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Inspection Qualification I

Overview of Inspection Qualification Activities in Slovakia

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ABSTRACT

In Service Inspection plays an important role in achieving safety of nuclear power plant. Inevitable requirement is to make NDT efficient and feasible. Inspection qualification is a way to achieve efficiency and feasibility of NDT inspection system.

For utilities with no or limited experience in inspection qualification it is important to adopt the methodology, which is well described and relatively easy to implement. The European methodology developed by ENIQ provides up to day know-how for systematic assessment of inspection system.

Slovenské elektrárne, a.s. have started the program of inspection qualification, based on European Methodology, in 2002. It was initiated by both the utility and the regulatory body requirement. It was also the initiative of the vendor of majority inspection activities, which was the part of the utility and which was interested in improving inspection efficiency.

In period of 2002 – 2007, the ambitious and generous inspection qualification programme has been completed. The subject of the programme was to qualify the set of procedures used for automated in-service inspection of the main components of primary circuit of VVER 440 by means of ultrasonic and eddy current methods.

In the presentation, the contents of qualification programme are presented, along with the overview of qualification targets. The lessons learned during the qualification exercises are also presented.

The qualification activities, from this moment on, will continue in two main streams: procedure qualification for areas not defined in the original programme, and the personnel qualification.

The personnel qualification is the logic continuation of inspection procedure qualification, since the qualified procedures have to be implemented by qualified personnel. In Central Europe region, it can be considered as a pioneering activity.

The presentation provides the basic information about the scope and way of planned personnel qualification.

INTRODUCTION OF SLOVENSKÉ ELEKTRÁRNE A.S.

Slovenské elektrárne are the main electricity producer in Slovakia. Enel is the majority owner of the company.

The Company operates four VVER 440 units. Another two VVER 440 units are in construction. Slovenské elektrárne provide maintenance and inspection services to JAVYS, the state owned utility, which operates two VVER 440 units.

The similarity of design of all VVER units operated in Slovakia allows high level of unification of technical and personnel resources.

INITIAL STEPS TOWARDS INSPECTION QUALIFICATION

It was the requirement of the regulatory body to control the quality of in-service inspection by means of inspection qualification. The safety guideline BNS II.5.4/2004 Qualification of Systems for Non-Destructive Testing in Nuclear Power Industry was drafted in 2001 and final edition was issued in 2004.

This document of the regulatory body follows the recommendations of Methodology for Qualification of In-Service Inspection Systems for WWER Nuclear Power Plants, IAEA, 1998.

The qualification body, called KOSENDT, was established on April 3, 2002, and has acted as the administrator for the qualification of NDT systems in nuclear power industry. It introduces unified qualification for NPP's in the Slovak Republic.

KOSENDT meets the independence criteria equivalent to those specified in EN 45004 for a type B inspection body.

The quality system of KOSENDT has been approved by the Nuclear Regulatory Authority of the Slovak Republic (ÚJD SR).

QUALIFICATION APPROACH

Since Slovenské elektrárne entered ENIQ in 1998, the company has been familiar with the European Methodology.

The remarkable progress in application of the methodology was obtained during Phare projects 1.02/95 and 1.02/97, dedicated to qualification of inspection on primary circuit components.

Considering the existing knowledge, it was obvious that the European methodology would be adopted as the working tool.

The main characteristics of working approach, when qualifying inspection procedure, is the use of open trial and technical justification to approve that inspection targets are met.

QUALIFICATION COMMITTEE

Qualification committee is an expert group established by KOSENDT to assess certain qualification cases.

It is tailored and set up for each qualification case separately, considering members' expertise. However, it is usual, for similar qualification cases, to set up the committee from members who have the previous experience with inspection procedure and inspection system being qualified.

The chairman of the committee has always been selected to be completely independent of inspection vendor and has been often an expert from abroad.

IMPLEMENTATION OF QUALIFICATION

Plan

The qualification plan has been established in 2004 and had to be finalized in 2007. For this stage, the objects of qualification have been the inspection procedures.

Inspection areas

The qualification scope covers the main primary circuit components. The respective inspection areas of components have been selected with regard to estimated safety importance level. Due to easier definition of essential parameters, only automated UT and ET inspections have been subject to qualification. The examination areas, for which inspection procedure has been qualified, are listed in table 1 below

Table 1 - List of qualification areas

Reactor	Circumferential welds of pressure vessel	UT, inside, outside
	Circumferential weld of the reactor cap	UT, outside
	Nozzle inner radius	UT, inside
	Nozzle dissimilar weld	UT, inside, outside
	Nozzle weld to pipe	UT, inside, outside
	Emergency cooling nozzle dissimilar weld	UT, outside
	Flange threaded hole M140	ET
Primary piping	Main primary piping circumferential welds	UT
	Pressurizer piping /surge lines/ welds	UT
Pressurizer	Dissimilar weld on lower nozzle	UT
Steam generator	Primary collector dissimilar weld	UT
	Primary collector austenitic welds	UT
	Primary collector flange threaded hole	UT, ET
	Primary collector bolts	UT, ET
	Heat exchanger tubes	ET

Qualification elements

The inspection procedure is assessed in terms of its unambiguousness, straight forwardness and whether it describes all necessary parameters of inspection.

