umweltbundesamt

ETE Road Map

According to Chapter IV and V of the
"Conclusions of the Melk Process and Follow-Up"

Item 4

Integrity of Primary Loop Components – Non Destructive Testing (NDT)

Final Monitoring Report

Report to the Federal Ministry of Agriculture, Forestry, Environment and Water Management of Austria

Vienna, May 2005

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Project Coordination

Katja Lamprecht
(Umweltbundesamt – Federal Environment Agency – Austria)

Layout

Claudia Kubelka
(Umweltbundesamt – Federal Environment Agency – Austria)

Technical Project Management

ENCONET Consulting – Austria

Authors

K. Gudek
(Consultant, Slovenia)

D. Pete
(Consultant, Slovenia)
P. Kauppinen
(Consultant, Finland)
H. Wüstenberg
(Consultant, Germany)

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Should you encounter technical problems, please do not hesitate to contact mailto: marlene.engel@umweltbundesamt.at.

EXECUTIVE SUMMARY

The quality of the in-service inspection of the main primary loop components (reactor pressure vessel, main coolant lines, primary side of steam generator, surge line) has been recognized as an important aspect of the safety of NPP Temelín. As the methods originally used for WWER-1000 NPPs are being improved to correspond to the Western safety standards, the issue of in-service inspection and non-destructive methods applied to the integrity of primary system components has been identified as Item No 4 among seven items to be monitored on technical level according to the "Conclusions of the Melk process and follow-up" ("Brussels Agreement"). The aim of monitoring is to evaluate the level of completeness and the appropriateness of in-service inspection and non destructive testing of integrity of primary loop components at Temelín, aimed at assuring their integrity under all normal and accidental conditions envisaged at Temelín plant.

A "Roadmap" regarding the monitoring on the technical level in the framework of the pertinent Czech-Austrian Bilateral Agreement as foreseen in the "Brussels Agreement" has been elaborated and agreed by the Deputy Prime Minister and the Minister of Foreign Affairs of the Czech Republic and the Minister of Agriculture and Forestry, Environment and Water Management of the Republic of Austria on 10 December 2001.

According to the ANNEX I of the "Brussels Agreement", each item to be monitored is linked to:

- Specific objectives set in licensing case for NPP Temelín units
- Description of present status and future actions foreseen by the licensees and State Office for Nuclear Safety (SONS), respectively.

Following the "Roadmap" guidance that a Specialists' Workshop be held in the 2-nd half of 2004, the workshop was held in Rez near Prague on October 7-8, 2004 to discuss this issue. Recognizing that the Czech-Austrian Bilateral Agreement is an appropriate framework that provides the opportunity for further discussion and sharing additional information on this issue, it is understood that any findings warranting further attention would be addressed and resolved within the monitoring process as defined by the Bilateral agreement.

ENCONET Consulting was contracted by Umweltbundesamt (Federal Environment Agency) on behalf of the Austrian Government to provide the technical support for the monitoring process related with the ISI and NDT of primary loop components, succinct to the ANNEX I of the Conclusions of the Melk Process and Follow-up. This technical support to the monitoring was defined as a specific project, which is referred to as the "Project PN10: Integrity of Primary Loop Components – Non Destructive Testing (NDT)". The project itself comprises several predefined "project milestones" (PM), each devoted to specific technical aspect and/or interface requirements.

The main aspects of the situation in Temelín NPP considered in the project are related with the in-service-inspection and with non-destructive testing qualifications issues.

Since the introduction of the Atomic Act in 1997 and the accompanying regulations the program of in-service inspection has been required by law and is subject of State Office for Nuclear Safety (SONS) approval. Generally the ISI programme qualification approach is based on the requirements adopted by Western Europe countries in accordance with European Network for Inspection Qualification (ENIQ) methodology for Nondestructive Tests, on EUR 17299 and on IAEA methodology for qualification of ISI systems for WWER NPPs.

State Office for Nuclear Safety (SONS) issued its own safety guide on ISI of Main Primary Circuit Components in WWER Reactors (1998), and it is the basis of ISI/NDT in Temelín NPP. The basic standard for the qualification of the NDE personnel has been also published and it is similar to the European standard EN 473.

SONS provides supervision of all ISI qualification activities, and has determined the rules for performance demonstration which is a part of ISI qualification system. The responsibilities of the plant owner are determined by SONS decrees and the Atomic Act.

The extent and frequency of examinations, the methods and acceptance standards are clearly defined within the ISI programme and in work instructions. Acceptance standards are specified for each NDE method applicable for ISI program. The acceptance criteria for UT inspection have been replaced with analytical thresholds, which means that in the case of indications which exceed the registration level an analytical procedure is applied to judge upon the defect relevance using state-of-the art method. The criteria used at the end of the analytical procedure have not been clearly discussed.

Reactor Pressure Vessel is inspected both from inside and outside. All nozzle to pipe welds, including dissimilar welds are requested to be 100% inspected both from outside and inside. UT techniques are applied to all welds with commonly recommended pulse echo probe arrangements and registration thresholds are comparable with those in western states, e.g. in Germany, UK or USA. For all the different inspection tasks previous qualification trials including performance demonstration had to be performed. Further developments of NDT techniques especially in respect of RPV crack detection should be followed by the plant and applied as appropriate. This should be one of the items of future bilateral information exchange.

Atomic law and decrees prescribe responsibilities for preparation and retention of records and reports. The content is prescribed by the ASI requirements. When the acceptance criteria are exceeded, a submittal of reports to SONS is required.

The Qualification Body is established at CEZ as a permanent institution supported by external experts. Since a representative of Temelín NPP is a member of QB, there is a doubt about the independence of QB. The participation of the plant representative in the QB is not usual but it can be understandable in the case of reactor pressure vessel inspection because the inspection manipulators and mock-ups used in qualification are permanently stored inside the plant area and the qualification trials have to be performed in the plant area. Therefore the participation of plant personnel can be necessary. It was understood that the representative of Temelín NPP has been a non-voting member in the QB and has not the possibility to affect the results of qualification. The qualification process is supervised by SONS. The transparency and independence of the qualification is assured by the participation of APC (Association for Personnel Certification in Czech Republic). The content of qualification procedure is described in SONS document and is similar to the content given in EUR 17299 EN.

Inspection procedures are in general the effect of transferring recommendations of EUR 18117 EN and EUR 18101 EN to the Czech situation in a somewhat modified form.

The calibration block design, calibration, equipment set-up the data collection, interpretation, recording and ways of reporting are included in the ISI programme and described in detail. The surveillance activities of SONS include also during the qualification trials the check of personnel qualification.

It is recognized, that the Czech organizations apply modern eddy current equipment and analysis tools produced by the company ZETEC (USA). This confirms that Czech experts follow common western practices.

Other kinds of inspection like eddy current of collector surfaces and threaded holes, or visual inspections of welded joints, guarantee the confidence to all- embracement of the SG ISI program.

Determination of steam generator tubing plugging criteria represents the typical and correct way how the plugging criteria should be calculated based on performed burst test. Taking in account eddy current tool accuracy, flow growth rate followed by the statistical evaluation, shows that SG ISI experts are competent in this field.

The ideas of technical justification defined in EUR 18099 EN have been taken into consideration, and the qualification trials demonstrated for the ISI at the RPV and at 850 DN piping prove that the TJ philosophy was a starting point for qualification activities at Skoda and NRI. In some aspects however the Czech interpretation is not in agreement with the intentions of EUR 18099, in particular what concerns the use of worst case test defects and test conditions at the test block design.

The cases observed by Austrian experts indicate that the minimal personnel requirements follow the EUR18099 EN. The qualification specimen trials are conducted under SONS supervision in a secure area, the qualification assessment reports and certificates are drawn in accordance with the approach established in Western European countries.

There are some hints from discussions with Czech experts that one should in future carefully observe that they will continue with the positive efforts which have been stated by the Austrian experts during their investigations in order to improve the NDT also at those items where critical remarks have been made within this report. In particular it is recommended to revisit the following issues:

- establishment of a written working policy concerning responsibilities of qualification body and practical actions in qualification, as recommended in European ENIQ methodology
- links of new Czech ISI to US and EUR standards
- independence of qualification procedures
- extension of inspection scope in case of detected flaws
- statistical analysis influence on judgment about the accuracy of results
- detectability of defects perpendicular to the inner surface of the reactor vessel
- upgrading the qualification process by bringing the conditions of artificial defects closer to those which may appear during ISI in the plant components.

Although these items warrant further bilateral information exchange, it should be realized that most of the issues mentioned here are connected with the fast development of NDT techniques and are expected to be resolved with time. The level of achievement so far and consideration of the on-going activities in Temelín NPP is such as to allow the conclusion that the ISI and NDT of integrity of primary loop components at Temelín is comparable with Western European NPPs.

ZUSAMMENFASSUNG

Die Qualität der wiederkehrenden Prüfungen (In-Service-Inspection) der wichtigsten Primärkreislaufkomponenten (Reaktordruckbehälter, Hauptkühlmittelleitungen, primäre Seite der Dampferzeuger, Volumenausgleichsleitung) hat sich als wichtiger Aspekt der Sicherheit des AKW Temelín herausgestellt. Da die ursprünglich für Kernkraftwerke vom Typ WWER-1000 angewendeten Methoden verbessert werden, um den westlichen Sicherheitsstandards zu entsprechen, wurde der Problemkreis der wiederkehrenden Prüfungen und der zerstörungsfreien Prüfmethoden, die auf die Integrität der Primärkreislaufkomponenten angewandt werden, als Punkt Nr. 4 unter 7 Punkten identifiziert, die, gemäß den „Schlussfolgerungen des Melk-Prozesses und Folgemaßnahmen", auf technischem Niveau zu überwachen sind. Das Ziel der Überwachung ist es, das Niveau der Vollständigkeit und die Angemessenheit der wiederkehrenden Prüfungen und zerstörungsfreien Prüfungen der Integrität der Primärkreislaufkomponenten in Temelín zu bewerten und deren Integrität unter allen möglichen normalen und Unfall-Bedingungen im KKW Temelín sicherzustellen.

Die Überwachung findet innerhalb des Rahmens statt, den die „Roadmap" zur Umsetzung von ANNEX I und ANNEX II der „Schlussfolgerungen des Melk-Prozesses und Folgemaßnahmen" vorgibt, die im Rahmen des Tschechisch-Österreichischen Bilateralen Abkommens im November 2001 festgehalten wurde. Gemäß dem ANNEX I der „Schlussfolgerungen des Melk-Prozesses und Folgemaßnahmen" ist jeder der 7 Punkte verbunden mit:

- Spezifischen Zielen, festgelegt im Genehmigungsverfahren für die Blöcke des AKW Temelín
- Beschreibung des gegenwärtigen Status und der von den Betreibern und dem tschechischen Staatsamtes für Kernsicherheit (State Office for Nuclear Safety, SONS) jeweils zukünftig geplanten Aktionen.

Gemäss der Vorgabe durch die "Roadmap", dass ein Spezialisten-Workshop in der 2. Hälfte des Jahres 2004 abgehalten werden sollte, wurde der Workshop in Řež in der Nähe von Prag am 7./8. Oktober 2004 abgehalten, um diesen Punkt zu besprechen. In Anbetracht dessen, dass das Tschechisch-Österreichische Bilaterale Abkommen einen angemessenen Rahmen darstellt, der die Gelegenheit für weitere Diskussionen und Informationsaustausch zu diesem Problemkreis bietet, ist es selbstverständlich, dass alle Ergebnisse, die näherer Untersuchung bedürfen, innerhalb des Überwachungsprozesses behandelt und geklärt werden, wie vom bilateralen Abkommen vorgesehen.

ENCONET Consulting wurde von Umweltbundesamt im Namen der Österreichischen Regierung vertraglich verpflichtet, den technischen Support für den Überwachungsprozess bereitzustellen, soweit wiederkehrende Prüfungen und zerstörungsfreie Prüfungen der Primärkreislaufkomponenten betroffen sind, entsprechend dem ANNEX I der „Schlussfolgerungen des Melk-Prozesses und Folgemaßnahmen". Dieser technische Support für die Überwachung wurde als spezifisches Projekt definiert, welches als das „Projekt PN10: Integrität der Komponenten des primären Kreislaufs – Zerstörungsfreie Prüfungen" bezeichnet wird. Das Projekt selbst umfasst mehrere vordefinierte „Projekt-Meilensteine", von denen jeder einen spezifischen technischen Aspekt und/oder Anforderungen zu Schnittstellen zum Inhalt hat.

Die im Projekt behandelten Hauptaspekte der Situation im KKW Temelín stehen mit der Qualifikation der wiederkehrenden Prüfungen und der zerstörungsfreien Prüfungen in Verbindung.

Seit der Einführung des Atomgesetzes von 1997 und der begleitenden Bestimmungen wird das Programm der wiederkehrenden Prüfungen vom Gesetz gefordert und unterliegt der Zustimmung des SONS. Generell beruht die Qualifikation der wiederkehrenden Prüfungen auf den Anforderungen, die von den westeuropäischen Ländern in Übereinstimmung mit der Methodologie für zerstörungsfreie Prüfungen des Europäischen Netzwerkes für Inspektionsqualifikation (ENIQ), der Richtlinie EUR 17299 und der Methodologie der IAEO für die Qualifikation des Systems der wiederkehrenden Prüfungen für WWER-Kernkraftwerke übernommen wurden.

Das Staatsamt für Kernsicherheit (SONS) veröffentlichte seine eigenen Sicherheitsrichtlinien über wiederkehrende Prüfungen der wichtigsten Komponenten des primären Kreislaufs in WWER Reaktoren (1998), welche die Grundlage der wiederkehrenden Prüfungen / zerstörungsfreien Prüfungen im Kernkraftwerk Temelín bilden. Die Grundlagen für die Qualifikation des Personals für die zerstörungsfreien Prüfungen wurden ebenfalls veröffentlicht und sind ähnlich dem Europäischen Standard EN 473.

Das SONS ist für die Aufsicht über alle Aktivitäten zur Qualifikation wiederkehrender Prüfungen zuständig, und legt die Regeln für die Leistungsnachweise fest, die ein Teil des Qualifikationssystems für die wiederkehrenden Prüfungen sind. Die Verpflichtungen der Kraftwerksbetreiber sind in den Bestimmungen des SONS und dem Atomgesetz festgehalten.

Das Ausmaß und die Häufigkeit der Untersuchungen, die Methoden und Abnahme-Standards sind innerhalb des Programms der wiederkehrenden Prüfungen und in Arbeitsrichtlinien klar definiert. Abnahme-Standards sind für jede zerstörungsfreie Prüfmethode, die für das Programm der wiederkehrenden Prüfungen anwendbar ist, spezifiziert. Die Abnahmekriterien für Ultraschall-Prüfungen wurden durch analytische Schwellenwerte ersetzt, d. h. dass im Falle von Indikationen, die die Registriergrenze übersteigen, ein analytisches Verfahren angewendet wird, um die Schadensrelevanz unter Verwendung von Methoden gemäß dem aktuellen Stand der Technik zu beurteilen. Die Kriterien, die am Ende des analytischen Verfahrens benutzt werden, sind noch nicht vollständig festgelegt.

Der Reaktordruckbehälter wird sowohl von innen als auch von außen inspiziert. Alle Schweißstellen zwischen Stutzen und Rohren, einschließlich Schweißstellen zwischen verschiedenen Materialien, müssen zu 100% von innen und außen inspiziert werden. Ultraschall-Techniken werden mit dem allgemein empfohlenen Puls-Echo-Messverfahren auf alle Schweißstellen angewendet, und die Registriergrenzen sind vergleichbar mit denen in den westlichen Ländern, z. B. in Deutschland, England oder USA. Für alle verschiedenen Inspektionsaufgaben mussten vorher Prüfversuche zur Qualifikation, einschließlich Leistungsnachweis, durchgeführt werden.

Es steht zu erwarten, dass weitere Entwicklungen der Verfahren zur Zzerstörungsfreien Prüfung, speziell bezüglich der Auffindung von Rissen im Reaktordruckbehälter von Kernkraftwerken, aufgegriffen und entsprechend angewendet werden.

Das Atomgesetz und die begleitenden Bestimmungen legen die Verantwortlichkeiten für die Erstellung und Aufbewahrung der Aufzeichnungen und Berichte fest. Der Inhalt wird durch die Anforderungen des American Standard Institute (ASI)vorgeschrieben. Wenn die Abnahmekriterien überschritten werden, müssen Berichte an das SONS geliefert werden.

Die Qualifikationsbehörde (Qualification Body, QB) wurde beim Elektrizitätsversorgungsunternehmen CEZ als ständige Einrichtung gegründet, unterstützt von externen Experten. Da ein Vertreter des Kernkraftwerkes Temelín Mitglied des QB ist, bestehen Zweifel über die Unabhängigkeit des QB. Die Teilnahme des Kernkraftwerks-Vertreters im QB ist nicht üblich, ist aber im Falle der Reaktordruckbehälter-Prüfungen verständlich, da die Prüfmanipulatoren und Modelle, die bei der Qualifikation benutzt werden, ständig im Bereich des Kernkraftwerkes gelagert werden und die Prüfversuche zur Qualifikation auch dort stattfinden müssen. Deshalb kann die Teilnahme von Kernkraftwerks-Personal notwendig sein. Es wurde vereinbart, dass der Vertreter der Kernkraftwerkes Temelín ein Mitglied ohne Stimmrecht im QB ist und keine Möglichkeit hat, die Resultate der Qualifikation zu beeinflussen. Der Qualifikationsprozess wird vom SONS beaufsichtigt. Die Transparenz und Unabhängigkeit der Qualifikation wird durch die Teilnahme der APC (Association for Personnel Certification in Czech Republic, Gesellschaft für Personalzertifizierung in der Tschechischen Republik) sichergestellt. Der Inhalt des Qualifikationsprozesses ist in einem SONS Dokument beschrieben und ist ähnlich dem Inhalt von EUR 17299 EN.

Die für die Inspektionen entwickelten Vorgehensweisen haben im Allgemeinen den Zweck, die Empfehlungen von EUR 18117 EN und EUR 18101 EN in etwas abgeänderter Form auf die tschechische Situation anzuwenden.

Die Auslegung der Testkörper, die Kalibrierung, verwendete Ausrüstung, Organisation der Datensammlung, Interpretation, Aufzeichnungen und Berichte sind im Programm der wiederkehrenden Prüfungen beinhaltet und im Detail beschrieben. Die Überwachungsaktivitäten von SONS beinhalten während der Prüfversuche zur Qualifikation auch die Überprüfung der Qualifikation des Personals.

Die Nutzung von modernen Wirbelstromgeräten sowie Mitteln zur Analyse, hergestellt von der Firma ZETEC (USA), durch die tschechischen Prüforganisationen muss anerkannt werden. Dies bestätigt, dass tschechische Experten die verbreiteten westlichen Methoden anwenden. Andere Arten der Prüfung, wie Wirbelstromprüfungen der Kollektoroberflächen und Gewindebohrungen oder visuelle Inspektionen der geschweißten Verbindungen, garantieren, dass das Prüf-Programm für die Dampferzeuger alle wichtigen Bereiche umfasst.

Die Festlegung von Kriterien für das Verschließen von Dampferzeuger-Heizrohren erfolgt nach einer charakteristischen und korrekten Berechnungs-Methode, die sich auf durchgeführte Bruchtests stützt. Unter Berücksichtigung der Genauigkeit der Wirbelstromgeräte zeigt die Flusszuwachsrate, gefolgt von der statistischen Auswertung, dass die wiederkehrenden Dampferzeuger-Prüfungen von kompetenten Experten durchgeführt werden.

Das Konzept der „technischen Rechtfertigung“ (technical justification), definiert in EUR 18099 EN, wurde berücksichtigt. Darüber hinaus zeigen die Qualifikationsprüfversuche für die wiederkehrenden Prüfungen beim Reaktordruckbehälter und bei den 850 DN Rohren, dass die „technische Rechtfertigung“ der Ausgangspunkt für die Qualifikationsaktivitäten bei Skoda und KFI Řež war. In einigen Aspekten ist jedoch die tschechische Interpretation nicht in Übereinstimmung mit den Intentionen des EUR 18099, insbesondere betreffend die Nutzung von Testkörpern mit den ungünstigsten Fehlern (worst case defects) sowie die Bedingungen zur Auslegung der Testkörper.

Die Fälle, die von den österreichischen Experten überprüft wurden, zeigen, dass die minimalen Personalanforderungen der Richtlinie EUR 18099 EN folgen. Die Prüfversuche zur Qualifikation werden unter Aufsicht von SONS in einem abgesicherten Bereich durchgeführt. Die Qualifikationsbewertungsberichte und Zertifikate werden in Übereinstimmung mit den in westlichen Ländern bewährten Methoden ausgestellt.

