France

For activities on the plant it-self, no changes.

The changes occur due to the law in the relationship between the regulator/NOP/ND

Engineering department, and the introduction of the IQB as new partner.

Germany

Hungary

There is no reliable experience of using qualified NDT systems yet.

Japan

No answer because the question is not applicable to our country.

Korea

We will apply the NDT qualification from 2004.

Netherlands

Spain

None following either PDI or ENIQ Qualification Methodologies. However, a significant number of inspection areas of Spanish nuclear power plants have been inspected according to ad-hoc qualification schemes defined by the utilities and the ISI vendor in a case by case situation.

Sweden

Qualified NDT systems have now been used in Sweden since the requirements became mandatory in 1996. It is a common view that the quality of in-service inspections has increased. In several cases have qualified NDT systems detected cracks that previously were missed by non qualified NDT systems.

However, inspection failures with qualified NDT systems have also been observed. These failures were mostly caused by circumstances not considered during the qualification process. This was the case for the inspection in Ringhals 3 and 4 during 2000 when a qualified eddy-current system failed to detect the very tight inter dendritic stress corrosion cracks in the Alloy-182 safe-end welds. Such tight cracks was not expected and therefore not included in the qualification test blocks.

Switzerland

The experience of using qualified NDT systems for ISI activities in the plants is good. The systems, in general, performed well. There is confidence in their capability and reliability. Decisionmaking is transparent and more convincing. In some cases, an iteration in the qualification process was necessary as a result of feedback from the examination on site.

United Kingdom

Finding defects is a rare event, there is not much experience of this. There is even less experience of finding defects of structural concern.

There is an example where a Technical Justification was based on a defect specification which in the event was incomplete. Subsequent sectioning of plant items removed from service revealed this. Due to an assumption about the maximum credible defect depth through-wall, the inspection procedure was established to detect and size defects to a certain depth. Some defects were beyond this depth. Some indications associated with the defects beyond the supposed maximum depth were identified but were not characterised as cracking (of the three probe angles used only one was able to detect the deeper cracking).

Following the destructive examination of components removed from service and the discovery of deeper cracking, the inspection procedure was revised and the Technical Justification amended. This particular experience does not reveal shortcomings in the qualification process itself, but rather the input information to the process and then application of the inspection procedure.

United States of America

Inspections are being conducted at higher sensitivities than the prescriptive DAC based procedures that were implemented to meet ASME Code requirements prior to Appendix VIII. The consequence of this is that there are many indications that must be evaluated. However, the Appendix VIII qualified procedures provide detailed guidance on how to conduct these evaluations. Therefore, very high quality ISI is being conducted in a systematic and consistent manner but the data analysis time has increased because of the many indications that must be evaluated.

2.11 Discuss what further actions and developments that are needed to improve (from safety, cost-effective point of view, etc) the application of NDT qualification requirements?

Indicate also aspects that can be appropriate for further discussions in IAGE or its subgroups.

Belgium

It is believed that an adequate and flexible organisation has been developed in Belgium to deal with the problem of inspection qualification; the policy of the Belgian licensee fully endorsed by the Working Group is to stay open to various qualification methodologies in order to take advantage of all possibilities of tailoring qualification to specific cases (taking into account the technological evolution) and therefore to suit the quality of the inspection to the safety requirements.

The Working Group is a standing committee, which can meet rapidly on request and take the appropriate decisions. Actually, a qualification project can start as soon as a problem occurs, because the qualification is usually performed by the vendor, who has an interest to get things moving forward; of course, it can take a long time before a qualified procedure is available for site application.

No particular actions are envisaged at the present time to improve further the application of NDT qualification requirements.

Canada

Remote inspection technologies and techniques to reduce radiological exposure.

Czech republic

The following measures are being gradually introduced in both directions in the region among Czech and Slovak NPPs , partially with PAKS (Hungary) and KOZLODUY (Bulgaria) NPPs:

- sharing available documentation and test blocks designed and manufactured within the PHARE projects
- exchange of independent NDT experts hired by Qualification Bodies
- exchange/renting the test blocks for laboratory trials, inspection procedures optimisation examinations and qualification practical trials

a design of test blocks taking into account ISI/qualification requirements, criteria, opinions of several operators (a high level – shared design and expenses)

Aspects for further discussion:
Ways to NDT qualification cost reduction
a) a review of NDT qualifications

- A simple database containing a brief description of performed NDT qualifications with references in Europe

b) test blocks with intended defects

- IAGE should support a potential meaning in future of databases of test blocks applicable for NDT qualification created by ENIQ and IAEA Vienna

c) technical justifications
Similarly it is suggested to consider similar common sources of information and data applicable within elaboration of technical justifications – "handbooks of NDT evidence (no

expensive sophisticated databases, but a simple “storage” of data on internet)

Finland

In Finland procedures and documentation of qualifications shall be improved. The use of an ad hoc type qualification body affects the qualification process, which at least so far hasn't been according to ENIQ in detail.