The technical justification is checked whether it comprises all evidence necessary to prove that the inspection is capable to meet inspection targets.

During the open trial, the commission observes whether the team follows the inspection procedure, as well as if the result of the inspection is within the acceptable tolerance.

In certain qualification cases, it was not necessary to perform the open trial. As an example, we can introduce the case of UT examination of reactor pressure vessel on outside surface. The first qualification of this area considered the inspection with unlimited access to the weld. During the second qualification, all necessary evidence to convince that inspection will be capable even with defined access limits, was within the technical justification. Further practical trials were not necessary anymore.

Inspection targets

European methodology assumes that the role of inspection is to detect the defects, which could be critical in term of structural integrity. Therefore the inspection sensitivity should be derived from the calculated critical defects and should address the damage mechanism concerned.

The inspection usually cannot detect the defects with dimensions that are too much below acceptance limits without spoiling the false call rate. This is very obvious when inspecting the austenitic or dissimilar welds. Depending on the weld structure, the inspection sensitivity is more or less limited. It is difficult to reach sensitivity of detection and accuracy of sizing so that defect acceptance limits calculated in conservative way can be met.

Previously, we used the acceptance limits for austenitic piping with values approximately corresponding with ASME XI IWB 3514 /TWE appr. 10-12% of wall thickness/. Since these values could not be used as inspection targets, the calculation using more accurate approach had to be done. The values obtained, which have been used as criterion for 100% reliability of detection, finally were between 14-25% wall thickness, depending on wall thickness and location of the weld.

OVERVIEW OF INSPECTION SYSTEMS

In table 2 below, the main parts of inspection systems qualified is listed.

Table 2 - Overview of inspection systems

Reactor	All UT inspections performed from inside surface	Saphir Phase array system, ZMM manipulator
	All UT inspections performed from outside surface	P-Scan system 4, USK 213 manipulator/ upgraded/, set of magnetic wheel scanners
	Flange threaded hole M140, ET inspection	Handheld manipulator, TC 6700
Primary piping	Main primary piping circumferential welds	P-Scan system 4, set of pipe scanners
	Pressurizer piping / surge lines / welds	
Pressurizer	Dissimilar weld on lower nozzle	
Steam generator	Primary collector dissimilar weld	
	Primary collector austenitic welds, UT	P-Scan system 4, AMS-6 multi axis scanner
	Primary collector flange threaded hole, UT	
	Primary collector flange threaded hole, ET	TC 6700, DIZAP manipulator
	Heat exchanger tubes	TC 6700, ZOK-PG manipulator

OVERVIEW OF EXPERIMENTAL EVIDENCE

Testblocks

The main part of our experimental evidence has been obtained on testblocks. Up to 25 different testblocks with welds have been available up to know. Most of them are in the ownership of Slovenské elektrárne or in co-ownership with other VVER utilities. The rest of testblocks have been hired for the period of qualification. Testblocks are usually 1:1 mockups. Some of the testblocks are of simplified geometry. For elementary experiments, small simplified testpieces are often used.

Testblocks and testpieces contain defects. At present, majority of defects in our testblocks are artificially created. /EDM, SE, PISC-A etc/. For most of qualifications, certain percentage /10-30%/ of defects used are realistic. /SCC, FAT/. Real defects /pieces removed from plants/ are very rare. However, they are used to obtain experimental data whenever available.

All of the mentioned testblock are dedicated to open trials. Testblocks dedicated to blind trials will be available for personnel qualification.

The table 3 below comprises testblocks, testpieces and defects used to obtain experimental evidence for certain inspection areas.

Table 3 - Overview of testblocks, testpieces and defects

Inspection area	Number of testblocks and testpieces	Artificial defects	Real & realistic defects
Austenitic piping welds	5	40	12
Dissimilar metal welds	6	77	9
Steam generator collector flange	5	25	6
Steam generator collector welds and base material	4	31	6
RPV circumferential welds	3	51	7
SG heat exchanger tubes	96 tubes	61 tubes per 1-2 defects	35 tubes per 1-2 defects

Optimization of inspection techniques

Based on the operational experience gained during the outages and from experimental evidence presented above, the examination techniques had been optimized long time before the qualification had to take place.