Einige Hinweise aus Diskussionen mit tschechischen Experten deuten darauf hin, dass in Zukunft sorgfältig verfolgt werden sollte, ob sie mit den Bemühungen fortfahren, die zerstörungsfreien Prüfungen auch in jenen im Bericht kritisierten Punkten zu verbessern, die von den österreichischen Experten während ihrer Untersuchungen ermittelt wurden. Insbesondere wird die weitere Überwachung folgender Punkte empfohlen:

- schriftliche Festlegung der Arbeitsweise im Hinblick auf die Verantwortlichkeiten des QB sowie der praktischen Vorgehensweise bei der Qualifikation, entsprechend den Empfehlungen der Europäischen ENIQ-Methodologie.
- Verbindungen der neuen tschechischen Verfahren bei den wiederkehrenden Prüfungen mit den US und EUR Standards
- Unabhängigkeit der Qualifikationsprozesse
- Ausweitung des Prüfumfangs im Falle von entdeckten Fehlern
- Einfluss der statistischen Analyse auf die Bewertung der Genauigkeit von Resultaten
- Auffindbarkeit von Defekten, die senkrecht zu der inneren Oberfläche des Reaktordruckbehälters orientiert sind
- Verbesserung des Qualifikationsprozesses, indem die künstlichen Fehler in den Testkörpern mehr jenen angeglichen werden, die bei wiederkehrenden Prüfungen in den Komponenten des Kraftwerkes auftreten können.

Obwohl diese Punkte weiterer Beobachtung bedürfen, sollte angemerkt werden, dass die meisten der hier erwähnten Probleme mit der schnellen Entwicklung von Methoden der zerstörungsfreien Prüfung in Verbindung stehen und erwartet wird, dass sie im Laufe der Zeit gelöst werden. Das bisher erreichte Niveau sowie die Berücksichtigung der laufenden Aktivitäten im Kernkraftwerk Temelín erlauben den Schluss, dass die wiederkehrenden Prüfungen und zerstörungsfreien Prüfungen der Integrität der Primärkreislaufkomponenten in Temelín mit jenen in Westeuropäischen Kernkraftwerken vergleichbar sind.

TABLE OF CONTENS

1 INTRODUCTION

1.1 The framework

Republic of Austria and the Czech Republic have, using the good offices of Commissioner Verheugen, reached an accord on the "Conclusions of the Melk Process and Follow-up" (Brussels agreement) on 29 November 2001. In order to enable an effective use of the achievements of the initial "Melk Process" in the area of nuclear safety, the ANNEX I of this "Brussels Agreement" contains details on specific actions to be taken as a follow-up to the "trialogue" of the "Melk Process". The pertinent Czech-Austrian Bilateral Agreement governs this follow up.

To enable an effective "trialogue" follow-up in the framework of this Czech-Austrian Bilateral Agreement, a seven-item structure each presenting an important safety issue was adopted and specified in the ANNEX I of the "Brussels Agreement". These individual items are linked to 1) Specific objectives set in the licensing case for NPP Temelín and 2) Description of present status and future actions foreseen by the licensee and SÚJB, respectively. Each of seven items under discussion is pursued according to the work plan agreed at the Annual Meeting organized under the pertinent Czech-Austrian Bilateral Agreement.

Furthermore, the Commission on the Assessment of Environmental Impact of Temelín NPP, set up on the basis of the resolution of the Government of the Czech Republic, presented a report and recommended in its Position the implementation of twenty-one concrete measures (ANNEX II to the "Brussels Agreement). The signatories agreed that Czech and Austrian experts within the Czech-Austrian Bilateral Agreement would also regularly monitor the implementation of the measures.

The framework for the monitoring on the technical level of implementation was established in the "Roadmap" developed within the Czech-Austrian Bilateral Agreement as foreseen in the "Brussels Agreement". This Roadmap has been elaborated and agreed upon by the Deputy Prime Minister and Minister of Foreign Affairs of the Czech Republic and the Minister of Agriculture and Forestry, Environment and Water Management of the Republic of Austria on 10 December 2001.

This „Roadmap" is based on the following principles:

- *The implementation of activities enumerated in ANNEX I and II of the "Brussels Agreement" will be continued to ensure that comprehensive material is available for the monitoring activities set out below.*
- *Having in mind the peer review procedure foreseen by the EU to monitor the implementation of the recommendations of the AQG/WPNS Report on Nuclear Safety in the Context of Enlargement, the Czech and Austrian sides agree that this peer review should serve as another important tool to handle remaining nuclear safety issues.*
- *As a general rule the regular annual meetings according to Art. 7(1) of the bilateral Agreement between the Government of Austria and the Government of the Czech Republic on Issues of Common Interest in the Field of Nuclear Safety and Radiation Protection will serve to monitor the implementation of those measures referred to in Chapter V of the Conclusions and to address questions regarding nuclear safety in general, in particular those issues which – according to Chapter IV of the Conclusions have been found, due to the nature of the respective topics, suitable to be followed up in the framework of this Bilateral Agreement.*
- *In addition, specialists' workshops and topical meetings will take place, organized as additional meetings according to Art. 7(4) of the bilateral Agreement between the Government of Austria and the Government of the Czech Republic on Issues of Common Interest in the Field of Nuclear Safety and Radiation Protection, as set out in the "Roadmap".*

In Austria, the Federal Ministry of Agriculture, Forestry, Environment and Water Management entrusted the Umweltbundesamt(Federal Environment Agency) with the overall management of the implementation of the "Roadmap". For each of the items of the "Roadmap", specific technical project was established.

Item No. 4 "Integrity of Primary Loop Components – Non Destructive Testing (NDT)" of the ANNEX I of the "Brussels Agreement" is supposed to evaluate the level of completeness and the appropriateness of in-service inspection and non destructive testing of integrity of primary loop components at Temelín plant. This is to assure that primary loop components are tested to assure their integrity during all environmental conditions and under other external influences envisaged during normal and accidental conditions at Temelín plant.

Following the "Roadmap" guidance that a Specialists' Workshop be held in the 2-nd half of 2004, the workshop was held in Rez near Prague on October 7-8, 2004 to discuss this issue. Recognizing that the Czech-Austrian Bilateral Agreement is an appropriate framework that provides the opportunity for further discussion and sharing additional information on this issue, it is understood that any findings warranting further attention would be addressed and resolved within the monitoring process as defined by the Bilateral agreement.

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1.2 International requirements and practices in the area of In-Service Inspection and Non Destructive Testing

The requirements for In-Service-Inspection (ISI) and Non-Destructive Testing (NDT) of integrity of primary loop components exist in all countries operating NPPs, although practices vary, sometimes to a large extent. Very well documented systematic approach to the ISI and NDT is found in the USA and in many EU countries. Original requirements for Soviet-design were less developed than the western requirements. In particular, Soviet requirements for the detection and definition of defects were mostly taken as those in force in the process of manufacture. This required accuracy much higher than achievable under operational conditions in the plant, and so the detected defects could not be treated as admissible or non-admissible in absolute terms, but each case had to be judged by the experts of the plant and the decisions were taken for each case separately.

Typically, the ISI and NDT programme for equipment important to safety should be developed and started before fuel loading. Formal inspection reports should be completed (and where required, evaluated by the Regulator) before startup tests, and serve as the reference point for later tests. Normally, the NPP is responsible for the overall ISI/NDT program, which will cover all aspects of the primary loop components integrity to assure long-term preservation of the integrity of equipment important to safety. Where compulsory, the NPP would also submit relevant documentation to the Regulator to demonstrate the fulfillment of the ISI/NDT requirements.

It has to be noted that the ISI/NDT programs in their modern form were not in place at the time when most of the NPPs that are in operation today were starting up. Thus, the ISI/NDT has been implemented or improved on operating plants in most countries (as it is now being implemented at Temelín). This, however, does not apply to recent startups in western countries.

1.3 Assessment of Temelín ISI/NDT of primary loop components within the Melk follow up process

Within the framework of the project, ENCONET experts identified issues of interest and established criteria against which Temelín ISI/NDT program for integrity of primary loop components could be objectively assessed. This preparatory work encompasses establishing the criteria to reflect the state of the art practices and requirements in western Europe and USA. The regulatory requirements in the Czech Republic and the status of the ISI/NDT program for integrity of primary loop components at Temelín were assessed against these criteria. To document the status and the practices on the ISI/NDT program for primary loop components in western countries, ENCONET Consulting prepared several documents including the "Verifiable Line Items" (VLI) presenting the current status in this area in Germany, in Finland and in a Westinghouse reactor operated according to the US practice, "Specific Information Request", and extensive briefing materials for the Austrian delegation. The document on VLIs presented also a brief summary of Russian practices in the area and the expected status at Temelín NPP. All these data were used as the basis for the evaluation during (and after) the Workshop on ISI/NDT program for integrity of primary loop components of Temelín NPP, which was held in Rez near Prague on 7 and 8 October 2004.

The Workshop was the key element in establishing the findings on the following issues:

1. What are the content, requirements and current status of implementation of the ISI/NDT program for integrity of primary loop components in Temelín. In particular, of interest were the findings and results of the major features of this program, namely:
   a. Independence and responsibilities of the bodies involved in the process of ISI/NDT program for primary loop components,
   b. NDT methods,
   c. Requirements for examination and inspection,
   d. Acceptance standards,
   e. Qualification of NDE systems
2. What is the current status of the licensing process in relation with the ISI/NDT program for integrity of primary loop components;
3. What is the current status of the ISI/NDT program for integrity of primary loop components documentation at Temelín NPP;

Specific information to enable Austrian team to evaluate the status and qualification of ISI/NDE systems using the VLI and western practices as the criteria was supposed to be collected on the basis of Czech presentations and follow up discussions during the Workshop. The material presented at the Workshop included 10 topical papers. In addition, at ENCONET request, the Austrian delegation received an additional document, namely the regulatory guide on ISI/NDT program for integrity of primary loop components [SONS 98].

Thanks to extensive technical preparation and clarifying discussions during the Workshop, ENCONET experts achieved good level of technical understanding of the actual status of ISI/NDT program for checking integrity of primary loop components at Temelín NPP. This enabled the preparation of this monitoring report and a comprehensive identification of issues where further interest remains.

Following the completion of the evaluation of the Integrity of Primary Loop Components – Non Destructive Testing for Temelín NPP, that was based on the results of the workshop held in Rez in October 2004 as well as on additional investigations, consultations and contacts between Czech and Austrian experts, the findings were presented by the PN10 Team leader, Mr. Tomic at the Austrian Czech bilateral meeting held at Dolni Dunajovice in November 2004. Mr. Tomic's presentation addressed the objective and the scope of the evaluation as well as the methods and approach used for the evaluation. The presentation also addressed the findings of the evaluation and elaborated on specific findings including the status of the NDT in Czech Republic, the regulatory basis as well as use of NDT to support the VERLIFE concept. He also discussed a total of 6 issues of interest for future bilateral information exchange that were identified during the evaluation.

The discussion that followed on the preparations saw comments from the Czech NDT experts and replies for Austrian experts. The Czech experts pointed out that the issues identified by the Austrian team are indeed recognized as areas for improvement and that on some of these the activities are on-going to address possible deficiencies. The Austrian experts replied that these activities are seen as going into the right direction and that this was already recognized in the evaluation. The schedule for the completion of the activities was briefly discussed.

One point of partial disagreement was the capabilities of detection of small undercladding cracks. On this point the Czech experts pointed our that the approach taken by Austrian experts might have focus too much on use of a very specific method to detect the undercladding cracks, while other methods and approaches might have assured similar precision and accuracy. The Czech practice, however, is based on those other methods. In its reply to the comment the Austrian experts acknowledged that it was identified in the report that the Czech experts are already proposing the measures that would increase the accuracy of the detection by using alternative methods and specially designed evaluation approach. Both the Czech and Austrian experts agreed that this is not a safety issue of big importance because the Temelín reactor pressure vessel is young (i.e. in terms of radiation damage) and that the high accuracy might become an issue later in the operational life of the vessel.

1.4 Objective of this report

The objective of this report is to present the evaluation of the status of the ISI/NDT program for verifying the integrity of primary loop components in Temelín based on the information available to the Austrian experts. In particular, the aim of the report is to clarify and establish the issues which were resolved, and to point out the issues which are still pending. This could create the basis for further discussions within bilateral Czech-Austrian activities, if so decided.

It should be kept in mind, that the present report is just one of a series of reports presenting the results of Temelín safety studies undertaken by the Austrian side within the framework of information exchange according to the Melk agreement. The overall conclusions concerning the NPP Temelín safety should not be based on any single report, but will be developed as the result of the whole work done by Austrian side with the support of information provided by the Czech counterpart.

1.5 Report structure

The evaluation of the actual status of the ISI/NDT program for checking integrity of primary loop components in Temelín NPP is presented in the Section #2 and 3. This evaluation is mostly based on the information received during the Prague workshop, specific discussions with Czech counterparts but also on other information sources available to the evaluation team within this project. In section #2 the status of ISI and in section #3 the qualification of NDT is presented. To enable comparison with international standards as well as specific western practices and criteria the numbers of respective VLIs are given in brackets for each section, and the actual status in the EU countries is presented in the ANNEX I to the report.

Section #4 of the report discusses topic relevance for specific aspects of the implementation of ISI/NDT program for checking integrity of primary loop components at Temelín. Section #5 summarizes general conclusions, focused on specific elements of ISI/NDT program for primary loop components. Section #6 highlights the issues related with the ISI/NDT program for checking integrity of primary loop components at Temelín, which warrant further expert discussions within bilateral Czech-Austrian activities.

2 SITUATION IN TEMELÍN ACCORDING TO FINDINGS BASED ON VERIFIABLE LINE ITEMS PART A: IN-SERVICE INSPECTION PROGRAM

2.1 Applicable Documents and Basis (VLIs 1.1 – 1.6)

In-service inspection program for selected safety classified primary circuit components and piping is required by Czech Atomic Law and it is subject to State Office of Nuclear Safety (SONS) approval.

The basis for the requirements for ISI Program was, first, Russian, PNAEG. Later, Czech organizations started to develop their own Code system to adopt Czech standards and other adequate international standards. Actually, general requirements are stated in the Atomic Act, and the Decrees of 1997 and 1998, and detailed requirements in the SONS Guide of 1998. The ISI/NDT programme is a transition phase from the Russian Code to a Czech Code. Since Russian PNAEG Code was used for the design of Temelín NPP, a justification was not needed for the implementation of PNAEG Code for the ISI Program. ISI qualification is in compliance with ENIQ (European Network for Inspection Qualification) methodology, IAEA methodology for WWER NPPs and SONS guideline. Time schedule of ISI qualification is approved by SONS [Svab 04].

“Code Cases” (mentioned in VLI 1.4) are specific issues of the ASME Code and may be used, as needed, when ASME Section XI is applicable for ISI Program.

Other regulatory documents, like the paper of [Brumowski 04] “Unified Procedure for Lifetime Assessment of Components and Piping WWER Type NPPs” are not included in ISI Program, but inspections within ISI Program could support the subject assessment.

The experiences from other WWER plants are or will be included in generic problems from PHARE projects indicated by SONS.

2.2 Classification of Components (VLIs 2.1 – 2.2)

The classification of equipment at Temelín NPP is based on the division into two classes: safety systems and safety related systems.

The review of "safety related systems" as defined for Temelín NPP shows that some of the elements of equipment and systems classified at Temelín as "safety related" would be classified according to the IAEA [IAEA 98] as "non-safety systems". While the naming scheme introduces some doubts (appears to be different from Western practices and the IAEA requirements), a careful evaluation of the actual classification confirmed that all systems that the IAEA lists as "safety" and "important for safety" are in Temelín classified as "safety systems" and their ISI/NDT is being conducted as the first priority.

Concerning the equipment classified as "safety systems", the requirements for their ISI/NDT follows the IAEA recommendations [IAEA 98] and the US practice. This yields generally satisfactory results in practical work. Although no formal documents were produced which would specify the required basis for classification, the classification is documented in the Safety Analysis Report, which has been reviewed by SONS.

In relation to the “safety related systems”, in some cases it appears that the requirements for the ISI/NDT may be even stricter than typical in western plants for systems having similar functions. However no systematic comparison was made to fully support this finding.

2.3 Responsibilities (VLIs 3.1 – 3.6)

The Owner's (NPP) responsibilities are determined by SONS decrees and in general by the Atomic Law. Thus the ISI Program is subject to the SONS approval as well as any deviations from the program. Access for inspectors during ISI examinations and subsequent evaluation is provided. Individual QA programmes include references to the tests prescribed by the designer for the manufacturing, assembling, commissioning and operation period. ISI programme includes definition of tested areas, time period between tests and testing methodology. Qualification of NDT is performed in compliance with SONS requirements and the time schedule of ISI qualification is approved by SONS. During qualification SONS inspectors are present

2.4 Non Destructive Examination Methods (NDE) (VLIs 4.1 – 4.9)

A detailed description of the NDE methods to be used within the ISI Program has to be proposed together with the plant work instructions by the utility and approved by SONS. The description must include:

- tested areas
- time period between tests
- testing methodology

General requirements on NDT are included in:

- Decree No. 214/1997 Coll., on "QA assurance"
- Decree No. 106/1998 Coll., on "Commissioning and Operation of Nuclear Facilities"

Detailed requirements are stated by the SONS Guide on "Qualification Methods: ISI of Main Primary Circuit Components of WWER Reactors" (1998)

As a basic requirement it is stated by SONS, that the testing must be done in a "transparent and traceable way". This concerns especially the definition of the inspection procedures.

Alternative examination methods or newly developed techniques can be substituted for the methods specified in the usual standards. Since the inspection purpose of an NDT at a specific component has a higher priority than the methods proposed within the ISI program, it is already used practice by the NRI and Skoda to choose alternative methods after having them qualified. As an example may be regarded the application of the TOFD approach in UT, which may in future be replaced by other strategies due to the large number of indications during its first practical use during a ISI at the pressure vessel. Skoda plans to replace its actually applied UT system based on the Microplus electronic by another modern system, which probably implies for certain inspection task a new qualification.

The ISI qualification system prescribed seems to be in accordance with

- ENIQ (European Network for Inspection Qualification) Methodology for Nondestructive Tests,
- EUR 17299 EN
- Methodology for qualification of ISI systems for WWER NPP´s (IAEA Vienna)
- State Office for Nuclear Safety (SONS) guideline for ISI Qualification of main components of WWER primary circuits

The major task of the qualification system is the demonstration of the performance of the applied ISI techniques like UT and ET by the use of qualified procedures and qualified personnel.

A Czech standard for the NDT personnel qualification exists. In the qualification process the EN 473 rules are applied with an additional special training for automatic UT and ET.

EN 473 is in use and adapted to nuclear practices by company specific special training for automatic UT and ET, e.g. with a Microplus UT system at Skoda and a Midas System at NRI. A part of the training must be seen in the preparatory work for the qualification trials of the specific UT inspection tasks.

A written practice in a form of a procedure is prepared in accordance with ENIQ and EN 473.

Performance demonstrations for ultrasonic examination systems and other NDT methods are required by the SONS guidelines and are now an essential part of the ISI in The Czech Republic, since the preparation of each planned ISI with UT is e.g. at Temelín up to day linked to the use of a previously qualified UT technique.

The ISI qualification system applied implies a performance demonstration according to the rules of SONS (State Office for Nuclear Safety).

All ISI qualification activities are performed under the supervision of the regulatory body.

The time schedule and scope of ISI qualifications are agreed with SONS.
Inspectors of SONS are present during the qualification.

The actual practice in Temelín is characterized by the fact, that almost all ISI measures are prepared by a previous qualification of the methods intended to be used. This implies that the link to prior pre-service inspections results is somewhat restricted, because almost all qualified methods are new for the application in Temelín and have not been available at the time of the pre-service inspections.

Special efforts have been made concerning the inspection of the Steam generators.

The SG ISI program (see also the SONS-guidelines) includes:

- visual inspection of sealing surfaces
- visual inspection of welded joints
- EC inspection of collector surfaces
- EC inspection of threaded holes
- EC inspection of SG tubes
- EC inspection of collector tube-to tube gaps

The inspections are carried out by Vitkovice, which is nowadays a part of the NRI. The evaluation of the SG tube inspection indications is based on experiences with WWER 440 reactors, since at Vitkovice the experiences are actually limited to this case. This is especially related to the plugging criteria and the statistical evaluation of the SG life time.

2.5 Requirements for Examination and Inspection (VLIs 5.1 – 5.16)

The inspection intervals and periods for the scope of the ISI program are for all components defined according to the Russian practice, which prescribes a 4 years period.