We have found it difficult to write reliable technical justification, especially to find evidences from the reliable sources and use them in the correct way.

It would be of advantage to co-ordinate the R&D activities in an international level.

France

The efficiency of the requirements based on realistic request compare to the NDE capability
What is the goal of the qualification?

a) to pass an exam (ASME practice)
b) to increase the knowledge level about NDE practice (ENIQ rules)

Clarify how to define the qualification performances; not the best you can do

Germany

Hungary

Further actions needed are described in 2.2. and 2.8.

Japan

To set up a place for making discussion to establish NDT qualification system in Japan.

Korea

Followings are needed to improve the application of NDT qualification;

- To develop New UT techniques for the cast stainless steel and bi-material piping
- To develop the manufacturing techniques of the crack in the specimen
- To encourage the training with the specimen

Netherlands

Spain

We identify as further actions, in the field of NDT qualification, to share national initiatives in order to obtain a feedback of practical experiences. Also, a database identifying all qualification test specimens with their features and their owners could be of great interest in order to share them for qualification purposes, upon agreement. Mutual recognition between countries (licensees and regulators) will also be cost-effective and time-saving.

Sweden

Examples of areas for further development are defect simulations to be used in qualification exercises, the use of parametric studies and modelling in technical justifications to optimise practical open and blind demonstrations, and the strategies for qualification of NDT operators. A more general validity is needed for these qualifications, which then have to be based on systematic assessments of tasks in frequently used NDT-procedures.

There is also a need for more comprehensive surveys of the nature of real defects. This type of information is necessary to guide both further development works in the area of defect simulation production and the assessments of technical justifications.

Switzerland

International collaboration should be intensified (e. g. exchange of test pieces, mutual assistance, joint projects). The realistic simulation of service-induced flaws is a key issue of the qualification methodology; research efforts are necessary in this area. It should be considered whether mutual recognition of qualifications could be promoted by some level of standardisation.

United Kingdom

Qualification of inspection has a reputation for being expensive and time consuming and to be fraught with difficulty: for instance what happens if the inspection fails qualification? Perhaps qualification needs to be de-mystified so that it can come to be seen as a more common-place tool.

Qualification is in essence an administrative or project activity which provides a platform for combining knowledge of:

- physical technique information
- and human performance
- at a point in time to produce an inspection process (equipment, procedures, personnel) which has received a degree of care in its creation.

The qualification activity in many ways provides a vehicle for learning during the process of evolving the inspection process. It is perhaps least helpful to view qualification in terms of a pass/fail process.

United States of America

There are several areas where further improvements are needed. The inspection of cast stainless steels and the far side inspection of austenitic stainless steels are coarse grained anisotropic materials that need to be reliably inspected and current technology does not provide this capability.

Because of the prohibitive cost of quantifying the performance of a given inspection system (personnel, equipment and procedure) the testing is based on screening tests. Fortunately, most procedures and equipment combinations are used by a number of inspectors and thus, insights into true performance can be determined by collapsing the test data across the inspectors.

Desired improvements would be to refine the testing process to make it very economical:

1. Perhaps the use of computer based training can be used to rapidly train personnel using data from real field flaws
2. Develop less expensive means to create specimens and flaws while still making them very good simulations of field conditions
3. Develop a more rigorous test for the equipment and procedures so that the personnel test can be less costly but yet have a high pass rate of only highly qualified inspectors.

Because for the first time the performance of the population of field inspectors is known, the next step needs to be taken to couple this with good fracture mechanics modelling (covering flaw initiation and growth) to develop optimized inspection programs. POD by itself does not mean anything because even a perfect performance will not insure structural integrity if the inspection interval is so long that a flaw can initiate and grow through wall before the next inspection.

Qualification testing needs to be considered in the design stage of nuclear components so that the repairs, replacements or next generation plants take advantage of lessons learned and provide access and material selections which insure that highly reliably inspections can be conducted.

The Appendix VIII performance test program is based on dealing with inservice degradation (cracking) and it does not deal with issues of repair and replacement (welding defects such as lack of fusion, porosity, etc.). The question is how to cost effectively achieve an Appendix VIII quality of inspection for PSI of repairs and replacements.