For lot of qualifications, the great part of evidencing material had been collected before qualification process started.

Blind trials

The blind trial is a great opportunity for testing overall inspection system capabilities, including personnel. We have taken the opportunity to take part in a blind trial within NESC III project, as a part of our preparation for qualification of dissimilar metal weld testing.

The brief results of our team can be described as follows: excellent detection and false call rate, excellent length sizing, average or poor TWE sizing. The result was not surprising at all. It was shown, during the qualifications followed after NESC III, that TWE sizing on austenitic and dissimilar weld was the most difficult problem.

USE OF MODELLING

The software platform CIVA 7.1 and CIVA 8.0, since 2007, has been used to simulate some testing situation in order to fill in the gap in experimental and theoretical evidence. However, up to now, only small part of the product capabilities has been used, i.e. only the simulation of ultrasonic inspection of isotropic materials with simplified shape of reflectors.

Since the model contained only simplified shape reflectors on simplified testpiece, the predictions were not accurate enough. However, some useful results have been obtained mainly for the assessment of defects missorientation and its influence on the detection.

Qualitative predictions are much easier to get rather than quantitative predictions and they can be used as a tool for inspection data interpretation.

LESSONS LEARNED

General issues

Technical specification and its most important part – inspection targets are very essential for successfull qualification. It must be designed as a compromise between demands on integrity issues and inspection possibilities. If this compromise cannot be found, the inspection has no sense.

The qualified procedure is much easier and faster to apply in the field, rather than unqualified.

Technical issues

Our inspection system is capable to detect defects and avoid false calls according to technical specifications, with great safety reserve. There are two exceptions, where the reserve is not as big: this is detection on heavy wall dissimilar welds and detection of skewed flaws /typically over 10°/. Both effects could be predicted and thus improved by means of modelling. Modelling of responses of missoriented defects is quite feasible and can bring usefull feedback to inspection procedure. Modelling of ultrasound beam behaviour in anizotropic material will probably soon be feasible, using latest models.

TWE sizing on austenitic and dissimilar weld, using our procedures, meets the requirement. However, the scatter of results should be reduced.

OVERVIEW OF FUTURE ACTIVITIES

Inspection areas and inspection problems not addressed in the original qualification plan will be dealt with in the future, i.e.

- Pipe to pipe corner welds
- Small diameter austenitic welds
- Welds on ferritic piping of steam lines etc.
- Austenitic welds – transverse defects

Some techniques, regularly used for several years, have not been qualified yet, for example ET inspection of surfaces.

Based on the experience with application of inspection procedures, which have been already qualified, they will be continuously optimized, and re-qualified, if necessary.

The advanced techniques, rarely used up to now or just in lab trials, promise great potential, i.e.

- UT Phase array detection and sizing
- ET Pipe and surface multi-coil inspection

All of above items are already dealt with and are being prepared for industrial application at Slovenské elektrárne.

PERSONNEL QUALIFICATION

Besides the qualification according to EN473 standard, the personnel will be qualified for application of the inspection procedures, which have been already qualified in terms of European Methodology. The personnel qualification was determined mandatory by the regulatory body.

Our main activities in this area started in 2006.

The Guideline and principles

The guideline is a working document and has been drafted in 2006. It describes the main principles of personnel qualification. It should be based on the examination of testblock with defects. The examination should be either performed by evaluating inspection data, which have to be collected in advance, or by full examination of testblock, including data acquisition.

In order to avoid the necessity of separate qualification for each inspection area configuration, the inspection areas will be grouped into the so called „families", representing certain range of inspection problems. The qualification will be performed based on these families.

The testblocks or data used will be strictly maintained blind. Since there are no suitable blind testblocks available, Slovenské elektrárne will procure one or more testblock for each inspection family.

ENIQ activity in personnel qualification

Slovenské elektrárne proposed ENIQ /European Network for Inspection and Qualification/ to deal with personnel qualification. The idea was accepted, and supported by certain interest of GAIN project respondents, regarding human factors. The discussion about personnel qualification within ENIQ has started, and the ENIQ draft of the guideline for personnel qualification is just being prepared.

The 1st case on personnel qualification

The first qualification was executed at the beginning of 2007. The inspection problem selected was the ET of steam generator heat exchanger tubes. We used the advantage of our ownership of a set of tubes with realistic defects and real data, which are easy to handle as blind. The first personnel qualification had the nature of a „Pilot Qualification". It means that the outcome was not just qualifying personnel, but gaining experience for the next qualifications as well.