There is actually no hint, that a system of examination categories or a similar approach as described for the ASME Code Section XI exist for Temelín. All welds have to inspected, if not with mechanically guided probe systems, then with a manual inspection

The scope of components to be inspected is agreed by SONS and includes:

At the Reactor Pressure Vessel

Testing from the outer surface

- Vessel shell base metal
- Vessel circumferential welds
- Base metal-cladding interface
- 850 mm nozzle base metal
- 850 mm nozzle homogeneous weld
- 270 mm nozzle austenitic weld
- Vessel bottom head base metal
- Vessel bottom head cladding interface

Testing from the inner surface

- Vessel shell base metal
- Vessel circumferential welds
- Base metal-cladding interface
- 850 mm nozzle base metal
- 850 mm nozzle inner radii
- 850 mm nozzle homogeneous weld

At other primary circuit components

ISI programme for DN 850 piping welds – UT

- DN 850 nozzle to piping weld – UT from inner and outer surface
- Other piping circumferential site welds – UT from outer surface
- Welds on the piping of the emergency core cooling system (ECCS) – UT from the outer surface
- Piping of the pressurizer
- Steam generator heat exchanger tubes
- Steam generator primary collectors

Additionally, the steam and feed water pipelines at the 28.8 meter level and their circumferential welds and fillet welds at the fixation plates are included within the ISI scope with the same rules for periodicity as applied for all primary circuit components.

No exemptions from the ISI are allowed, but there are areas with restricted access. During the last ISI e.g. two circumferential welds had to be inspected manually.

The ISI program prepared according to the SONS guidelines and corresponding to the scope explained above refers to a more detailed description as presented by Skala and Zelenka-Martinu containing drawings and material data, taken out from the work instructions, but not indicating e.g. the pressure and temperature.

The frequency of inspection follows the Russian rules, which means a period of 4 years.

The extent and frequency of examination, the methods and acceptance standards are defined within the ISI program and – as explained by Skoda JS – in work instructions. The acceptance criteria are for the UT inspection replaced by the introduction of an analytical threshold. That means in general, that a decision about a more or less important ISI-indication, which exceeds the registration and the analytical level has to be based on further investigations to clear the NDT findings, their background and safety relevance. There is no automatism directly linking an NDT result to a replacement or repair decision without such an analysis. But the criteria used after the end of an analytical procedure are still unclear. During the October workshop Mr. Zdarek from NRI explained that one uses the state of the art methods to judge upon the fracture mechanical, fatigue and corrosion relevant importance of a given defect.

Since all welds of the primary circuit piping are included in the ISI scope, a special selection of welds with a certain inspection priority based on stress analysis could not be found.

There are up to now no especially defined areas exceeding the normal ISI scope, but it seems, that some attention has already been paid to areas with e.g. thermal shock risks like at the inlet nozzles of the ECCS line. Test blocks for those areas are available, but no inspection methods have been qualified on them yet.

In most internationally available codes the acceptance criteria are linked to the registration or recording threshold of the NDT method, stating for instance, that at the UT an echo amplitude exceeding a registration threshold by more than 6 dB is not acceptable. But usually such non acceptable indications have to be further analyzed before a final decision about repair or replacement or continuous operation under special observation is made. In parallel the scope of inspection is usually extended to similarly loaded and fabricated areas.

At the Temelín ISI program the notion of acceptance threshold is for the UT inspection replaced by the introduction of an “analytical threshold”. That means in general, that a decision about a more or less important ISI-indication, which exceeds the registration and the analytical level has to be based on further investigations to clear the NDT findings, their background and safety relevance. There is no automatism directly linking a NDT result to replacement or repair decision without such an analysis.

It can be understood with high probability on the basis of information provided by Mr. Skala from Skoda JS that in such cases additional examinations are carried out. However, no direct confirmation of this was given.

An open question is the extension of the inspection scope in case of detected flaws, because there is no clear information about the procedure. The plant should follow the common practice in NDT, which requires such an extension even if the precise analysis of the background of an individual flaw indication is not finished yet. Since the Czechs maintain that they follow EU practices, it can be expected to be the case, but it has not been determined during the meeting.

There are obviously areas non accessible for automatic NDT as required by the ISI scope. During the last ISI at Temelín two circumferential welds had to be inspected manually.

For areas inaccessible to ISI one usually has to demonstrate that these areas are not critical from the standpoint of safety. There is actually no information available about such a situation at Temelín NPP.

2.6 Reactor Vessel Examination (VLIs 6.1 – 6.10)

All of the RPV inspection areas have to be covered within a 4 years term, carrying out during each yearly outage a certain part of the total amount of inspections. This results in more than one inspection during one inspection interval.

All circumferential welds including the adjacent base metal and the cladding are required to be inspected 100%. Inspections are foreseen from the outside and the inside

All nozzle-to-pipe welds including the dissimilar metal welds are required to be inspected 100%. The nozzle to DN 850 pipeline welds are ferritic welds with a complex structure close to the cladding. They are inspected from the inside and the outside. The DN 270 austenitic pipe is welded to a ferritic, but cladded nozzle with a dissimilar metal weld and has to be inspected 100% from the outside.

The nozzle inner radius sections at the DN850 nozzle are required to be 100% examined, the DN270 are up to now not covered with a special inspection.

UT techniques are applied for all welds with commonly recommended pulse echo probe arrangements (0 °, 45 °, 55 ° or 60 ° and TRL70 ° probes at the cladding) and registration thresholds comparable with those applied in western states (e.g. Germany, UK or USA). It is claimed that the detectability of defects perpendicular to the surface inside the wall at the cylindrical shell must be assured by angle beam probes and at the three circumferential welds additionally with a TOFD approach. Tandem probe arrangements especially suited for this purpose are not applied. This is the situation similar as in all countries that base their NDT approach on ASME code, but different than in Germany, UK and partly in Japan (where the components subject to earthquake loads are checked using tandem arrangements). The issue of appropriate NDT techniques for the concerned defects has been investigated in PISC trials during the 80ties with the reported statement, that only the French approach with large focusing probes and the tandem technique applied in Germany and at the British PWR plant had been able to detect very large defects perpendicular to the surface. The ASME code based techniques can assure the detection only at originally not foreseen very high sensitivity levels (10 or 20% of the DAC values). The sensitivities actually applied for the pulse echo probe arrangements (0 °, 45 °, 55 ° or 60 °) at Temelín are in between the former PISC recommendations for improved ASME based techniques and the conventional ASME code. Therefore it is not possible to give a definite answer to the question whether the detectability of defects perpendicular to the surface inside the wall at the cylindrical shell is really assured by the pulse echo angle beam probes (45 °, 55 ° or 60 °) without using the additional information from the TOFD technique. During the qualification trial the detectability of corresponding defects seemed to be based mainly on the TOFD approach.

It is clear that the application of tandem probe arrangement ensures higher capacity for detection and sizing the dangerous cracks. According to the Czech side, the redundancy of an inspection from the in- and outside and in addition the TOFD approach guarantee that no dangerous inner wall cracks remain undetected. It has to be observed however, that there had been no special inspection for those defects during the fabrication (an X-ray inspection of the root areas with a betatron cannot be regarded as a valuable replacement) or during pre-service period. In addition, it has to be recognized, that the recent TOFD application at the three circumferential welds of the RPV produced an unusual large number of indications (96 indications have been noticed by Skoda JS), which is normal for a TOFD technique but rather strange for an in-service inspection at an RPV. Given the fact that a normal TOFD application on very thick welds must end up with a fairly high amount of unclear indications (which are classified as to be out of interest only with the additional information from the standard pulse echo techniques), it remains unclear, whether the TOFD can in future be regarded as a realistic replacement of a tandem technique or not. The first experiences and data available indicate that this cannot be the case. The TOFD approach should be therefore treated as a valuable tool for analytical purposes in case of indications exceeding the analytical threshold but not as a tool for detection tasks.

Thus the current situation in Temelín in this respect can be treated as normal for the current status in many other NPPs, but it is expected that further developments of NDT techniques especially in respect of RPV crack detection will be followed by the plant and applied as appropriate.

All UT probes are contact technique probes. The refraction index based difference between a contact technique and a probe coupling in an immersion technique with a water delay path vanishes for the fairly smooth surfaces at the inner wall of the RPV. At the outside there is no choice: probes have to be coupled in a contact technique.

For all the different inspection tasks previous qualifications trials (which do include the performance demonstration) had to be executed.

Usually the visual examination is combined with the mechanical scanning of the inner wall surface by the UT manipulation system. There is no evidence of an extra step for a visual inspection.

2.7 Acceptance Standards (VLIs 7.1 – 7.8)

The acceptance standards are specified for each NDE method applicable for ISI Program.

But there is a special situation introduced at the UT inspection, which announces a slightly changed attitude concerning the notion “acceptance criteria”. This seems to be valid also for other NDT tasks e.g. at the Steam Generator.

In most internationally available codes the acceptance criteria are linked to the registration or recording threshold of the NDT method, stating for instance, that at the UT an echo-amplitude exceeding a registration threshold by more than 6 dB is not acceptable. But usually such non acceptable indications have to be further analyzed before a final decision about repair or replacement or continuous operation under special observation is made.

At the Temelín ISI program the notion of acceptance threshold is for the UT inspection replaced by the introduction of an “analytical threshold”. That means in general, that a decision about a more or less important ISI-indication, which exceeds the registration and the analytical level has to be based on further investigations to clear the NDT findings, their background and safety relevance. There is no automatism directly linking a NDT result to replacement or repair decision without such an analysis.

For each NDT method and each individual application the analytical thresholds replacing to some degree the acceptance standards are specified.

There is apparently no document existing describing a precise repair/replacement procedure after the analysis of a detected flaw indication. The criteria used after the end of an analytical procedure are still unclear. During the October workshop Mr. Zdarek from NRI explained that one uses the state of the art methods to judge upon the fracture mechanical, fatigue and corrosion relevance of a given defect in order to decide upon repair/replacement activities or other consequences. However, it has been explained by the Czech experts, that repair and replacement procedures have to be qualified and accepted by SONS as well as possible re-examination measures as an alternative for repair/replacement activities.

There is no precise information available about the exact procedure in the case of continued operation at the presence of non acceptable indications. But one has to assume that one follows the common practice in NDT, which requires more intense and more frequent inspections.

It is likely to assume that additional examinations are carried out in such a case according to information given by Mr. Skala from Skoda JS.

Alternative criteria are in use at the ultrasonic inspection, where by the introduction of the TOFD technique the usually amplitude based definition of the criteria is replaced by a picture based interpretation. TOFD can be regarded as an additional source of information about the defect sizes. But for the time being, there is no report available about a pure analytical application of TOFD or other alternative sizing and evaluation strategies. No alternative techniques are foreseen for a better quantitative evaluation at the steam generator tubes and gaps for indications to be analyzed.

The acceptance criteria for the SG tubes are linked to the experiences from Dukovany. At the steam generator different ET techniques are applied:

- bobbin coil probes for SG tubes and collector gaps
- pancake probes for collector surface and threaded holes
- motorized rotating probes for collector gaps

Since the analytical potential for the bobbin coil probes at the SG tubes is limited, there is an activity on the way to take advantage from the experiences at other WWER 440 NPP´s – especially Dukovany – where e.g. the plugging criteria have been derived from the relation between EC indications and burst tests of the tubes. A more precise strategy based on real defect sizes derived from EC signals is at present not foreseen.

2.8 Records and Reports (VLIs 8.1 – 8.6)

Atomic Law and decrees prescribe responsibilities for preparation and retention of records and reports. The content is prescribed by ASI requirements.

The submittal of reports to SONS is required when the acceptance criteria are exceeded.

The records and reports are stored by the plant and the archive is protected against internal hazards.

Access to the archive is restricted, as is the standard practice in the Czech Republic.

2.9 ISI Plans and Schedules (VLIs 9.1 – 9.8

The reactor vessel welds and areas, steam generator tubing and primary collector welds and areas, main circulation piping welds, ECCS and pressurizer piping welds are included in the scope of ISI Program, together with their classification, description, identification, referenced drawings, and applied NDE methods.

In-service inspection is based on 4-year interval and 100% examination of all included welds and areas.

Calibration blocks for UT and ET examinations are referenced in the working instructions.

2.10 Supporting Documents to ISI Program (VLIs 10.1 – 10.5)

By the plant design generated flow charts, isometric drawing of piping and detailed drawing of the components are available. Whether they are attached to the ISI Program or only referenced there, that is a non relevant issue for the safety. A list of working instructions is available.

Due to the actually required 100% coverage, allocation of the completion of examinations per periods is not needed.

2.11 Preservice Examination (VLIs 11.1 – 11.3)

Pre-service inspection is performed on the scope of systems and component included in ISI Program. Results of shop and field examinations can be used as additional reference material during in-service examinations.

3 SITUATION IN TEMELÍN ACCORDING TO FINDINGS BASED ON VERIFIABLE LINE ITEMS PART B: QUALIFICATION OF NDE SYSTEMS

3.1 Qualification body (VLIs 1.1 – 1.9)

In the Czech Republic the Qualification Body (QB) is established at the CEZ (Czech Energy Society) as a permanent institution supported by external Experts. The QB consists of 3 permanent members: chairman, vice-chairman and secretary. Through these permanent members the continuation of the work and the same practical approach in all qualifications is assured. In addition, external experts are nominated separately for each qualification case.

As an example, the QB for ultrasonic inspection of reactor pressure vessel was formed by representatives of CEZ, NRI, Temelín NPP, APC (Association for Personnel Certification in Czech Republic) and of the Bohunice NPP (Slovakia) as an external expert. The transparency and independence of the qualification is assured by the participation of APC. In addition, the qualification process is supervised by the nuclear regulatory body SONS. The work of QB is financed by the plant which is a usual practice in most countries.

In a country where a small number of nuclear power plants are in operation, this kind of arrangement of QB is normal. This is the case e.g. in Finland. For economic and practical reasons it is not possible to organize a totally independent institute for qualification purposes due to the limited number of experts in this very specific area and due to the fact that the number of qualifications performed annually is too low to support a full-time organization. The participation of the plant representative in the QB is not usual but it can be understandable in the case of reactor pressure vessel inspection because the inspection manipulators and mock-ups used in qualification are permanently stored inside the plant area and the qualification trials have to be performed in the plant area. Therefore the participation of plant personnel can be necessary. It was understood that the representative of Temelín NPP has been a non-voting member in the QB and has not the possibility to affect the results of qualification.

In the case of piping inspections the exclusion of plant staff from the QB should be considered especially if the practical trials are performed in facilities outside the plant.

The independency of the QB has been approved by Czech Institute for Accreditation (CIA). At least in some cases this is assured through the participation of representative of APC.

The connection between CEZ and Temelín NPP was not separately clarified but based on information received earlier CEZ is the biggest producer of electricity in the Czech Republic and is managing both Dukovany and Temelín NPP.

According to the common practice followed in European countries the members of QB should not belong to the same line organization as the staff operating the plant. It is not clear how the QB working in CEZ is organized and how its independence from plant operations is assured.

A document describing the responsibilities of QB members has not been seen. The SONS document which is based on the ENIQ-document EUR 17299 EN gives the outlines of the qualification process but more detailed instructions are necessary for practical work. It is recommended to establish a written working policy of QB to specify the tasks and responsibilities of the members of QB.

It is also recommended to create national working instructions (in Czech language) describing the different practical actions in qualification. These can be based on the Recommended Practices of the European ENIQ-methodology.

QB is normally formed by technical experts knowing the details of inspection techniques, equipment etc. However, it might be necessary to establish also a national steering committee for supervision and coordination of inspection qualifications. The role of steering committee would be to guide the work of QB, to accept the national guidelines and practices used in qualification and to initiate development projects when necessary. In addition, steering committee would make the final decisions concerning any discrepancies and conflicts met in the qualification process.

All the essential documents related to the qualification of an inspection system are collected to a Qualification Dossier. The content of the Qualification dossier is described in the SONS document and it corresponds to the requirements presented in EUR 17299 EN.

3.2 Input information (VLIs 2.1 – 2.7)

The level of qualification is determined based on the safety significance of the component to be inspected and the principles are presented in the SONS document. The principles are following the principles of EUR 17299 EN. It is not known if the more detailed instructions given in EUR 18685 EN are followed.

The utility provides to the QB the input information as specified in the SONS document. The information describes the component to be inspected (dimensions, geometry, material, description of welded joints etc.). Also, the qualification criteria for detection capability, sizing capability etc. are given in the Input information. The false call rate is only applied in blind trials where the personnel is qualified. It is not used in connection to the open trials, which are at present the typical qualification trials for the ISI at Temelín. However, some "false calls" measured in open trials are also important because they can reveal some artifacts or deficiencies in the measurement system. These deficiencies may affect the interpretation of inspection results and should therefore be known and taken into account.

The structure and content of inspection procedures seen in the Qualification Dossiers of some PHARE-projects correspond to the European practices.

3.3 Qualification procedure (VLIs 3.1 – 3.5)

The content of qualification procedure is described In the SONS document and is similar to the content given in EUR 17299 EN. The acceptance of the qualification procedure is problematic because the QB is preparing the procedure and in the QB there are representatives of CEZ as permanent members. On the other hand, the plant owner is CEZ. Therefore the transparency and independency of the acceptance has to be assured. It is not usual in European practices that some party (CEZ) is accepting its own work as it seems to be the case in Temelín. This is a topic where further clarification is necessary.

Normally in countries following ENIQ-methodology the qualification dossier is at the end of the qualification process sent to the nuclear regulatory body for acceptance. Because qualification procedure is part of the dossier it will be formally accepted in connection to the acceptance of the dossier.

3.4 Inspection Procedure (VLIs 4.1 – 4.7)

The recommendations of EUR 18117 EN and EUR 18101 EN for the checklist of the IP assessment are apparently transferred to the Czech situation in a somewhat modified form.

It has not been checked during the workshop whether the inspection procedures are in agreement with the requirements of SONS, which also has to review all the qualification activities for the individual NDT methods and tasks, as should be the case in accordance with the ENIQ methodology as claimed by Svab and others from SONS. However, it has been also mentioned that concerning the IP individual QA Programs have to include references to the tests prescribed by the designer for the manufacturing, assembling, commissioning and operation period.

The ISI Program should include the tested areas, the time period between tests and the testing methodology.

It must be assumed, that a formal application of the recommendations of EUR 18117 EN and EUR 18101 EN concerning the checklist of the IP assessment does not exist for Temelín. The ENIQ methodology is essentially applied in a formal way only for the whole qualification procedure for NDT methods, but not concerning the total administrative overhead.

A formal check for the inspection procedures concerning their coverage of specific inspection techniques, the component and joint description, the essential variables and equipment details together with safety class is probably not foreseen.

The calibration block designs, calibration, equipment set-up, the data collection, interpretation, recording and way of reporting are included in the ISI program and described in detail within the work instructions of the individual NDT methods and tasks. (See also the examples from the Workshop contributions of Skoda JS by Mr. Skala, NRI by Mr. Zelenka and Vitkovice by Mr. Papp)

The surveillance activities of SONS include also during the qualification trials the check of the personnel qualification according to EN 473 (Information given by Mr. Horacek from NRI).

3.5 Technical Justification (TJ) (VLIs 5.1 – 5.9)

Since the qualification measures for the NDT methods to be applied at the NPP Temelín have been structured within the frame of the European PHARE projects as to be compatible with the ENIQ methodology it can be assumed, that the ideas of technical justification as defined by the document EUR 18099 EN are fully taken into consideration, that means that the technical justification (TJ) involving the systematic gathering of all evidence on the effectiveness of the test including previous experience of its application, experimental studies, mathematical modeling, physical reasoning and so on is used intentionally before the planning of test blocks, methods, the training of personnel and qualification procedures.

The qualification trials demonstrated during the PN9 and PN10 Workshops (e.g. for the ISI at the RPV and at the DN 850 piping) prove that the TJ philosophy has been a starting point for the planning of the qualification activities at the NRI and at Skoda JS. The input data related to the components, expected defects and method of inspection are clearly defined. However, there are some aspects of TJ, where the Czech interpretation is not in agreement with the intentions of the EUR 18099 EN and other EUR documents. This concerns e.g. the use of worst case test defects and test conditions at the test block design.

Since the experts have not been informed about the exact procedure and discussions of the Czech colleagues during the planning of the qualification trials, it cannot be clarified which influential parameters had been taken into consideration, but the demonstrated qualification measures and their results indicate that the most important of the influential parameters are taken into account.

The Austrian experts have not seen any document as a proof for the observation of the minimal personnel requirements as foreseen by EUR 18099 EN, but the cooperation with other European partners (e.g. Tecatom from Spain) within the PHARE projects and the exchange of personnel let assume that this has been the case.

The choice of UT probes e.g. for the inspection of the cladding and the stainless steel welds at the ECCS lines and for the nozzle corner is a clear proof for a correct physical reasoning.

There are 30 years of experience at Skoda JS with the inspection of components for the primary circuit of NPP´s. Those experiences have apparently influenced the choice of the inspection methods especially at more difficult inspection tasks as e.g. the bimetallic welds. The qualification trials are on the way since 1998. There has been an information about the necessity to repeat a not-passed qualification at the RPV test block for the crew applying the TOFD technique. Other information is not available.

Separate parametric studies have not been performed, but via the European PHARE projects there is access to many studies of that kind e.g. concerning nozzle corner inspection, stainless steel and bimetallic weld inspection and others. The economic relations created and promoted by the partnerships within the PHARE projects result in diverse equipment acquisitions by the Czech partners, the purchase and use of specific equipment is hardly driven by a previous technical justification. The inverse must be admitted: During the qualification trials and their preparation the evidence has been reviewed that the inspection goals can be met effectively with the available equipment (see also the fact, that the major Czech NDT vendor for ISI at NPP´s, Skoda JS, uses actually a British Microplus equipment for automatic UT inspection, whereas the NRI, his research partner, operates with a Midas UT equipment from Spain for the same inspection tasks). As far as the analysis of detected indications is concerned, the TOFD technique has been chosen for analysis but not yet fully introduced in the field at a real situation for the analysis of a critical indication. Pure software analysis e.g. with a SAFT approach or with phased array UT probes may be applied in future. There are at the NRI some activities with NDT modeling and related computer based modern UT techniques on the way, but actually not yet available for a practical use.

The use of test specimens in open and blind trials is explained by various EUR documents (EUR 18686 EN, EUR 18100 EN) which, according to the presentations at the October 2004 Workshop in Rez, had been taken into account, but the Czech experts (Mr. Horacek) explained that there had been a preference for open trials in all cases where the performance of the equipment and method had to be proven. This statement is surprising, if one considers the fairly naïve choice of defects at the RPV wall test block, which uses rather expensive fabrication methods for the defects, but neglects the worst case concept, which is especially helpful for open trials and justifies their use. The performance of the personnel together with a given inspection ensemble should be checked with a situation simulating a blind trial, but there is no clear proof for a corresponding event.

3.6 Description of Defects (VLIs 6.1 – 6.15)

The component specific requirements e.g. concerning the defects to be detected are defined before the test, but there are different cases to be mentioned. The inspection requirements are in most cases defined according to the access possibilities and postulated defects or damages (e.g. outside and inside inspection at the RPV wall and DN850 to nozzle weld). In other cases with obviously difficult access from both sides only a on side inspection is required. This can in future give rise to conflicts, e.g. with stress corrosion attack at the inside of cladded or stainless steel pipelines difficult to detect in an early stage from the outside.

For all of the components to be inspected the defects of interest are specified in work instructions. Some of the defects have been presented during the October workshop in detail. The used recording, registration and analytical thresholds for their detection and evaluation are in some cases oriented at the critical defect sizes (in terms of fracture mechanical concepts, e.g. for the RPV wall at the PTS relevant crack sizes), in other cases at the performance limits of the used NDT technique (in terms of signal to noise ratio and false call rates). The used thresholds are in all cases in the same range as used during ISI with NDT in western reactors.

At the qualification and performance demonstration trials the definition of the used artificial defects or test reflectors within the test blocks should follow according to EUR 18686 EN a worst case concept in order to guarantee, that the detection demonstrated is not only linked to very fortunate conditions for the flaw detection, which may in practice not be present.

The worst case concept (EUR 18686 EN) is not yet fully implemented in the design of the test blocks. Direct discussion with Czech specialists revealed that the “worst case” which they used was merely based on the defects that would be the worst for the integrity of the vessel. This is not the same as the “worst case” defects from the standpoint of detection, that is the defects most difficult to detect. This difference can be especially detrimental at the test block for the RPV wall used to judge the performance limits of the TOFD and other techniques at the detection of inner wall defects perpendicular to the surface and in order to evaluate the distinction between pure underclad cracks and cracks opened to the wet side of the RPV wall (cracks through the cladding). The influence of the “worst case concept” on the evaluation and judgment of the qualification trial at the RPV wall test block (and also other blocks) will certainly be regarded more intensively in future. For the time being one has to admit that the rather optimistic conclusions of Mr. Horacek about the qualification trial concerning the RPV wall test block should be considered with some scepticism. This seems also to be justified by the first available TOFD results from the inspection of three circumferential welds at the RPV wall, which showed a fairly high number of “reportable” indications. Mr. Skala reported 96 indications, which is not astonishing for a TOFD application at a thick wall butt weld, but a problem, if one is looking for one single indication of a real dangerous large crack perpendicular to the surface, which can be completely hidden among the high number of mostly irrelevant indications. The work in this area should be continued by NPP Temelín. This should be a subject of future bilateral information exchange.

Different arguments are used for the definition of the critical defect sizes (that means critical for the safety): At the RPV wall the PTS relevant crack sizes are considered (20 mm deep, 30 or 60 mm in length), at other situations the standard thresholds of NDT rules are used, which are mostly derived from the performance limits of the given NDT technique at an individual task. E.g. for the inspection of the inner nozzle corner of the DN850 pipes at the RPV the assumed thresholds of a 7 (10) mm deep crack are probably close to the capabilities of the foreseen UT method. These are typical values used as the assumed threshold, so this approach is again typical for many NPPs. However, the calculations of the PTS are still missing, so it is yet to be proven whether the value of crack depth is conservative regarding a PTS related critical crack size. The work in this area is expected to be continued.

The verification of inspection methods at already available specimens is considered as to be performed in future. If blocks are available with similar properties, the question to use them depends on economy and representability in relation to the real test conditions and on the ability to represent worst case defect and material conditions. The question of special test specimen is more relevant for unusual test situations due to geometry, access and material. The NRI has already collected a number of test pieces probably relevant for the more complex test situations at the ECCS lines and intended to be used for the corresponding qualification trials. Especially in all cases of stainless steel and bimetallic welds one has to take into account, that the inspectability with UT depends to a large extent on the very specific weld conditions on site often difficult to simulate in a workshop. It is therefore highly recommended to check in before by special acoustic transfer measurements the representability of test blocks intended to be used for qualification trials. Mr. Zdarek from NRI answered at a question concerning this problem, that one is aware of those difficulties and will clear them by corresponding measurements during coming outages.

For the production of the artificial test defects standard techniques as in use at other places in Europe and abroad are applied. Electro erosion, implantation and machining are used in an appropriate manner for the production of the test defects. (e.g. Electro erosion for ET reference tubes).

The quality control during the production of the test blocks is apparently based on the QA system of the defect producing institute, the NRI at Rez.

The nature of the defects introduced in a test block is known to the qualification body. There is usually no intention to destroy the test block after a trial.

The statistical evaluation of the qualification results presented at the workshops is sometimes based on a fairly small number of relevant defects and their size variations. The influence of the number is considered, but their limiting influence on the accuracy of the final results seems to be underestimated.

Up to now there is no common practice to perform both, open and blind tests during particular qualifications. The qualification for a procedure, a method or an inspection task is performed as open trial and the qualification of the personnel in separated actions as blind trial. This means probably that the usual examination of the NDT operator according to EN 473 is considered as such a trial. It remains unclear whether there are real blind trials for the whole test ensemble including the personnel or are there only so called simulated blind trials.

The number of the test blocks is in general too small for realistic blind trial conditions with a high degree of the required confidentiality. That means that one has to work with simulated blind test conditions.

The positions and orientations of defects are at some testblocks (e.g. for the RPV wall) varied in order to simulate unfortunate detection conditions, but apparently only considering the surface of the defects, not the borderline, which is important for a check of the detection performance of the TOFD technique.

The RPV test block contained also some defects of the underclad type, but the discrimination between pure underclad cracks and cracks running through the cladding to the wet inner surface needs to be checked under more realistic conditions representing the special difficulties of crack tips close to the interface region.

According to the reports given at the October Workshop in Rez, the detection, length and depth sizing criteria as well as the false call rate are verified by the qualification trials for the RPV wall test block with very optimistic results. The report of Mr. Skala from Skoda JS confirmed this by corresponding results from the first ISI at the RPV wall after the qualification.

However, care should be exercised in using these results for several reasons.

1) The number of available defects for a specific situation and with a specific size variation is too small for a relevant statistical judgment on the accuracy of the results.
2) The lack of a worst case concept for inner wall defects perpendicular to the surface does not allow a reliable conclusion concerning the detectability of those defects by the applied techniques, among them the TOFD approach.
3) The underclad reflectors do not realistically represent those cracks concerning their structure close to the interface. This is especially relevant for the discrimination between pure underclad cracks and cracks running through the cladding up the wet inner surface. According to the current VERLIFE approach, pure underclad cracks can be expected and are generally not dangerous, but the absence of through cladding cracks must be demonstrated. This discrimination has not been realistically proven during the RPV wall inspection qualification trial. It is essential for the application of the VERLIFE concept and its consequences for a PTS accident, which requires a sound cladding. However, as the reactor pressure vessels in Temelín have just started their operational life, there is still some time available for improvement and implementation of techniques that will make such a discrimination possible in Temelín NPP.

It has been discussed during the October Workshop, to add as a redundant NDT measure at the cladding a Low frequency Eddy current inspection in order to prove that on places with an UT indication from underclad-inspection probes there are no cracks reaching the wet surface. This should be qualified during the preparation of the next ISI at the RPV wall.

3.7 Conduct of Qualification Specimen Trials (VLIs 7.1 – 7.5)

The supervision of the practical trial is performed by a team which is a part of the qualification body. In addition, the representative of SONS is present during the qualification (practical trial).

Normally, a secure area is arranged for qualification trial. In case of open trial this is not very critical but all kind of disturbing actions in the same area should be avoided. In the case of blind test it is necessary to assure that no information about the test blocks and their defects is by any means transferred to outsiders. This means that no paper documents can be brought out from the test facility and the memories of all electronic equipment must be checked and cleaned before leaving the test facility. Normally, the invigilation is made by one or two members of the QB in order to minimize disturbances to the performance of the test.

If invigilators notice deviations from the inspection procedure they are carefully recorded, analyzed and accepted if well justified.

3.8 Qualification Assessment Report (VLIs 8.1 – 8.5)

QB performs the assessment of qualification results based on the criteria given in the Input information. If the procedure is for detection of defects only the defect detectability is monitored and defect sizing is not included in the qualification. If sizing is required in the procedure then also this is assessed.

It is normal that the detection rate and false call rate can't be assessed due to the low number of defects in test specimen. For statistical assessment large number of defects with different sizes are necessary which is not practical. It is normal to assess the detectability of defects based on a limited number of defects only.

If a person does not pass the qualification test, he (she) should be further trained before participating the re-test. It is not clear what will happen if it turns out after qualification that in practical in-service inspections at site errors have been made (defects not detected or analyzed improperly). In this case the qualification of the person that performed the inspection should be terminated or if there are any doubts about the performance of the inspection system it should be re-assessed and qualification possibly cancelled until a new qualification has been successfully performed.

3.9 Qualification Certificate (VLIs 9.1 – 9.3)

The qualification body issues a recommendation, the certification is issued by the plant owner (CEZ). The certification must be based on the recommendation. (The plant wants to have control over the operators.)

In most countries the qualification certificate is issued by the Qualification Body and plant owner(s) are not involved in this process. From the QB the plant receives a list of inspectors that have passed the qualification and based on this list the plant owner can check that all inspectors working at site are properly qualified. Normally the qualification certificates are issued individually for each inspector and contain information about the inspection procedure, equipment, scope of validity etc. Basically, the practice used in Czech Republic where this information can be found in the dossier is acceptable but it is more practical when this can be seen directly from the certificate.

4 EVALUATION OF SPECIFIC TOPICS OF INTEREST FOR ISI/NDT TO CHECK INTEGRITY OF PRIMARY LOOP COMPONENTS

This chapter presents in more detail specific topics of interest for ISI/NDT of primary loop components. Most of them involve issues that are being studied in many countries and international organizations, and further progress is expected. Therefore while the current situation in Temelín can be regarded as normal, close characterization of the current status of the resolution of those issues is provided as a reference point for the future

4.1 Independence of the qualification body (QB)

According to the common practice followed in European countries the members of QB should not belong to the same line organization as the staff operating the plant. It is not clear how the QB working in CEZ is organized. The participation of the plant representative in the QB is not usual in the countries following ENIQ-methodology so some doubts may be raised about the independence of QB. However, it was understood that the representative of Temelín NPP has been a non-voting member in some QB and has no possibility to affect the results of qualification.

The practice to include in the QB independent experts from other organizations (and countries) operating VVER-plants is strongly recommended. In the case of Slovakian experts not even language barriers are met. In several countries following the ENIQ-methodology the nuclear regulatory body is not directly involved in the qualification process and is not supervising the practical trials. Only very seldom the representatives of nuclear regulatory body have sufficient technical expertise for in-depth supervision of the inspection work. Therefore the supervision is made by NDT-experts of the qualification body. Naturally, nuclear regulatory body always has the right to follow the trial.

It is not clear how the secrecy of blind test blocks is assured. If the test blocks and mock-ups are stored directly at the plant it is necessary to make sure that information concerning the blocks and their defects is not leaking to outsiders. The details of the blind test blocks should be only known by the manufacturer of the block and by restricted number of experts being involved in the qualification trial. The test blocks containing intended defects are very expensive and it is necessary to assure that they can be used for a long time during plant operation.

It is recommended to create national working instructions (in Czech language) describing the different practical actions in qualification. The principles given in the SONS document (or in EUR 17299 EN) are very general. Based on the experience gained in Finland more detailed working instructions are necessary to guide the practical work.

The independent acceptance of qualification procedure has to be assured. It is not usual in European practices that some party (CEZ) accepts its own work as it seems to be the case in Temelín.

The necessity to establish a national steering committee for supervision and coordination of inspection qualifications should be considered. The role of steering committee would be to guide the work of QB, to accept the national guidelines and practices used in qualification and to initiate development projects when necessary. In addition, steering committee would make the final decisions concerning any discrepancies and conflicts met in the qualification process. The steering committee could be formed e.g. by higher level managers of utilities (CEZ), main inspection vendors and representative of SONS. Thus the supervision of the qualification process by SONS would happen through participation in the steering committee and participation in the qualification body would perhaps not be necessary. The final acceptance of each particular qualification is normally based on documents presented in the qualification dossier and direct supervision is not made during the process.

4.2 Modernization of the NDT techniques

The effort to use modernized NDT techniques for the ISI at Temelín is welcomed and encouraged.

As an example may be regarded the application of the TOFD approach in UT or the introduction of theoretical modeling in UT. It should be taken into account that each modernization must maintain a data compatibility with the previous inspections in order to guarantee that a comparison with the results of earlier inspections is possible. Temelín has already a problem with a somewhat reduced correlation between the pre-service inspections and the currently applied ISI techniques (see also the general requirement of SONS for "transparency and traceability of the applied inspection procedures"). Skoda plans e.g. to replace its actually applied UT system based on the Microplus electronic with another, more modern system, which probably implies for certain inspection tasks a new qualification, with as an additional requirement the compatibility with the previous inspections.

4.3 Open and blind trials for the qualification of NDT

The use of test specimens in open and blind trials is explained by various EUR documents (EUR 18686 EN, EUR 18100 EN), which, according to the presentations at the October 2004 Workshop, had been taken into account. The Czech experts explained that there had been a preference for open trials in all cases where the performance of the equipment and method had to be proven. This statement surprises, if one considers the fairly simple choice of defects at the RPV wall test block, which uses rather expensive fabrication methods for the defects, but neglects the worst case concept. This is especially helpful for open trials and justifies their use. It remains unclear whether there are real blind trials for the whole test ensemble including the personnel, or if there are only so called simulated blind trials. The number of the test blocks is in general too small for realistic blind trial conditions with a high degree of the required confidentiality. That means that one has to work with simulated blind test conditions.

4.4 Examination Categories and Relation to the ASME Code

Since there is actually no evidence that a system of examination categories or a similar approach as described for the ASME Code Section XI exist for Temelín, it may be of common interest to know if a comparable strategy with the introduction of examination categories and inspection classes is foreseen in future. This can be seen in a certain relation to the discussion about risk informed inspection. There are tendencies in other countries to use the risk informed inspection concept just simply for a reduction of the inspection costs. It must be recognized that the safety guaranteed by an ASME based ISI program is linked to a complex ensemble of documents and requirements, which only are effective as a whole structure. The Temelín ISI situation is characterized by a mixture of Russian, Czech and European influences. The present status has already reached a level which becomes more and more comparable with other European situations. A change towards an ASME strategy would not support this development, because it could be only partially realized and would end up with a less fortunate status than exists at present.

4.5 The Treatment of Generic Damaging Mechanism

The handling of data and experiences from “code cases” (that means from generic damaging cases detected e.g. at other NPP’s with a similar concept) is not fixed by specific rules. This concerns e.g. the case of the collector gap inspection with ET, which at the Temelín SG involves ferritic steel with its well known cracking problems instead of the austenitic steel at the WWER 440 NPPs. For the time being it is assumed, that those cracks will not occur at the Temelín SG´s and the foreseen ISI is therefore considered as a purely precautionary measure without being triggered by real damages. But this problem may need some attention in the future.

4.6 The detection of inner wall defects perpendicular to the surface of RPV

UT techniques are applied for all welds with commonly recommended pulse echo probe arrangements (0 °, 45 °, 55 ° or 60 ° and TRL70 ° probes at the cladding) and registration thresholds comparable with those applied in western states (e.g. Germany, UK or USA). It is claimed that the detectability of defects perpendicular to the surface inside the wall at the cylindrical shell must be assured by angle beam probes and at the three circumferential welds additionally with a TOFD approach. Tandem probe arrangements especially suited for this purpose are not applied. This is the situation similar as in all countries that base their NDT approach on ASME code, but different than in Germany, UK and partly in Japan (where the components subject to earthquake loads are checked using tandem probes). The issue of appropriate NDT techniques for the concerned defects has been investigated in PISC trials during the 80ties with the reported statement, that only the French approach with large focusing probes and the tandem technique applied in Germany and at the British PWR plant had been able to detect very large defects perpendicular to the surface. The ASME code based techniques can assure the detection only at originally not foreseen very high sensitivity levels (10% or 20% of the DAC values). The sensitivities actually applied for the pulse echo probe arrangements (0 °, 45 °, 55 ° or 60 °) at Temelín are in between the former PISC recommendations for improved ASME based techniques and the conventional ASME code. Therefore it is not possible to give a definite answer to the question whether the detectability of defects perpendicular to the surface inside the wall at the cylindrical shell is really assured by the pulse echo angle beam probes (45 °, 55 ° or 60 °) without using the additional information from the TOFD technique. During the qualification trial the detectability of corresponding defects seemed to be based mainly on the TOFD approach.

It is clear that the application of tandem probe arrangement ensures higher capacity for detection and sizing the dangerous large cracks, According to the Czech side, the redundancy of an inspection from the in- and outside and in addition the TOFD approach guarantee that no dangerous inner wall cracks remain undetected. It has to be observed however, that there had been no special inspection for those defects during the fabrication (an X-ray inspection of the root areas with a betatron cannot be regarded as a valuable replacement) or during pre-service period. In addition, it has to be recognized, that the recent TOFD application at the three circumferential welds of the RPV produced an unusual large number of indications (96 indications have been noticed by Skoda JS), which is normal for a TOFD technique but rather strange for an in-service inspection at an RPV. Given the fact that a normal TOFD application on very thick welds must end up with a fairly high amount of unclear indications (which are classified as to be out of interest only with the additional information from the standard pulse echo techniques), it remains unclear, whether the TOFD can in future be regarded as a realistic replacement of a tandem technique or not. The first experiences and data available indicate that this cannot be the case. The TOFD approach should therefore only be treated as a valuable tool for analytical purposes in case of indications exceeding the analytical threshold but not as a tool for detection tasks.

Thus the current situation in Temelín in this respect can be treated as normal for the current status in many other NPPs, but it is expected that further developments of NDT techniques especially in respect of RPV crack detection will be followed by the plant and applied as appropriate.

4.7 The Definition of Acceptance

In most internationally available codes the acceptance criteria are linked to the registration or recording threshold of the NDT method, stating for instance, that at the UT an echo amplitude exceeding a registration threshold by more than 6 dB is not acceptable. But usually such non acceptable indications have to be further analyzed before a final decision about repair or replacement or continuous operation under special observation is made.

At the Temelín ISI program the notion of acceptance threshold is for the UT inspection replaced by the introduction of an “analytical threshold”. That means in general, that a decision about a more or less important ISI-indication, which exceeds the registration and the analytical level has to be based on further investigations to clear the NDT findings, their background and safety relevance. There is no automatism directly linking an NDT result to replacement or repair decision without such an analysis. But the criteria used after the end of an analytical procedure are still unclear. During the October workshop it was explained that one uses the state of the art methods to judge upon the fracture mechanical, fatigue and corrosion relevance of a given defect.

It is likely to assume that additional examinations are carried out in such a case.

Different arguments are used for the definition of the critical defect sizes (that means critical for the safety): At the RPV wall the PTS relevant crack sizes are considered (20 mm deep, 30 or 60 mm in length), at other situations the standard thresholds of NDT rules are used, which are mostly derived from the performance limits of the given NDT technique at an individual task. E.g. for the inspection of the inner nozzle corner of the DN850 pipes at the RPV the assumed thresholds of a 10 mm deep crack are probably close to the capabilities of the foreseen UT method. These are typical values used as the assumed threshold in many NPPs, so that this approach in Temelín NPP does not differ from standard approaches used for other nuclear power plants. However, although the results of calculations of 15 cases considered so far gave positive results, some calculations of the PTS are still missing, so it is yet to be proven whether the value of crack depth is conservative regarding a PTS related critical crack size. The work in this area is expected to be continued. The whole set of PTS calculations is planned to be finished by the end of 2004.

Half of the PTS relevant crack size (that means a 10 mm depth underclad crack) is taken at the Temelín plant as the defect dimension which must be detected with a 100% reliability within the RPV cylindrical wall. Although this has been proven by the qualification trials for the RPV wall inspection and is at most other NPP vessels regarded as an achievable goal, one has to analyze the results of the practical ISI carried out e.g. during May 2004 and evaluate them and later ISI´s according to the signal to noise ratio achieved under the circumstances of the vessel, its weldments and cladding including their repairs, which may give a hint on the realistic detectability safety margins presently to be realized during the ISI.

So far one has to recognize that for the PTS relevant defect input data, the detectability of the RPV ISI is correctly prepared and executed to cope with the special VERLIFE defect size requirements. What realistically can be achieved in practice must be judged by experts after the first inspections. This is a situation similar to Western plants, where one had to correct the original ISI concepts in order to adapt them to newer safety analysis.

5 MONITORING FINDINGS

The main findings of the monitoring process are described in this chapter. Those items which are recommended for further monitoring are also presented in the following chapter 6.

5.1 In-Service Inspection Program

Since the introduction of the Atomic Act in 1997 and the accompanying regulations the program of in-service inspection has been required by law and is subject of SONS approval. Generally the ISI programme qualification approach is based on the requirements adopted by Western Europe countries in accordance with European Network for Inspection Qualification (ENIQ) methodology for Nondestructive Tests, on EUR 17299 and on IAEA methodology for qualification of ISI systems for WWER NPPs.

State Office for Nuclear Safety (SONS) issued its own safety guide on ISI of Main Primary Circuit Components in WWER Reactors (1998), and it is the basis of ISI/NDT in Temelín NPP. The basic standard for the qualification of the NDE personnel has been also published and it is similar to the European standard EN 473.

SONS provides supervision of all ISI qualification activities, and has determined the rules for performance demonstration which is a part of ISI qualification system. The actual practice in Temelín is characterized by previous qualification of all the methods intended to be used.

The responsibilities of the plant owner are determined by SONS decrees and the Atomic Act.

The classification of equipment at Temelín in based on the Western approach and is in agreement with the IAEA guidance, since all systems that IAEA listed as “safety” and “important for safety” are in Temelín classified as “safety systems” and their ISI/NDT is conducted as the first priority.

The extent and frequency of examinations, the methods and acceptance standards are clearly defined within the ISI programme and in work instructions. Acceptance standards are specified for each NDE method applicable for ISI program. The acceptance criteria for UT inspection have been replaced with analytical thresholds, which means that in the case of indications which exceed the registration level an analytical procedure is applied to judge upon the defect relevance using state-of-the art method. The criteria used at the end of the analytical procedure have not been clearly discussed.

Temelín ISI program is clearly determined for the subject systems and components. The inspection of all welds and areas is to be done every 4 years, what is significantly more than required by ASME Section XI. For example, min. 25% of reactor coolant piping welds is required to be inspected every year.

Reactor Pressure Vessel is inspected both from inside and outside. All nozzle to pipe welds, including dissimilar welds are requested to be 100% inspected both from outside and inside. UT techniques are applied to all welds with commonly recommended pulse echo probe arrangements and registration thresholds are comparable with those in western states, e.g. in Germany, UK or USA. For all the different inspection tasks previous qualification trials including performance demonstration had to be performed.

Atomic law and decrees prescribe responsibilities for preparation and retention of records and reports. The content is prescribed by the ASI requirements. When the acceptance criteria are exceeded, a submittal of reports to SONS is required.

Calibration blocks for UT and ET examinations have been prepared and are referenced in working instructions.

5.2 Qualification of NDE Systems

The Qualification Body is established at CEZ as a permanent institution supported by external experts. The qualification process is supervised by SONS. The transparency and independence of the qualification is assured by the participation of APC (Association for Personnel Certification in Czech Republic). The content of qualification procedure is described in SONS document and is similar to the content given in EUR 17299 EN. However, since a representative of Temelín is a member of QB, the independency of the Qualification Body remains an open issue. This can be especially problematic in view of the planning of blind trials with their extreme confidentiality requirements.

There is no organization supervising and guiding the work of qualification body (Qualification Committee). In Czech Republic, the qualification body is established directly in CEZ which is the plant utility and the supervision is made by SONS. In most countries a national steering committee for inspection qualification has been established to guide and supervise the work of QB. The need for this should be considered also in Czech Republic.

Inspection procedures are in general the effect of transferring recommendations of EUR 18117 EN and EUR 18101 EN to the Czech situation in a somewhat modified form. It seems that there is no formal application of those recommendations to the checklist of inspection procedures (IPs). The ENIQ methodology is applied in a formal way only to the whole qualification procedure for NDT methods, but not concerning the total administrative overhead.

The calibration block design, calibration, equipment set-up the data collection, interpretation, recording and ways of reporting are included in the ISI programme and described in detail. The surveillance activities of SONS include also during the qualification trials the check of personnel qualification.

The eddy current technology in the recent years has experienced a fast development. Czech organizations use a modern generation of eddy current equipment and analysis tools produced by ZETEC (USA). This definitely confirms that the Czech experts follow common western practice. Also, the scope of inspection (25% of tubes inspected each outage with a bobbin probe), shows that their approach concerning the inspection sample is stronger than, for example the approach defined by the Electric Power Research Institute (USA) in the “PWR Steam Generator Examination Guidelines” (mandatory in USA) which requires 100% of tubes to be inspected within 60 “Effective Full Power Months”.

A well known issue is the effectiveness of inspection on the entire length of tube due to small radius bends in some of the tubes. Czech experts stated that the eddy-current technology and the probes applied by “Eddy Test” A Czech contractor) is capable of adequate crack detection at every tube of the SG at entire length using “fill factor” probes.

Other kinds of inspection like eddy current of collector surfaces and threaded holes, or visual inspections of welded joints, guarantee confidence to all-embracement of the SG ISI program.

Steam generator tubing plugging criteria are determined so as to assure that the tubing will not fail during plant operation between the periods of in-service inspection. The parameters of failure are determined on the basis of performed burst test. The thickness of material necessary to ensure tube integrity during reactor operation should be determined taking into account eddy current tool accuracy, flaw growth rate estimate and the statistical evaluation. The approach used in Temelín NPP takes all these aspects in consideration, shows that the SG ISI experts are competent in this field.

The basis for technical justification defined in EUR 18099 EN were taken into consideration. The qualification trials demonstrated for the ISI at the RPV and at 850 DN piping established that the TJ philosophy was a starting point for qualification activities at Skoda and NRI. In some aspects, however, the Czech interpretation is not in agreement with the intentions of

EUR 18099, in particular what concerns the use of worst case test defects and test conditions at the test block design.

The cases observed by Austrian experts indicate that the minimal personnel requirements follows the EUR18099 EN.

The experience of Skoda and NRI in NDT of WWER primary circuit components has been demonstrated and the effective work of these Czech organizations within PHARE projects confirmed good competence of Czech experts.

The requirements concerning the defects to be detected are described before the tests, but the question of acceptance involves some difficult aspects which are discussed in special topics above.

The qualification specimen trials are conducted under SONS supervision in a secure area, the qualification assessment reports and certificates are drawn in accordance with the approach established in Western Europe.

5.3 The ISI of the RPV and the VERLIFE consideration

Half of the PTS-relevant crack size (that means a 10 mm depth underclad crack) is taken at the Temelín plant as the defect dimension which must be detected with a 100% reliability within the RPV cylindrical wall. Although the 100% detection reliability was proven in the qualification trials for the RPV wall inspection and is, at most other NPP RPVs, regarded as an achievable goal, one has to analyze the results of the practical ISI carried out (e.g. during May 2004) to determine realistic detectability margins presently possible in the ISI.

Considering the PTS-relevant defect input data, the RPV ISI is correctly prepared to address the VERLIFE defect-size-requirements. However, what realistically can be achieved in practice must be judged by experts after the first inspections. This is a situation similar to Western plants, where one had to correct the original ISI concept in order to adapt it to recent safety analysis.

The discrimination between real underclad defects and cracks within the cladding has not been thoroughly proven during the RPV wall inspection's qualification trial. This is, however, essential for the applicability of the VERLIFE concept (and its effects for the PTS) which requires a sound cladding. Nevertheless, the reactor pressure vessels in Temelín have just started their operational life, there is time available for improvements of techniques (e.g. low frequency eddy current) that will make the discrimination between small cladding and undercladding cracks possible at Temelín NPP, before it became a critical safety issue.

During the October 2004 Workshop, a discussion was held on plans for performing redundant NDT inspection of the cladding using a Low frequency Eddy current inspection process. This could prove that there are no cracks in places where an UT indication from underclad-inspection probes was observed. This should be qualified during the preparation of the next ISI at the RPV wall.

6 ISSUES OF FURTHER INTEREST

With the consideration of extensive discussions and assessment on the subject matter, both before and after the Workshop held in Prague in October 2004, as well as brief discussion held during the 2004 Czech-Austria Bilateral meeting, the expert team established a series of conclusions on the status of the ISI and NDT process at Temelín. Those conclusions are presented in the Section #4 and some specific findings highlighted in the Section #5 of this report.

The general conclusion is that the ISI and NDT for the primary circuit components for Temelín are comparable, in most respects, with the western practices. The level of achievement so far and consideration of the on-going activities is such to allow the conclusion that the ISI and NDT of integrity of primary loop components at Temelín is comparable with Western European NPP's. There are, however, some elements that Czech experts should carefully consider to continue the positive developments which have been identified by the Austrian experts. Improvements in the NDT practices are possible and some of the critical remarks have been made within this report should be (and in many cases already are) addressed.

In addition to the conclusion and findings discussed earlier in this report, this section discuss those issues that remain in order to upgrade the ISI and NDT at Temelín. The monitoring, as used in the discussion below, is meant to suggest future discussions between Czech and Austrian experts in the framework of Bilateral agreement, if so decided.

The Czech-Austrian Bilateral Agreement and regular meetings are seen as an appropriate framework for any further discussion and sharing information on ISI/NDT related issues

6.1 Documents and policy issues

It is recommended to establish a written policy of QB to specify the tasks and responsibilities of the members of QB. It is also recommended to create national working instructions (in Czech language) describing the different practical actions in qualification. These can be based on the Recommended Practices of the European ENIQ-methodology.

6.2 ISI codes

As the Czech organizations are now in a transition from Russian Codes for ISI to their own, particular issues within this subject could be: existing or new classification, scope of systems included, extension and frequency of examinations, unified acceptance standards, and links to US and European standards.

6.3 Independence for the qualification procedure

The independence in the acceptance of the qualification procedure may be an issue. The QB is the entity preparing the procedure and one of the permanent members of the QB is the representative of CEZ. On the other hand, the plant owner, who is to qualify its staff under this procedure, is CEZ. Therefore the independence of the acceptance may not be fully assured.

In the European practices it is not usual that same party (CEZ) is establishing the acceptance and qualifying the staff under the same procedure. Use of external independent experts from other VVER-plants could be considered.

6.4 Inspection activities when faults are found

An open question is the extension of the inspection scope in case of detected flaws, because there is no clear requirement stated in the procedure. It is assumed that additional inspection/ examinations are carried out in such a case.

The information on the established practices in a case when an indication (i.e. crack) is identified was not made available. Also, it is understood that there is no document describing the repair/replacement procedure when, after an analysis of a detected flaw, a repair is warranted. International practices recognizes additional inspections and/or immediate repairs as remedies.

6.5 Statistical analysis

Number of recorded defects for a specific location and with a specific size(s) is too small for a relevant statistical judgment on the accuracy of the results. The effects of the number of findings is considered. Further collection of data and statistical evaluation is encouraged. This also concerns the documentation of the signal to noise ratio achievable at the different RPV and piping sections.

6.6 Detectability of defects perpendicular to the surface

The detectability of defects perpendicular to the surface of the inside the wall at the cylindrical part of the RPV is, at Temelín NPP, similar to in many other NPPs, but lower than in Germany, UK and in Japan. In those countries, so called “tandem arrangements” are used for inspecting the components subject to earthquake loads. The issue of the choice of the appropriate NDT techniques has not been finally resolved in the world practice. Therefore this comment appears for the consideration only and not as a strong suggestion by Austrian experts.

Temelín NPP uses angle beam probes and TOFD approach for circumferential welds. The former does not provide sufficient sensitivity, and the latter yields an excessive number of indications that must be later clarified with the additional information from the standard pulse echo techniques. Further developments in this respect and the success of Temelín in their application should be followed.

The worst case concept is not fully implemented in the design of the test blocks, which can have negative effect on evaluation of performance limits of TOFD and other techniques for the detection of inner wall defects perpendicular to the surface. As the TOFD application to thick wall butt welds yields typically a large number of indications, a possibility remains of a large crack hidden among the number of mostly irrelevant indications. Therefore further work on qualification trials concerning RPV wall test block could be suggested.

The differentiation between pure underclad cracks, which are usually not dangerous, and the through-cladding cracks is important and should be realistically proven during RPV wall inspection trials.

Since the Temelín NPP has just started the operation, and the danger of undetected underclad cracks becomes an issue with the age of the plant (and accumulated RPV material “damage” due to neutron flux), there is time available for the developments and implementation of better crack detection techniques.

Further developments in NDT techniques should be followed by the plant, especially in the area of RPV crack detection. The activities of the plant in this respect should be on the agenda of future bilateral information exchange.

6.7 Qualification process

Only the artificial defects are used for the qualification processes and no real cracks were induced into the qualification trial specimens. Manufacturing processes are available that allow producing different damage or corrosion mechanisms. It is suggested that the Czech qualification body investigate possibilities to require that the trial specimen contain the defects that might be more similar to those expected to be found during the ISI of plant’s components.

Additionally, for eddy current qualification process for steam generator tubes, qualification body could collect parts of used and discarded tubes having defects originated in operation. This is a common practice in western countries. These defects represent best “like to like” conditions of flaws and eddy current data can be checked and measured by metallographic methods.

In general, the inspection qualification is a process that is in a "learning phase" in most European countries. Especially, in small countries where the number of operating power plants and NDT experts is limited, special arrangements are needed. In spite of some comments concerning the independency of the QB, the Czech approach which is described in the SONS document (and based on EUR 17299 EN) is a good start. During the last few years remarkable progress was made. Especially, the investments made in the technology and materials needed for manufacturing qualification test blocks containing realistic defects should be mentioned. In addition, Czech NDT-experts have intensively participated in the work of ENIQ and have established a good contact network worldwide.

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8 LIST OF ABBREVIATIONS

APC	Association for Personnel Certification
AQG	Atomic Question Group
ASI	American Standards institute
ASME	American Society of Mechanical Engineers
BM	Base Metal
CEZ	Czech Energy Society
CIA	Czech Institute for Accreditation
EC	Eddy Current
ECCS	Emergency Core Cooling System
ED	External Diameter (External surface of the pipe or component wall)
ENDEF	European Non-Destructive Examination Forum
ENIQ	European Network for Inspection Qualification
ET	Eddy-current Testing
HAZ	Heat Affected Zone
ID	Internal Diameter (Internal surface of the pipe or component wall)
IP	Inspection Procedure
ISI	In-Service Inspection
KTA	Kerntechnischer Ausschuss (German Rules issued by KTA)
LBB	Leak Before Break (Concept for Safety assessment of piping systems)
LLT	Transverse wave to Longitudinal wave and reflection of Longitudinal wave
LPT	Liquid (Dye) Penetrant Testing
MCL	Main Coolant Lines
MCP	Main Coolant Pumps
NDE	Non-Destructive Examination
NDT	Non-Destructive Testing
NPP	Nuclear Power Plant
NRI	Nuclear Research institute
PISC	Programme for the Inspection of Steel Components
PNAE-G	Rules and Norms for Nuclear Energy (Russian Design Code)
PSI	Pre-Service Inspection
QB	Qualification Body
RPV	Reactor Pressure Vessel
RT	Radiographic Testing
SG	Steam Generator

SONS	State Office of Nuclear Safety
TJ	Technical Justification
TOFD	Time of Flight Diffraction
TOR	Terms of Reference
TTT	Transverse-Transverse-Transverse Wave
UT	Ultrasonic testing
VLI	Verifiable Line Items
VT	Visual Testing
WM	Weld Metal
WPNS	Working Party on Nuclear Safety

ANNEX

STATUS OF ISI AND NDE IN WESTERN COUNTRIES AND IN THE RUSSIAN FEDERATION ACCORDING TO THE VLI LIST

PART A: IN SERVICE INSPECTION PROGRAM

1. Applicable Documents and Basis

1.1	Is the applicable Code or Standard for In-service Inspection establish by the SONS requirements
1.2	Is the applicable Code or Standard for In-service Inspection required by plant Technical Specifications
1.3	Is a study prepared justifying applicability of such Code or Standard for In-service Inspection at NPP Temelín
1.4	Are some Code Cases included in ISI Program
1.5	Are the other regulating documents included in ISI Program (regulatory guides, bulletins, VERLIFE, etc)
1.6	Is the experience from other plants used to adjust/enhance the ISI program/inspections

US requirements

1.1 Paragraph (b)(2) of [10CFR50.55a] designates the Edition of ASME Section XI, Division 1 and specifies limitations and modifications. Use of ASME Section XI, Division 1 is required by paragraph (g) of [10CFR50.55a].

1.2 Standard format of plant Technical Specifications prescribes that In-service Inspection shall be based on [10CFR50.55a] and ASME Section XI requirements

1.4 Application of ASME Section XI Code Cases is defined in [IWA-2440].

1.5 In subarticle F-2300(d) of [Appendix F] of ASME Section XI regulatory documents are specified as the applicable documents

Russian requirements

1.1 PNAEG-7-010-89 issued by Gosatomnadzor (GAN)

1.2 The main designer of the plant has to follow the PNAEG Codes during the construction of the plant. During operation the in-service inspections are made by the plant itself under supervision of GAN.

Finnish requirements

[This belongs to the Russian requirements and is already above]

1.1 YVL-guide YVL3.8 issued by STUK (Radiation and Nuclear Safety Authority)

1.2 Nuclear Energy Decree (161/1988) stipulates that an in-service inspection summary program shall be submitted to the Finnish Radiation and Nuclear Safety Authority together with the application for an operating licence. The requirements for ISI are specified in the YVL Guide and these are taken into account in Technical Specifications of the plant. In case of Loviisa plants the requirement for ASME XI based in-service inspections was specified when ordering the plant from USSR.

1.3 For Loviisa plants the applicability of ASME XI was carefully studied by the utility (materials, plant design, operational conditions, accessibility of components etc.). The results were presented to STUK for approval.

1.4 ASME XI is followed in all requirements

1.5 IAEA safety guide Maintenance, Surveillance and In-Service Inspection in Nuclear Power Plants, IAEA Handbook In-Service Inspection of Nuclear Power Plants

1.6 Loviisa plant is a member of the VVER Operators' Group and receives information from other VVER plants (e.g. Paks, Kozloduy, Kola etc.) During the operation of the plant the ISI program has been revised based on experience received from other plants. Also failures occurred in western PWR and BWR plants have been taken into account when revising the program.

According to the Guide YVL1.9 the in-service inspection programs and procedures are regularly reviewed for possible need of revision and for adequacy.

German requirements

1.1 10CFR50.55a
Atomic Law*), Radiation protection decree**), Safety criteria for NPPs***)

1.2 RSK Guidelines for PWR. Test and inspection plans and schedules must be available according to **AtVfV** Ordinance****) (and KTA 1202)
10CFR50.55a

1.3 Reactor safety research programs (e.g. RS 27) during 1970 – 1987 in the FRG as a basis for the RSK Guidelines and the KTA 3201.4

1.4 Experiences from cases like stainless steel IGSCC test programs (mode conversion probes, TRL 70° probes, additional x-ray and ET) are implemented in the last version of KTA 3201.4
ASME XI, IWA-2440

1.5 The KTA 3201.4 includes the use of rules like the RSK-Guidelines for PWR and the General specification for basic safety and the DIN 25435. Part 1 to 7
ASME XI, Appendix F

1.6 The German Reactor safety commission (RSK) prepares and issues regularly informations about actual cases and if necessary special rules for NDT concerning actual problems

2. Classification of Components

2.1	Are the components (including supports) classified for the purpose of In-service Inspection
2.2	Are the boundaries of classes determined and clearly designated on the adequate Flow Charts (P&IDs)

US requirements

2.1 Paragraph [IWA-1320] requires that the rules of IWB are to be applied to those systems whose components are classified ASME Class 1 (Quality Group A), IWC to ASME Class 2 (Quality Group B), and IWD to ASME Class 3 (Quality Group C). Classification is done in accordance with the requirements of NRC Regulatory Guide 1.26, and in accordance with NUREG-0800 for later plants.

2.2 Paragraph [IWA-2420] specifies content of an inspection plan and requires in (2) »the classification of the component and the boundaries of system classifications«.

Russian requirements

2.1 Instruction AIE-9-92 specifies the in-service inspection of the base metal and welded joints in the equipment and pipelines at NPPs with the WWER-1000 reactors. Instructions are given for primary and secondary circuits as well as for auxiliary systems

2.2 The instructions AIE-9-92 shows the inspection items in table format.

Finnish requirements

2.1 Classification in Safety Classes based on ASME XI was made by the plant utility and was approved by STUK.

2.2 For Loviisa plants necessary flow charts showing the boundaries between safety classes were drawn by the utility.

German requirements

2.1 A formal classification like the one introduced with the ASME code does not exist in German codes, but there are strategies defined for the priority of inspection measures (KTA 3201.4, Fig. 3-1) and detailed lists for the inspections to be foreseen at diverse components (KTA 3201.4, Chapter 5.2 and 6, tables 5.1 to 5.8)
ASME XI, IWA–1320;
NUREG – 0800

2.2 In German codes classes are defined within the General specifications for basic safety (A1, A2, A3), but with another goal.
See also 2.1
ASME XI, IWA-2420

3. Responsibilities

3.1	Are the Owner’s responsibilities and commitments clearly determined
3.2	Is the acceptance of ISI Program by SONS required
3.3	Are the potential deviations from the Code or Standard required to be approved by SONS (Relief Requests)
3.4	Is the use of Code Cases subject to SONS acceptance
3.5	Is the access for the Inspector provided during ISI examinations and subsequent evaluation?
3.6	If SONS does not approve ISI, is the SONS inspector expected to review ISI in the plant?

US requirements

3.1 Owner's responsibilities are specified in 16 items of the paragraph [IWA-1400] which include responsibilities for classification of components, design to enable access for examinations, preparation of plans, schedules and inspection summary reports, preparation of procedures, verification of personnel qualifications, performing examinations and tests, recording and evaluation of examination results, maintenance and retention of records and reports.

3.3 [10CFR50.55a], paragraph (g)(6)(i)] requires that any deviation from examination requirements by the code or addenda must be subject to NRC approval.

3.4 [IWA-2440], paragraph 2441(f) requires that the use of any Code Case and revision to previously approved Code Case are subject to acceptance by the regulatory and enforcement authorities having jurisdiction at the plant.

3.5 Access for the Inspector, examination personnel and equipment is required by [IWA-1500].

Russian requirements

3.1 PNAEG-7-010-89

Finnish requirements

3.1 Yes, in YVL3.8.

3.2 STUK has accepted the overall ISI plan before the start-up of the plant. Annually the ISI plan is submitted to STUK for approval before starting ISI.

3.3 All deviations from the plan have to be reported and justified to STUK.

3.4 STUK acceptance required.

3.5 STUK is free to follow the performance of ISI at any time. At the end of ISI main results are introduced to the representative of STUK at site before starting the reactor.

German requirements

3.1 All QA related responsibilities are defined within KTA 1401 (06/96) (General Requirements Regarding Quality Assurance) and by the licensing procedure (See the AtVfV Ordinance)
ASME XI, IWA-1400

3.2 The ISI Plans have to be defined and approved by the licensing Authority (a governmental department of the concerned German Land) as described by KTA 1401, KTA 1202 and the AtVfV Ordinance

3.3 Depending on the case KTA 3201.4 allows different procedures for deviations. Most of them are handled in direct interaction between the owner and the regional TÜV as the major surveillance organisation, the more relevant cases have to be discussed and decided by the RSK
10CFR50.55a (g) (6) (i)

3.4 Code cases have to be decided by the RSK issuing corresponding guidelines or recommendations which are during their practical realisation surveilled by the regional TÜV´s
ASME XI, IWA-2440

3.5 TÜV and depending on the case other inspectors must be present during the whole ISI and the evaluation
(KTA 3201.4)
ASME XI, IWA-1500

3.6 TÜV must approve the foreseen ISI measures before an ISI takes place. The owner can execute special not planned ISI measures by its own but will then in general not need to have a TÜV approval

4. Nondestructive Examination Methods (NDE)

4.1	Are the NDE methods to be used within ISI Program specified and their purpose described
4.2	Are the basic standards for conducting of NDE methods determined
4.3	May the alternative examination methods or newly developed techniques be substituted for the methods specified
4.4	Is the use of Code Cases subject to SONS acceptance
4.5	Are the additional requirements for the qualification of ultrasonic examination personnel established
4.6	Is a written practice in a form of a procedure prepared in accordance with the basic standard mentioned in 4.4 and additional requirements for the qualifications
4.7	Is a performance demonstration for ultrasonic examination systems required
4.8	Is a program prepared for performance demonstration mentioned in 4.7
4.9	Are the requirements for eddy current examinations of SG tubing defined?

US requirements

4.1 and 4.2 In paragraphs IWA-2210 trough IWA-2331 of [IWA-2200] NDE methods for the use during in-service inspection are defined, described and the basic standards for their conducting are determined. The following methods are used for in-service inspection.

Visual examinations:		VT-1, VT-2, VT-3
Surface examination:	Magnetic Particle	(MT)
Liquid Penetrant		(T)
Eddy Current		(ET)
Volumetric examinations:	Radiographic	(RT)
	Ultrasonic	(UT)
	Eddy Current	(ET)

4.3 Alternative examinations, or newly developed techniques may be substituted for the methods specified above, provided that the results are demonstrated to be equivalent or superior to those of the specified method.

4.4 Paragraph IWA-2310 of the subarticle [IWA-2300] requires that NDE personnel are to be qualified in accordance with ANSI/ASNT CP-189 Standard amended by the requirements of Section XI.

4.5 Paragraph [IWA-2312] requires that training, qualifications, and certification of ultrasonic examination personnel also comply with the requirements specified in [Appendix VII].

4.6 A written practice, i.e. a procedure for training, qualification, and certification of NDE personnel is to be prepared in accordance with ANSI/ASNT CP-189, as required by [IWA-2311].

4.7 and 4.8 [Appendix I] defines requirements for application of ultrasonic examination method to different components. Performance demonstration of ultrasonic examination systems per [Appendix VIII] is required for the reactor vessel and piping welds. [Appendix VIII] defines qualification requirements and requires that Owner or Vendor have a written program to ensure compliance with Appendix VIII

4.9 See 4.1

Russian requirements

4.1 AIE-9-92, PNAEG-7-010-89

4.2 PNAEG-7-010-89, section 9, several other regulations

4.4 PNAEG-7-010-89, section 4.

Finnish requirements

4.1 According to ASME XI the NDE methods to be used at each item are specified in the ISI program (UT, PT, MT, ET, RT, VT)

4.2 Basically the inspections are performed following the principles given in ASME V

4.3 If original inspection technique is changed the performance of the new technique has to be demonstrated to STUK for approval before using the technique in ISI.

4.4 In YVL3.8 the general requirements for qualification of NDE personnel are specified. In addition, national lower level instructions for performance of qualification have been issued by the National Steering Group for Inspection Qualification. The basic documents for qualification are The European methodology for qualification, EUR 17299 EN and the Common position of European regulators on qualification of NDT systems for pre- and in-service inspection of light water reactor components, EUR 16802 EN

4.5 Additional training and practical examination are required for ultrasonic inspectors that are performing inspections in areas where intergranular stress corrosion cracking may occur.

4.6 Basic certification according to EN473. Qualification based on YVL3.8

4.7 So far the performance demonstration is required for ultrasonic examination systems applied to selected pipings/components. In future the complete primary circuit will be covered.

4.8 YVL3.8 and national instructions specify the performance demonstration.

4.9 For eddy current examination of SG tubing the instructions of ASME XI and ASME V are followed.

German requirements

4.1 Due to the historic development, the NDT methods for ISI are in Germany specified and described in several mutually linked documents: RSK Guideline for PWR, KTA 3201.3 and 4, DIN 25435. 1 to 7 (NDT Methods for ISI), DIN 25450 (UT Equipment for ISI) and the DIN EN standards for the concerned NDT technique like DIN EN 583(UT), DIN EN 1290 (MT), DIN EN 1435 (RT)
ASME XI, IWA-2200

4.2 Besides the definition within the RSK Guideline and the KTA 3201.4, the basic standards are the DIN 25435 series (1 to 7) for the NDT methods to be used at ISI measures
ASME XI, IWA-2200

4.3 During the last revision of the KTA 3201.4 (1999) some alternative techniques have already been implemented into the code. Section 4.1.5 of the KTA 3201.4 allows the use of other techniques, if their performance is demonstrated. (see also 4.7)
ASME XI, IWA-2200

4.4 The basic standards are prescribed in DIN 25435. 1 to 7. The basis is the European standard DIN EN 473, but additional specific requirements are given for each NDT method in DIN EN 25435. 1 to 7.
ASME XI, IWA-2300

4.5 The requirements are established in DIN EN 25435. the specific training and certification is governed by the German society for NDT (DGZfP) in cooperation with the vendors of NDT services
ASME XI, IWA-2312, Appendix VII

4.6 The written procedure for the training, qualification and certification of NDT personnel is based on the training and certification program of the DGZfP and exist in various versions at the different NDT service vendors.
ASME XI, IWA-2311

4.7 No general re-qualification of standard techniques already qualified is needed, but for new or alternative NDT techniques or problems a qualification according the ENIQ EUR 17299 EN is required, which has been adapted to the specific German situation by the VGB-ENIQ Guidelines, issued 1997
ASME XI, Appendix I & VIII;
EUR 16802
EUR 17299 EN

4.8 The VGB-ENIQ Guideline describes and recommends a procedure for the performance demonstration according to EUR 17299 EN under the specific aspect of the federal and regional competences in Germany. This is meanwhile daily practice at the different TÜV´s and NDT vendors in Germany
ASME XI, Appendix VIII

4.9 The requirements for the Eddy current inspection of SG tubes are described in KTA 3201.4 and in DIN 25435 Part 6

5. Requirements for Examination and Inspection

5.1	Are the inspection intervals and periods determined for the scope of ISI program
5.2	Are Examination Categories for the welded joints and other inspection areas determined
5.3	Is the scope of components (piping systems and piping lines including vessels, pumps and valves) subject to inspection determined
5.4	Are the components exempted from examinations specified
5.5	Are "line lists" prepared where piping system lines are specified with their sizes, materials, pressures and temperatures that serve as the basis for establishing the scope and exemptions
5.6	Is the extent of examinations determined for Examination Categories and Items
5.7	Is the frequency of examination determined for Examination Categories and Items
5.8	Are the examination methods determined for Examination Categories and Items
5.9	Are tables prepared where extent and frequency of examination, examination methods, and acceptance standard are established for each Examination Category and Item, together with Temelín NPP response for the implementation
5.10	Is the scope of welded joints of primary circuit pipings selected on the basis of stress analysis
5.11	Are the areas (including welded joints) subject to particularly big stress, or potential cold/hot water mixing/stratification included in ISI Program as an augmented program
5.12	Shall examinations that reveal flaws or relevant conditions exceeding the acceptance standards be extended to include additional examinations during the current outage
5.13	Shall the additional examinations that reveal flaws or relevant conditions exceeding the acceptance standards be further extended to include the remaining number of welds and areas of similar material and service
5.14	Is the strategy for extended examinations prescribed?
5.15	Are there any areas in the Reactor Coolant System that are inaccessible to ISI at the present day status of equipment used in Temelín NPP?
5.16	If some areas are inaccessible to ISI, has it been demonstrated that these areas are not critical from the standpoint of safety?

US requirements

5.1 Paragraph [IWA-2430] defines inspection intervals in which the required examinations are to be completed. Inspection Program B (IWA-2433) is based on 10 years intervals. Inspection periods are defined in IWB-2412 and IWC 2412 for ASME Classes 1 and 2 and last 3-4-3 calendar years for the 10 years inspection interval.

5.2 Each group of welds and other inspection areas subject to the same inspection criteria is determined by an Examination Category as defined in [IWB-2500] for Class 1 and in [IWC-2500] for Class 2 components.

5.3, 5.4 and 5.5 The scope of components (piping systems, piping lines, vessels, pumps, valves) of ASME Class 1 and ASME Class 2 which are subject to in-service inspection is defined in [IWB-1100] and [IWC-1100]. Also, the exemptions from the requirements are specified. Thus, all Class 1 pressure retaining components, except piping of NPS 1

and smaller, are subject to in-service inspection. For Class 2 exemptions are defined in paragraph IWC-1221 and IWC-1222 based on sizes and operating parameters.
In order to establish the scope for an inspection plan it is necessary to provide line lists for each systems, including system identification, Code classification, pipe size and schedule, piping material, and maximum operating temperature and pressure, as recommended by F-2500 of [Appendix F]. Such line lists enable to determine included and exempted piping lines as the scope for an inspection plan.

5.6, 5.7 and 5.8 Extent and frequency of examination, examination method, and acceptance standard are determined for each Examination Category and Item in [Table IWB-2500-1] for Class 1 and in [Table IWC-2500-1] for Class 2. Based on these requirements an ISI Program is provided with the tables for the actual plant's Examination categories and Items usually commenting implementation at the site.

5.10 Note (1)(b) under [Examination Category B-J in Table IWB-2500-1] requires that all terminal ends and joints in piping where stress level exceed certain values are to be subject to examinations.

5.11 [NRC Bulletin 88-08] requires establishing and implementation of a program to provide continuing assurance that unisolable sections of all piping connected to the RCS will not be subjected to combined cyclic and thermal and other stresses that could cause fatigue failure.
[NRC Bulletin 88-11] requires licensees to demonstrate that the pressurizer surge line meets the applicable design code, considering the phenomenon of thermal stratification in the fatigue and stress evaluation.
Need for the augmented scope of examinations may be based on analysis.

5.12 and 5.13 Paragraphs [IWB-2430] and [IWC-2430] require that:

a) Examinations that reveal flaws or relevant conditions on Class 1 components exceeding the acceptance standards shall be extended, during the current outage to include an additional number of welds, areas, or parts included in the inspection item, equal to the number that is scheduled to be examined during the present inspection period.
For Class 2 components additional examinations shall include 20% of the number of welds, areas, or parts that scheduled to be performed during the interval.
b) If the additional examinations reveal flaws or relevant conditions exceeding the acceptance standards, the examinations shall be further extended during the current outage to include the remaining number of welds, areas, or parts of similar material and service subject to the same type of flaws or relevant conditions.

Russian requirements

5.1 AIE-9-92 specifies the inspection frequency.

5.2 The welded joints are categorized in PNAEG-7-010-89, section 2

5.3 PNAEG-7-010-89, section 6, AIE-9-92

5.5 AIE-9-92 lists the inspection items. No information about dimensions and materials is given.

5.6 AIE-9-92 specifies the scope of inspection.

5.7 Inspection frequency for each item given in AIE-9-92

5.8 Inspection methods for each item specified in AIE-9-92

5.9 AIE-9-92 shows the inspection items in table form.

Finnish requirements

5.1 The inspection intervals and periods are determined in the ISI program based on ASME XI.

5.2 Examination Categories based on ASME XI, IWB-2500, IWC-2500

5.3 ASME XI, IWB-1100; IWC-1100

5.4 ASME XI, IWB-1200; IWC-1200

5.5 Isometric drawings of piping show the dimensions, materials, temperatures etc. Correspondingly information about components in component drawings.

5.6 ASME XI,
Table IWB-2500-1
Table IWC-2500-1

5.7 ASME XI,
Table IWB-2500-1
Table IWC-2500-1

5.8 ASME XI,
Table IWB-2500-1
Table IWC-2500-1

5.9 ASME XI,
Table IWB-2500-1
Table IWC-2500-1

5.10 ASME XI,
Table IWB-2500-1
Exam. Cat. B-J

5.10 Areas of potential cold/hot water mixing/stratification are included in the ISI program.

5.12 ASME XI,
IWB-2430
IWC-2430

5.13 ASME XI,
IWB-2430
IWC-2430

5.15 The inside radius section of primary circuit nozzle of RPV is inaccessible both for OD and ID inspection.

German requirements

5.1 The inspection intervals are defined within the KTA 3201.4 (tables 5.1 to 5.8) specifically for the different components and are ranging from 5 to 10 years with at present the tendency of the RSK to reduce the 5 years period again to the former 4 years.
ASME XI, IWA-2430

5.2 There are no categories introduced as an extra thing, but definitions of the tables 5.1 to 5.8 of the KTA 3201.4 can be considered as an equivalent
ASME XI, IWB-2500; IWC-2500

5.3 The scope of the different components is considered by the tables 5.6 to 5.8 of the KTA 3201.4
ASME XI, IWB-1100; IWC-1100

5.4 There are exemptions specified within KTA 3201.4, but the plant owner must demonstrate by other means that now risk is linked with the exemptions
ASME XI, IWB-1200; IWC-1200

5.5 The tables 5.6 and 5.7 of KTA 3201.4 have been developed regarding the size, material, load conditions etc. of the piping system, but are not intended to be used as a basis for exemptions
ASME XI,
Appendix F

5.6 See the tables 5.1 to 5.8 of KTA 3201.4
ASME XI,
Table IWB-2500-1
Table IWC-2500-1

5.7 See the tables 5.1 to 5.8 of KTA 3201.4
ASME XI,
Table IWB-2500-1
Table IWC-2500-1

5.8 See the tables 5.1 to 5.8 of KTA 3201.4
ASME XI,
Table IWB-2500-1
Table IWC-2500-1

5.9 See the tables 5.1 to 5.8 of KTA 3201.4
ASME XI,
Table IWB-2500-1
Table IWC-2500-1

5.10 See the tables 5.1 to 5.8 of KTA 3201.4
ASME XI,
Table IWB-2500-1
Exam. Cat. B-J

5.11 This has already been defined in German codes since the first issue of the RSK Guideline 1976 and is at present one of the major motivation of the tables 5.1 to 5.8 of the KTA 3201.4 (see also the requirements for nozzle corner inspection, the inspection of the ligaments between control rod tubes, specially intensified ISI at the RPV wall in the core belt region for older plants, special inspections at bimetallic welds, and welds at the thermal sleeves)
NRC Bulletins
88-08
88-11

5.12 This is usual practice and is generally required by the KTA 3201.4. The regional TÜV is regularly involved in the decision finding procedure for such cases.ASME XI,
IWB-2430
IWC-2430

5.13 This is usual practice and is generally required by the KTA 3201.4. The regional TÜV is regularly involved in the decision finding procedure for such cases.
ASME XI,
IWB-2430
IWC-2430

5.14 Such a strategy is not specially defined, but it is usual practice, that extended inspections (required as additional control inspections by the KTA 3201.4) are executed according to case specific agreements between plant owner and regional TÜV.

5.15 In case of inaccessible parts at the main cooling system the plant owner must demonstrate that there are alternative measures to cover possible risk’s from those areas. (KTA 3201.4)

5.16 In case of inaccessible parts at the main cooling system the plant owner must demonstrate that there are alternative measures to cover possible risk’s from those areas. (KTA 3201.4)

6. Reactor Vessel Examination

6.	General RPV Examination methods
6.1	Are more that one inspection of the reactor vessel foreseen to be performed during one inspection interval
6.2	Are all circumferential welds required to be 100% examined
6.3	Are all longitudinal welds required to be 100% examined
6.4	Are all nozzle-to-safe welds (dissimilar metal welds) required to be 100% examined
6.5	Are nozzle-to-safe welds required to be examined from the inside surface or from the outside surface
6.6	Are all nozzle inner radius sections required to be 100% examined
6.7	Is the ultrasonic examination method employed – for the examination of the reactor vessel welds
6.8	Is the contact technique used for the ultrasonic examination of the reactor vessel welds
6.9	Is the performance demonstration of the ultrasonic examination systems required for the reactor vessel welds examinations
6.10	Is a visual examination of the reactor vessel interior foreseen to be performed

US requirements

6.1 [Table IWB-2500-1] determines the frequency of examination for each Examination Category associated with the reactor vessel. ISI Program based on ASME Section XI requires two inspection of the reactor vessel: »intermediate scope« in the first inspection period and »full scope« at the end of the inspection interval.

6.2, 6.3, 6.4 [Table IWB-2500-1] requires that all circumferential vessel welds, nozzle-to-vessel welds, and inner radius sections are to be examined 100%.

6.7 [Table IWB-2500-1] determines examination method as volumetric. In practice this is ultrasonic examination. Examination technique is not subject to the ASME XI requirements.

6.9 Performance demonstration of ultrasonic examination systems employed on reactor vessel welds is required for all welds and inner radius section, except for the flange welds, in accordance with requirements of [Appendix I].

6.10 Visual examination VT-3 of the reactor vessel interior is required to be performed on the accessible surfaces in each inspection period by [Table IWB-2500-1].

Finnish requirements

6.1 100% must be covered during one inspection interval. Inspections can be performed in several parts during interval.

6.2. The requirement is to cover 100% of all circumferential welds.

6.3 In Finnish RPVs there are no longitudinal (vertical) welds to be inspected in ISI

6.4 100% inspection is required

6.5 It is not specified from which side but the coverage must be 100%.

6.6 Nozzle inner radius sections should be 100% covered in ISI.

6.7 Yes UT.

6.8 Inspections from the outside surface are made by contact technique and inspections from the inside by immersion technique.

6.9 Performance demonstration (qualification) is required

6.10 Normally not for vessel interior but for reactor internals.

Russian requirements

6.1 According to AIE-9-92 the circumferential welds are 100% inspected first time after 15000-20000 hours of operation and thereafter once every four years.

6.2 Circumferential weld between flange and upper nozzle shell is 25% inspected. All other circumferential welds should be 100% inspected.

6.3 Longitudinal welds nor mentioned in AIE-9-92

6.4 Yes.

6.5 Not specified from which side.

6.6 Yes.

6.7 Ultrasonic, visual and magnetic particle testing.

6.8 Not specified.

6.9 Possible qualification not known. The main designer has specified and approved the technique used.

6.10 Yes.

German requirements

6.1 ASME XI Table IWB-2500-1
The RPV wall including all nozzles has to be inspected 100% during the inspection interval of 5 years. Representative areas of the cladding have to be included. The connecting welds are inspected based on a special work instruction

6.2 ASME XI Table IWB-2500-1
Table 5.1 of KTA 3201.4 requires 100 % inspection of all welds for longitudinal and transverse defects

6.3 ASME XI, Table IWB-2500-1
Table 5.1 of KTA 3201.4 requires 100 % inspection of all welds for longitudinal and transverse defects

6.4 ASME XI Table IWB-2500-1
The connecting welds are inspected based on a special work instruction required by the KTA 3201.4 and adapted to the special design

6.5 The connecting welds are inspected based on a special work instruction required by the KTA 3201.4 but not necessarily from a specific side. Since at PWR´s the access is primarily available from the inside, all inspections at PWR´s are at present executed from the ID.

6.6 ASME XI
Table IWB-2500-1
Table 5.1 of KTA 3201.4 requires 100 % inspection of the all nozzle inner corner

6.7 Preference is given to the Ultrasonic inspection of all reactor vessel welds
(RSK Guidelines for PWR and KTA 3201.4)

6.8 Actually in Germany all UT examinations are executed with probes coupled in contact technique using a small water filled gap but guiding the probes by the inner surface of the RPV.
(In contrast to this all French reactors are inspected from the ID with large focusing probes with immersion technique as coupling and large water delay paths. The probes are guided by a heavy manipulator, not by the surface)

6.9 ASME XI Appendix I
The standard UT techniques (Angle beam and normal probes, Tandem technique, TRL 70° probes) are in use since more than 30 years and are regarded as qualified by experience and technical justification elaborated during research programs (E.g. RS 27 1974 to 1987). New techniques like LLT with phased array or TOFD have been qualified according to EUR 17299 EN

6.10 ASME XI Table IWB-2500-1
Video cameras are usually included at the ISI systems and are used among others for Visual inspection of the surface and the overall status

7. Acceptance Standards

7.1	Are the acceptance standards specified for each NDE method applicable for ISI Program
7.2	May the acceptance of a component whose examination detects flaws or relevant conditions exceed acceptance standards be done by repair/replacement activity or by analytical evaluation
7.3	Are the repair/replacement activities established by ISI Program or by a separate document
7.4	Are the repair/replacement program and the reexamination results subject to SONS review
7.5	Shall the analytical evaluation of examination results be submitted to SONS
7.6	Are the successive inspections required and determined if a component is accepted for continued service by analytical evaluation
7.7	Are any alternative criteria in use?
7.8	Are the acceptance criteria for SG tubing established?

US requirements

7.1 Acceptance standards and evaluation are specified in [IWB-3000] and [IWC-3000]. In subarticles [IWB-3500] and [IWC-3500] acceptance standards are defined for the Examination Category and flaw detected. In Tables IWB-2500-1 and IWC-2500-1 the method of examination is determined for each Examination Category.

7.2 As stated in [IWB-3100] and [IWC-3100] the acceptance of a component for continued service may be done by examination, by a repair/replacement activity, or by an analytical evaluation.

7.3 In [IWA-4000] paragraph IWA-4150 requires that repair/replacement activities shall be completed in accordance with the Repair/Replacement Program. According to the Appendix F (F-2400) R/R Program may be published as part of ISI Program or as separate program.

7.4 The Repair/Replacement Program and the examination results after a repair/replacement activity are to be subject to review by the regulatory authority as required by paragraphs IWB-3134 and IWC-3134 of subarticles [IWB-3100] and [IWC-3100].

7.5 Analytical evaluation of examination results shall be submitted to the regulatory authority as required by paragraph IWB-3134 and IWC-3134 of subarticles [IWB-3100] and [IWC-3100].

7.6 After acceptance by analytical evaluation the successive inspections are to be performed as required by paragraphs IWB-3132.3 and IWC-3132.3 of subarticles [IWB-3100] and [IWC-3100]. The successive inspections are defined by paragraphs [IWB-2420] and [IWC-2420].

Russian requirements

7.1 Acceptance criteria given in PNAEG-7-010-89, section 11

Finnish requirements

7.1 ASME XI,
IWB-3000&3500
IWC-3000&3500

7.2 ASME XI,
IWB-3100
IWC-3100
The acceptance can be based on fracture mechanics analysis. Based on analysis the repair or replacement can be postponed to next shutdown. More frequent inspections can be required.

7.3 ASME XI,
IWA-4000

7.4 All the repair/replacement actions have to be approved by STUK before taking any action. Results of reexamination are reviewed by STUK.

7.5 All results of analysis and examinations shall be submitted to STUK.

7.6 Normally, more frequent inspections are required.

7.8 The utility has determined plugging criteria.

German requirements

7.1 ASME XI,
IWB-3000&3500
IWC-3000&3500
Acceptance criteria are defined within KTA 3201. 4 specially adapted to the ISI purposes and distinguishing between fabrication needs and ISI goals.

7.2 ASME XI,
IWB-3100
IWC-3100
The Fig. 8-1 of KTA 3201.4 defines the procedure of decision finding in case of
Acceptance criteria exceeded by an indication
Special analytical activities are recommended

7.3 ASME XI,
IWA-4000
Repair measures have to be qualified but this is governed by other rules of the KTA (KTA 3201.3)

7.4 ASME XI,
IWB-3100
IWC-3100
All repair or replacement activities have to be approved by the TÜV before they are executed (Procedure corresponding the one described in KTA 3201.3)

7.5 ASME XI,
IWB-3100
IWC-3100
The evaluation of ISI results has to be performed under presence of a TÜV representative and must be approved by him. (KTA 3201.4, RSK Guidelines for PWR)

7.6 ASME XI,
IWB-3100&2420
IWC-3100&2420
Fig. 8-1 and section 8.1.1 of KTA 3201.4 indicate the procedure for successive inspections with shorter intervals

7.7 For image like presentations of the results of an ISI (preferably with automatic UT) special acceptance criteria can be used (KTA 3201.4)

7.8 Recommended are values like 20% of the wall thickness and 10 mm length within KTA 3201.4, but the final work instructions may deviate from this and must fix the criteria by an agreement between the plant owner, the NDT vendor and the TÜV.

8. Records and Reports

8.1	Are the Owner responsibilities for preparation and retention of records and reports defined?
8.2	Are the content and form of reports prescribed?
8.3	Is the submittal of reports to SONS defined?
8.4	Are all records and reports required to be retained for the service lifetime of the component or system?
8.5	Are the records and reports easily accessible for use?
8.6	Are the records and reports protected against internal hazards (fire, flood)?

US requirements

8.1 Paragraph IWA-6210 of [IWA-6200] prescribes Owner's responsibilities in preparing records of examinations and tests and summary reports for preservice and in-service inspections

8.2 Content and form are determined by paragraphs IWA-6220 for abstract of examination required by form NIS-1 and by IWA-6230 for the Summary report preparation.

8.3 Submittal of reports to the regulatory authorities is required by paragraph IWA-6240. The in-service inspection summary report shall be submitted within 90 calendar days of the completion of each refueling outage

8.4, 8.5 and 8.6 Paragraph IWA-6310 of [IWA-6300] prescribes the retention of all records and reports for the service lifetime of the component or system. Also, access by the Inspector and suitable protection against determination and damage are required.

Russian requirements

8.1 The practice is that plant owner storages all the records and reports.

8.2 Some model sheets are included in ПНАЕГ-010-89.

8.3 Not known. GAN is represented at site.

8.5 Not precisely known., but most probably yes.

8.6 Not known.

Finnish requirements

8.1 The owners responsibilities are defined in YVL3.8.

8.2 The blank inspection records for all methods are attached to the inspection procedures that are reviewed by STUK before they are used in ISI. The reports are reviewed by STUK and improved if necessary.

8.3 The report summarizing all the findings of ISI has to be delivered to STUK before the start-up of reactor after shutdown. If flaw indication exceeding the acceptance standard is left in the structure on the basis of fracture mechanical analyses, the approval of STUK shall be sought for the analyses and other actions prior to reactor start-up. Final summary report containing the complete results of annual ISI has to be delivered to STUK within 4 months from the start-up of the reactor.

8.4 The records and reports are stored by the utility for the service lifetime of the plant.

8.5 Access to the archive of original documents is through utility.

8.6 Archive is protected against internal hazards.

German requirements

8.1

ASME XI,

IWA-6200

With the KTA rules 1202 (Testing manual), 1401 (QA), 1404 (Documentation) and 3201.4 the responsibilities of the different partners (owner, NDT vendor, TÜV, authority) are defined.

8.2 KTA 1404 and 1401 are giving details for the form of the reports, the content is defined by DIN 25435. 1 to 7, KTA 3201.4 and 3201.3
ASME XI, IWA-6200

8.3 The general licensing Procedure as described within the Nuclear Licensing Procedure Ordinance (AtVfV) requires the participation of the TÜv or similar surveying organisations at the ISI and also the evaluation of the results and reports
ASME XI,
IWA-6200

8.4 KTA 3201.4, Section 11.3 requires the safe storage of all ISI reports for the lifetime of the concerned components
ASME XI,
IWA-6300

8.5 The safe storage has to be provided at the NPP (KTA 3201.4, Section 11.3). In case of deterioration of the document basis, safer copies have timely to be produced

8.6 The safe storage has to be provided at the NPP (KTA 3201.4, Section 11.3). In case of deterioration of the document basis, safer copies have timely to be produced

9. ISI Plans and Schedules

9.0	Is the following information included in ISI Plans:
9.1	System and component Code based classification
9.2	Examination Category and Item
9.3	Description and identification of welds and components selected for examination
9.4	Reference to drawings locating welds and components
9.5	Examination methods
9.6	Inspection period or outage in which the examination will be performed
9.7	Calibration blocks
9.8	Reference to examination procedure and/or special requirements

US requirements

9.0 [Appendix F] of ASME Section XI recommends contents of IWB and IWC plan tables to include items as specified in VLI 9.1 trough 9.8. Inspection period or outage under VLI 9.6 is the basis for examination schedule.

Russian requirements

9.0 (AIE-9-92)

9.2 Yes

9.3 Yes

9.4 No

9.5 Yes

9.6 Frequency yes

9.7 No

9.8 Yes

Finnish requirements

9.1 till 9.6 Yes

9.7 No (given in procedures)

9.8 Yes

German requirements

9.0 KTA 3201.4
ASME XI,
Appendix F

9.1 Table 5.1 to 5.8 of KTA 3201.4 see also 2.1 of the VLI

9.2 Table 5.1 to 5.8 of KTA 3201.4 see also 5.2 of the VLI

9.3 Table 5.1 to 5.8 of KTA 3201.4

9.4 KTA 3201.4, Section 11.2 and Fig. 11-1, KTA 1202

9.5 Table 5.1 to 5.8 of KTA 3201.4

9.6 Table 5.1 to 5.8 of KTA 3201.4

9.7 KTA 3201.4, section 4, DIN 25435.1, DIN EN 583

9.8 KTA 3201.4 makes reference to the DIN 25435. 1 to 7 standards describing the NDT methods in detail

10. Supporting Documents of ISI Programme

10.1	Are the (color coded) Flow Charts (P&IDs) of systems with marked boundaries of classes included
10.2	Are the isometric drawings of piping lines and drawings of the components included in ISI programme that identify welds, areas and parts to be examined
10.3	Is the list of calibration blocks included showing materials, and sizes
10.4	Is the list of examination procedures included
10.5	Are allocation tables included showing the completion of required percentage of examinations for Examination Categories and inspection periods

US requirements

10.1 Preservice examination shall be performed prior to initial plant startup as required by [IWB-2200] and [IWC-2200]. If the In-service Inspection Program starts when a plant is already in service a baseline inspection should be performed based on the requirements for the Preservice inspection.

10.2 [IWB-2200] requires that the preservice examinations shall be extended to include essentially 100% of the pressure retaining welds in all Class 1 components, except in those components exempted from examination.

10.3 As allowed by [IWB-2200] and [IWC-2200] shop and field examinations may be accepted to serve in lien of the on-site examinations provided that such examinations are conducted under conditions and with the equipment and techniques equivalent to those that are expected to be employed for subsequent in-service examinations.

Russian requirements

10.4 Yes

Finnish requirements

10.1 Yes

10.2 Yes

10.3 No

10.4 Yes

10.5 Yes by utility

German requirements

10.1 No such charts are required but may be used. The German plant owners are using similar systems adapted to their specific needs, but not standardized.
ASME XI,
Appendix F

10.2 KTA 3201.4 requires in section 11.2 a documentation of the inspection places and areas, but the kind of drawings is not prescribed. On site in the NPP isometric presentations are in use and required by the regional TÜV´s.
ASME XI,
Appendix F

10.3 According to KTA 3201.4 and DIN 25435.1 a work instruction for ISI must contain a description of the calibration blocks which have to be used for the inspection.
ASME XI,
Appendix F

10.4 According to KTA 1202 and KTA 3201.4 an list of inspections must be prepared before an inspection takes place. This list must contain among others the work instructions
ASME XI,
Appendix F

10.5 The surveillance of the inspection completeness is achieved by different means at the individual plant. There are no special rules how to do this. The only regulated item is, that the TÜV has to survey the whole ISI activities and therefore also the achievement of the requested goals.

11. Preservice Examination

10.1	Is the Preservice Inspection performed prior to initial plant start-up or is the baseline inspection performed prior to implementation of ISI Program
10.2	Are all pressure retaining welds of class 1 pipings examined during the Preservice Inspection or baseline inspection
10.3	Are the shop and field examinations accepted to serve in lieu of the on-site preservice examinations and under which conditions

Finnish requirements

11.1 Preservice inspection before start-up.

11.2 Yes

11.3 Are accepted if the technique is the same and comparison with the results of subsequent results of ISI is possible. Results of shop and field examinations can be used as additional reference material during ISI.

German requirements

11.1 For the old plants in Germany (Obrigheim 1967, Stade 1969, Würgassen 1970) one has to admit, that a comparable preservice inspection does not exist due to the lack of available techniques at that time. For all other plants baseline or fingerprint inspections have been carried out with the intention to use their results as a reference for future ISI.
ASME XI,
IWB-2200
IWC-2200

11.2 All welds of the RPV are inspected during the baseline inspection and some selected circumferential welds of the primary circuit. (KTA 3201.4 and RSK Guidelines for PWR).
ASME XI,
IWB-2200

11.3 Due to the lack of complete baseline inspections of all welds of the primary loop, the fabrication inspections are often taken as a reference, especially also x-ray films for doubtful UT indications at circumferential welds.
ASME XI,
IWB-2200
IWC-2200

PART B: QUALIFICATION OF NDE SYSTEMS

1. Qualification Body

1.1	Is the qualification process conducted, assessed and witnessed by qualification body
1.2	Is the qualification body founded for particular qualification or it is organized as a permanent body for different qualifications
1.3	Is the independency of qualification body assured (Who appoints the qualification body, who finances its operation)
1.4	Is the qualification body consisting of different experts and not only NDT level II and III persons
1.5	Is the qualification body working in accordance with defined organization chart showing responsibilities of their members
1.6	Is the qualification body working using written instructions
1.7	Is the responsibility of the qualification body report to SONS directly any fault during qualification
1.8	Is the qualification body opened to external audits
1.9	Is the qualification body gathering qualification dossier

European (ENIQ) requirements

1.1 EUR 20395 EN has foreseen that qualification of non-destructive tests is conducted, assessed and witnessed by qualification body.

1.2 EUR 20395 EN is considers three types of qualification bodies: independent third party, independent part of the utility, and ad hoc qualification body.

1.3 According to EUR 20395 EN qualification body should be independent and impartial.

1.4 EUR 20395 EN requires that qualification body personnel should have necessary technical expertise in the inspection methods and techniques, expertise in assessing procedures, technical justifications and test sample design.

1.5 EUR 20395 EN requires that qualification body should have organization chart showing personnel responsibilities.

1.6 EUR 20395 EN requires that qualification body is working according to written procedures and quality assurance manual.

1.8 According to EUR 20395 EN qualification body should be opened to internal and external audits.

Finnish requirements

1.1 Yes, following the principles of ENIQ (EUR 20395 EN) national practices are established.

1.2 The Qualification Body is formed for each particular qualification separately. The permanent members (1-2 members) are from SFS-Inspecta Certification

1.3 The principles for assuring the independency of qualification body are determined in national guidelines. In principle, inspection vendor performing the inspection and the utility representative of the plant concerned can not participate in qualification body. The body is nominated by the National Steering Committee for Inspection Qualification.

1.4 The body is formed by representatives of SFS-Inspecta Certification (national certification center), NDT-experts (level III) and representative of utility (not from the plant concerned)

1.5 National guidelines describing the working policy, responsibilities etc. of qualification body have been established.

1.6 Yes, see above. Guidelines for all main actions of the body have been established.

1.7 Representative of SFS-Inspecta Certification has the responsibility to report all deficiencies in the qualification actions to STUK. STUK has permanent access to the meetings and documents of the qualification body.

1.8 Internal audit is made annually. STUK has the right to audit the body at any time.

1.9 Qualification Dossier is gathered by qualification body and is stored by SFS-Inspecta Certification.

German requirements

1.1 The adaptation of the EUR 17299 EN as a VGB ENIQ Guideline requires a qualification body similar to EUR 20395 with the participation of neutral experts, the German Society for NDT (DGZfP), the TÜV and representatives of the plant owner, e.g. VGB employees and case-by-case also experts from NDT vendors or equipment producers.
EUR 20395 EN

1.2 Mostly ad hoc qualification bodies have been active so far.
EUR 20395 EN

1.3 Impartiality is guaranteed by the participation of neutral experts and the DGZfP. Financing has to be done by the plant owners group (e.g. VGB)
EUR 20395 EN

1.4 The qualification body is based on the participation of neutral experts, the German Society for NDT (DGZfP), the TÜV and representatives of the plant owner, e.g. VGB employees and case-by-case also experts from NDT vendors or equipment producers.
The level of the participants is of minor priority.
EUR 20395 EN

1.5 A general organization chart exist for the ad hoc qualification bodies
EUR 20395 EN

1.6 Written instructions exist for the ad hoc qualification bodies
EUR 20395 EN

1.7 TÜV is mostly participating at the Q body

1.8 Yes
EUR 20395 EN

1.9 Yes
EUR 20395 EN

QUALIFICATION DOSSIER

2. Input Information

2.1	Is the level of qualification determined based on safety significance of the component to be inspected
2.2	Does the utility provide the input information which concerns component to be inspected (dimensions, geometry, material, description of welded joints, surface conditions, possible restrictions, etc.)
2.3	Are the objectives of inspection defined, (detection capability and sizing capability, type, location and orientation of defects to be detected) as well as required accuracy and RMS
2.4	Are the objectives of qualification defined, (detection capability and sizing capability, type, location and orientation of defects to be detected), required accuracy and acceptable rate of false calls
2.5	Is the equipment for NDE defined including all necessary hardware and software
2.6	Is the inspection procedure established (techniques, probe selection, calibration, essential parameters, instrument settings, scanning, sensitivity, reporting and acceptance level, evaluation of indications, recording and documentation)
2.7	Is the basic and supplementary personnel qualification defined

European (ENIQ) requirements

2.1 EUR 18685 EN requires description of components to be inspected, defects to be detected, inspection technique and required inspection performance. This reflects to the choice of qualification level.

2.2 EUR 18685 EN requires that input information include all details to the component like dimensions, geometry, material and type of joints etc.

2.3 EUR 18685 EN requires definition of the ISI objectives and additionally EUR 18116 EN shows an example of RMS to be achieved.

2.4 Qualification objectives may be very similar to the ISI objectives with additional item – allowable false calls rate.

2.5 According to the EUR 18685 EN inspection system (equipment, procedure and personnel) should be defined before start of qualification.

Finnish requirements

2.1 All the components currently considered are in the primary circuit and the highest level of qualification is required.

2.2 The input information to be delivered by the utility is specified in YVL3.8 and in lower level guidelines. The issues mentioned here in the left column are all required in input information.

2.3 The objectives of inspection are specified in the input information and are reviewed by the qualification body.

2.4 The objectives of the qualification are defined by utility, and after review of qualification body delivered to STUK for approval.

2.5 The whole inspection system is defined in qualification procedure.

2.6 The inspection procedure is delivered by the vendor and is assessed by the qualification body.

2.7 In case of mechanized inspection the qualification requirements are separately specified for supplementary staff, inspectors and person analyzing the results.

German requirements

2.1 Three categories are introduced by the VGB-ENIQ Guideline
Cat. 1: Components with no know degradation
Cat. 2: Component with postulated degradation mechanism
Cat. 3: Components with know defect mechanism (e.g. Code cases)
EUR 18685 EN

2.2 Yes
EUR 18685 EN

2.3 Yes
EUR 18685 EN
EUR 18116 EN

2.4 Yes
EUR 18685 EN

2.5 Yes, since most qualifications are linked to the used equipment
EUR 18685 EN

2.6 Yes
EUR 18685 EN

2.7 This is in general described in DIN 25435. 1 to 7 for the different NDT methods and requires EN 473 certifications, but exceeds the definition of EN 473 corresponding to the different NDT method
EUR 18685 EN

3. Qualification Procedure

3.1	Is the qualification level and effect of quality discussed in qualification procedure
3.2	Is the balancing between technical justification and practical trials considered
3.3	Is the method of the assessment of technical justification, inspection procedure (IP), equipment and personnel qualification prescribed
3.4	Is the qualification procedure submitted to the plant owner for acceptance
3.5	Is the qualification procedure accepted by SONS?

European (ENIQ) requirements

3.1 According to the EUR 18685 EN qualification procedure should discuss purpose of the qualification, component to be inspected, type of qualification that should affect quality of the inspection.

3.2 EUR 18685 EN requires that balancing between technical justification and test specimens trials are defined.

3.3 EUR 18685 EN requires definition of assessment method for technical justification, equipment, inspection procedure and personnel.

3.4 EUR 17299 EN requires that qualification procedure will be submitted to the plant owner for acceptance.

Finnish requirements

3.1 In case of primary components qualification level is always high. Lower levels are currently not considered.

3.2 The balancing between technical justification and practical trials is considered in the qualification procedure.

3.3 Check-lists for assessment of technical justification, inspection procedure etc. are included in the national guidelines.

3.4 The qualification procedure is submitted to plant owner for approval and after approval to STUK for information.

3.5 Qualification procedure is submitted to STUK for information before practical qualification and will be approved/rejected by STUK at the end of qualification when the complete dossier is submitted to STUK.

German requirements

3.1 Three categories are introduced by the VGB-ENIQ Guideline
Cat. 1: Components with no know degradation
Cat. 2: Component with postulated degradation mechanism
Cat. 3: Components with know defect mechanism (e.g. Code cases)
EUR 18685 EN

3.2 Yes, especially modeling is more widely used for the technical justification
EUR 18685 EN

3.3 Not specially defined, but in the special case the written procedure contains recommendations for the TJ.
EUR 18685 EN

3.4 Yes the VGB is acting in place of the plant owner
EUR 17299 EN

3.5 Approved by the VdTÜV, an association of all German TÜV´s.

4. Inspection Procedure

4.1	Is the checklist for the IP assessment prepared
4.2	Does the IP checklist cover specific inspection technique?
4.3	Does the IP checklist include component and joint description
4.4	Are the essential variables and equipment details together with safety class included into IP checklist
4.5	Are the calibration block designs, calibration and equipment set-up included into IP checklist
4.6	Are the data collection, interpretation, recording and way of reporting covered by IP checklist
4.7	Are the personnel qualification requirements covered by IP checklist

European (ENIQ) requirements

4.1 EUR 18117 EN and EUR 18101 EN provide a detailed checklist how an inspection procedure should be assessed. VLI's 4.1 – 4.7 give the most important items which should be taken in consideration.

Finnish requirements

4.1 A check-list for assessment of inspection procedure is included in the working guidelines of qualification body.

4.2 So far only UT and ET are covered.

4.3 The area and scope of application are determined in the inspection procedure.

4.4 Essential parameters are discussed in the technical justification.

4.5 These are assessed as part of the assessment of inspection procedure.

4.6 These are assessed as part of the assessment of inspection procedure

4.7 These are general requirements specified in YVL3.8.

German requirements

4.1 Yes
Due to the historic development, the NDT methods for ISI are in Germany specified and described in several mutually linked documents: RSK Guideline for PWR, KTA 3201.3 and 4, DIN 25435. 1 to 7 (NDT Methods for ISI), DIN 25450 (UT Equipment for ISI) and the DIN EN standards for the concerned NDT technique like DIN EN 583(UT), DIN EN 1290 (MT), DIN EN 1435 (RT)
EUR 18117 EN

4.2 Yes
EUR 18117 EN

4.3 Yes
EUR 18117 EN

4.4 Yes
EUR 18117 EN
EUR 18101 EN

4.5 Yes
EUR 18117 EN

4.6 Yes
EUR 18117 EN

4.7 Yes, additional definitions are given in DIN 25435. 1 to 7
EUR 18117 EN

5. Technical Justification (TJ)

5.1	Does TJ define relevant input data related to the components, expected defects and method of inspection
5.2	Does TJ provide the analysis of the influential NDE parameters
5.3	Are the minimal personnel requirements (e.g. qualifications, eye test results), reviewed in TJ
5.4	Is a justification of chosen inspection parameters performed (physical reasoning)
5.5	Are the results from previous qualifications trials as well as field performances collected and justified
5.6	s a separate parametric study performed or is it already done in frame of previous question
5.7	Is a justification performed regarding the choice of inspection hardware and analyses software
5.8	Is a review of evidences performed that ISI objectives can be met
5.9	Does TJ give advice about test specimens for open and blind trials

European (ENIQ) requirements

5.1 Appendix 1 of EUR 18099 EN gives details of the possible content of relevant input data. Component, defects, and ISI objectives should be indicated.

5.2 EUR 18099 EN requires analysis of the influential parameters. EUR 18101 EN discusses in detail all parameters (input, procedure and equipment) that may have influence on particular inspection.

5.3 EUR 18099 EN requires review of personnel qualification requirements including basic qualification as well as supplemental training.

5.4 EUR 18099 EN and EUR 18101 EN prescribe justification of chosen inspection parameters in qualitative terms.

5.5 EUR 18099 EN allows that results from previous qualifications trials are included in to a technical justification.

5.6 Separate parametric study according to EUR 18099 may investigate influences like component surface roughness, defect roughness, comparison of responses from the real and artificial defect etc.

5.7 An important item in technical justification for EUR 18099 EN is consideration of equipment and analysis software package.

5.8 EUR 18099 EN prescribes review of presented evidences in view of the ISI objectives to be met.

5.9 EUR 18099 EN requires the section covering the advices about the test samples that should be used for practical trials that might be open and/or blind.

Finnish requirements

5.1 TJ is currently based on recommendations presented in EUR 18099 EN. The content of technical justification is presented in Appendix 5 of YVL3.8. National instructions for preparation of TJ are under development. Input data related to the components, expected defects and method of inspection are included.

5.2 This is required by YVL3.8

5.3 Minimum requirements for personnel are reviewed in TJ.

5.4 Physical reasoning is included.

5.5 Experimental evidence from previous qualifications is taken into account.

5.6 Separate parametric study is performed if not discussed in previous qualifications mentioned above.

5.7 Selection of inspection hardware and software is required in TJ.

5.8 Inspection objectives and how TJ provides evidence of their fulfillment is in included in TJ.

5.9 Recommendations for open and blind trial test pieces (geometry, materials, defects etc.) are included in TJ

German requirements later

5.1 Yes
EUR 18099 EN

5.2 Yes, the more intensive use of modeling enhances the analysis, The DGZfP has established a special working group for theoretical modeling to support the need of the NDT practice
EUR 18099 EN
EUR 18101 EN

5.3 Definitions are given in DIN 25435. 1 to 7 and are reflected during TJ
EUR 18099 EN

5.4 Yes, often checked by modeling or at test blocks
EUR 18099 EN
EUR 18101 EN

5.5 KTA 3201.4 requires the use of experiences and therefore during the qualification measures those experiences are a major part of the reasoning
EUR 18099 EN

5.6 There are a lot of basic publications available from previous national and European reactor safety research programs concerning parametric influences at the NDT
EUR 18099 EN

5.7 Yes
EUR 18099 EN

5.8 Yes
EUR 18099 EN

5.9 No advices for blind or open trials are given. For most personnel qualifications blind trials are preferred, whereas for equipment and method qualification open trials are chosen. (VGB ENIQ Guideline)
EUR 18099 EN

6. Description of Defects

6.1	Are the requirements related to the component to be inspected specified before the test
6.2	Are the requirements related to the type of defects to be detected and sized specified
6.3	Is the "Worst Case Concept" considered during designing the qualification specimens, regarding the most challenging situations at inspection performance
6.4	Are the critical defect sizes considered
6.5	Is the verification of test specimens performed if already available specimens are used for qualification
6.6	Is the special attention paid during designing to similarity of the macrostructure and surface conditions of the qualification specimens and components to be inspected
6.7	Is the influence of the number and the sizes of defects considered in the qualification specimens so as to perform objective and comprehensive qualification
6.8	Is the way of manufacturing of defects considered, for example electro-erosion, implantation technique etc.
6.9	Is the quality control performed on qualification specimens
6.10	Is it a common practice to perform both, open and blind tests during particular qualification
6.11	Is the confidentiality assured of qualification specimens intended to be used for blind tests
	Specific to reactor vessel
6.12	Does qualification body assess nature of the flaws induced in the test specimens and evaluate their possibility to occurring in the reactor vessel
6.13	Did positions and orientations of the flaws in the test specimens correspond to the most difficult directions for the detection of the flaws regarding geometry of the reactor vessel
6.14	Did reactor vessel test specimens contain specific flaws like under-cladding cracks
6.15	Is the qualification of the UT systems for examination of reactor vessel successful so that detection, length and depth sizing criteria as well as false call rate are achieved or there are some limitations?

European (ENIQ) requirements

6.1, 6.2, 6.3 and 6.4 Prior to the start of the qualification EUR 18686 EN requires utility make available necessary input information concerning description of the component to be inspected, description of the type of defects to be detected, critical defect sizes for definition of inspection performance and "worst case concept".

6.5 If suitable test specimens are already available, EUR 18686 EN requires their verification.

6.6 For design of test specimens, EUR 18686 EN requires special attention that should be devoted to the similarity of the macrostructure and surface conditions of the qualification test samples.

6.7 EUR 18686 EN prescribes determination of number of defects to be introduced in the test specimens with consideration of defect sizes distribution.

6.8 EUR 18686 EN requires verification of defect implantation techniques.

6.9 According EUR 18686 EN a brief report containing the main conclusions of the quality checks should be included in the qualification dossier.

6.10 EUR 18686 EN together with EUR 17299 EN defines possibilities to conduct practical qualification as open or blind test specimen trials.

6.11 EUR 18686 EN specifies all aspects of confidentiality of test specimens.

Finnish requirements

6.1 The detection target for defects is specified in the input information that is prepared by the utility.

6.2 Possible defect types (based on experience and on theoretical studies) are specified in the input information.

6.3 The "worst case concept" is considered in the design of qualification specimens.

6.4 Critical defect sizes are presented in the input information.

6.5 If "old " test specimen are used their applicability has to be verified. In addition, it has to be assured that no advance information about the defects of test block used in qualification test is available to the inspectors participating the blind test.

6.6 The surface conditions of qualification test blocks should correspond the actual surface condition of the component to be inspected. From the inspection techniques point of view the macrostructure should correspond the macrostructure of the item to be inspected. This means e.g. that in ultrasonic testing the acoustic noise caused by grain boundaries should be similar.

6.7 Based on input information the Qualification Body specifies the qualification defect and target. The number and sizes of defects is considered. However, a statistically remarkable amount of defects is not normally required.

6.8 The main item to be considered is that the defects are representing real defects and can not be revealed by factors originating from the manufacturing technology (e.g. additional welds caused by implanting)

6.9 The qualification blocks are inspected by at least one member of the Qualification Body having EN 473 level 3 certification in the technique in question.

6.10 Normally, either blind or open test is performed. For qualification of procedure and equipment open or blind test can be used. Inspectors are always qualified by a blind test.

6.11 Test blocks are stored by SFS-Inspecta Certification. All the material concerning the test blocks is strictly confidential. The candidates participating the qualification examination are not allowed to take any notes with when leaving the examination facility.

6.12 Yes.

6.13 Yes, if such defects can be produced in test block.

6.14 Yes.

6.15 False call rate can't be assessed due to limited number of test blocks/defects.

German requirements

6.1 Yes, e.g. based on the tables 5.1 to 5.8 of KTA 3201.4
EUR 18686 EN

6.2 Yes, in KTA 3201.4, acceptance criteria
EUR 18686 EN

6.3 For all open trials special care is taken to realize worst case defects within the test blocks and to support this by modeling
EUR 18686 EN

6.4 Critical defect sizes are only taken into account during the definition of the acceptance criteria, but usually not for the design of test blocks, where one has to assure that the smallest possibly detectable defect is present. If very large defects may be missed during detection due to their special physical behaviour, this must be demonstrated at special blocks. Usually the ISI codes like ASME XI or KTA 3201.4 are reflecting those phenomena by the use of special techniques (e.g. Tandem Technique or high sensitivities like the 20% DAC of the ASME code)EUR 18686 EN

6.5 A collection list of test blocks available in Germany including the TEST RPV vessel at Stuttgart has been compiled by the VGB as a parallel action to the preparation of the VGB-ENIQ Guideline
EUR 18686 EN

6.6 Test blocks must correspond to the inspected object in coupling conditions, acoustic attenuation and elastic anisotropy and electric and magnetic behaviour (KTA 3201.4 and KTA 3201.3). This is also valid for all test blocks used for qualification purposes.
EUR 18686 EN

6.7 Yes
EUR 18686 EN

6.8 Special attention is paid to the manufacturing in order to reproduce the same physical interaction at the test reflector as the one used during the defect search and detection. E.g. diffraction effects at the defect border are considered. For ET all test defects have to be spark eroded with low currents and special electrodes.
EUR 18686 EN

6.9 Yes
EUR 18686 EN

6.10 Blind trials are in use only if the personnel influence is regarded as to be essential
EUR 18686 EN

6.11 The confidentiality is maintained only if a large number of similar test blocks are available, Otherwise confidentiality is an utopia.
EUR 18686 EN

7. Conduct of Qualification Specimen Trials

7.1	Does qualification body check that inspection personnel posses adequate qualifications and experience
7.2	Does qualification body check that equipment and probes to be used are the same as specified in the inspection procedure?
7.3	Is the secure area organized to conduct the trials
7.4	Are the qualification trials monitored by invigilation team
7.5	Are any deviations from inspection procedure recorded and their effect on trial results evaluated

European (ENIQ) requirements

7.1 and 7.2 Before start of specimen trials, according EUR 18686 EN qualification body should check inspection personnel qualifications and experience that should match requirements of inspection procedure. Additional check should be performed that equipment, probes, and other features used correspond to the features prescribed in the inspection procedure.

7.3 and 7.4 EUR 18686 EN requires two secure areas: one for inspectors carrying out practical trials and second for invigilation team that should monitor that procedure is followed accurately.

7.5 EUR 18686 EN prescribes that any departures from inspection procedure should be recorded and evaluated by the inspection team.

Finnish requirements

7.1 The certificates and experience of personnel is checked by Qualification Body.

7.2 Equipment and probes are checked and must be the same as used in the inspection.

7.3 The qualification trials are organized at SFS-Inspecta Certification in facilities that can not be entered by outsiders. If some test have to be performed at site the security will be separately checked.

7.4 A representative of Qualification Body is invigilating the trial.

7.5 In principle, no deviations from inspection procedure are allowed. If these occur they are recorded and justifications are required. If the deviations are well justified the procedure should be revised accordingly.

German requirements

7.1 Yes, since the requirements for ISI NDT personnel qualification are clearly defined in DIN 25435, 1 – 7
EUR 18686 EN

7.2 Yes
EUR 18686 EN

7.3 Yes but not for all cases of a qualification
EUR 18686 EN

7.4 Yes
EUR 18686 EN

7.5 Yes
EUR 18686 EN

8. Qualification Assessment Report

8.1	Does qualification body perform assessment of qualification results
8.2	Are the adequacy and restrictions of practical trials stated in assessment of qualification results
8.3	Are the deviations from qualification procedure stated in assessment of qualification results
8.4	Do qualification results show information consisting of detection rate, depth sizing, length sizing and false calls rate
8.5	Has Temelín NPP ever experienced negative results of NDE tests? What action is foreseen in such a case?

European (ENIQ) requirements

8.1 EUR 17299 EN and EUR 18685 EN require assessment of the qualification results by the qualification body.

8.2 and 8.3 Adequacy of the practical trials should be discussed in the assessment report. EUR 17299 EN and EUR 18685 EN prescribe that all restrictions and deviations from qualification procedure recorded.

8.4 The main objective by the EUR 17299 EN and EUR 18685 EN is to verify whether the inspection system is capable of meeting required detection, characterization and sizing as well as acceptable false calls rate.

Finnish requirements

8.1 Qualification Body evaluates the results of qualification trial and writes an evaluation report to be attached to the Qualification Dossier.

8.2 The adequacy and restrictions of practical trials are carefully assessed and reported.

8.3 All deviations from qualification procedure are reported and their effects are assessed.

8.4 Detection rate is normally not statistically assessed. The accuracy of defect sizing (depth, length) is assessed. False call rate is based on limited number of defects and is not statistically assessed.

German requirements

8.1 Yes
EUR 17299 EN
EUR 18685 EN

8.2 Yes
EUR 17299 EN
EUR 18685 EN

8.3 Yes
EUR 17299 EN
EUR 18685 EN

8.4 Depending on the goal of an inspection different priorities are given to the detection rate, the false call rate and the defect sizing
EUR 17299 EN
EUR 18685 EN

9. Qualification Certificate

9.1	Does qualification body issue a qualification certificate after successful completion of qualification
9.2	Does qualification certificate present information like list of qualified examiners, inspection procedures and equipment configuration
9.3	Is the qualification certificate time limited and valid under certain conditions

Finnish requirements

9.1 The Qualification Certificates are issued by SFS-Inspecta Certification.

9.2 The Qualification Certificate is issued separately for each inspector and contains e.g. the identifications of inspector, inspection procedure, equipment, scope of validity, reference to the qualification report etc.

9.3 The Qualification Certificate is valid for 5 years provided that :

- the certificate of the inspection company is valid
- the basic certification (EN473 level 2) is valid
- the inspector is regularly performing inspection work with the equipment and procedures used in ISI
- The inspector is annually participating in training organized for inspectors performing ISI

German requirements

9.1 Yes

9.2 The certificate is mostly limited to the special NDT technique and the equipment. The examiners are figuring only at the signature part of the certificate.

9.3 Usually time limited and linked according to EN 473 to the a continuous activity in the field.

Expected situation in Temelín

9.1 The qualification body issues a recommendation, the certification is issued by the plant owner. His certification must be based on the recommendation. (The plant want to have the control over the operators

9.2 Not the certificate, but the dossier contains those informations

9.3 The qualification for the procedure is not automatically expiring unless essential parameters are changed. The time limits of the qualification for the personal are regulated in compliance with EN473