Seminar 2
Nuclear Installation Safety
Research

QUALIFICATION OF NON-DESTRUCTIVE EXAMINATION METHODS ON CRITICAL COMPONENTS

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Abstract: Czech Dukovany and Temelín Nuclear Power Plants face a challenge to improve and optimise their in-service inspection programmes based on requirements of the Czech law No. 18/97 and the Decree 214/97. As priorities for new inspection programmes of critical components are considered inspection intervals that ought to be prolonged up to eight years, application of qualified NDT methods and techniques and to identify inspection areas that are not covered by the current ISI programmes. This approach is based on a detailed review of ISI programmes available, application of recent structural integrity assessments and programme of in-service inspection qualifications in compliance with ENIQ and IEAE methodologies. Approaches used by Dukovany and Temelin NPP are similar for qualifications of inspection procedures that are expected to be used for selected RPV inspection areas as nozzle inner radii, safe-end (or nozzle to MCP homogenous weld) and circumferential RPV shell welds, required by the Czech Regulatory Authority in compliance with the Decree 214/97 to be completed till the end of the year 2002. A review of all NDT qualification projects including PHARE projects completed or at least started in Czech Republic is given in the paper with more detailed explanation for some of them as examples. Described in detail are PHARE project 4.1.2/93 and PHARE project 1.02/95 and one national project devoted to WWER 440 circumferential RPV shell weld qualification (1999-2000).

Introduction

Czech Nuclear Power Plants Dukovany NPP with four Units of WWER 440 Type Reactors and Temelin NPP with two WWER 1000 Units in construction face a challenge to improve and optimise their in-service inspection programmes based on requirements and responsibilities written in the Czech law No. 18/97 (so called „Atomic law") and the Decree 214/97. Temelin NPP has a unique opportunity to change and supplement not only the in-service inspection programme, but pre-service inspection programme, as well. The above changes are monitored and supported by the Czech Regulatory Authority (State Office for Nuclear Safety SONS).

Priorities for new inspection requirements taking into account current four year prescribed inspection intervals, new inspection areas not covered by the current ISI programme are based on:

1. a detailed check of ISI programmes available
2. recent structural integrity assessment
3. in-service inspection qualification in compliance with ENIQ and IAEA methodologies and recommendations [1],[2]. Examples of new inspection areas required and suggested for prolonged inspection intervals are given in detail in this contribution.

Approaches for improvement and optimisation of inspection programmes used by Dukovany and Temelin NPP are based on application of advanced/modernised NDT systems and qualifications of inspection procedures that are expected to used for selected RPV inspection areas as nozzle inner radii, safe-end (or nozzle to MCP homogenous weld) and circumferential RPV shell welds.
These NDT qualifications of inspection procedures and applied equipment required by the Czech Regulatory Authority in compliance with the Decree 214/97 shall be completed till 2002.

A review of NDT qualification projects including PHARE projects

A review of NDT qualification projects completed or at least started including PHARE projects is given in the following 3 tables.

WWER 440 and WWER 1000 RPV Inspection Areas (see [3])			
Inspection Area	Test Assembly Manufacture	TJ completion	Practical Trials performance
WWER 440 RPV shell weld	In December 2000	in September 2001	open trials in January or February 2002
WWER 440 RPV nozzle inner radius of 500 mm diam.	PHARE 4.1.2/93 September 1997	assumed in February 2002	open trials assumed in May 2002
WWER 440 RPV safe-end weld	PHARE 4.1.2/93 September 1997	assumed in February 2002	open trials assumed in May 2002
WWER 1000 nozzle inner radius of 850 mm diameter	PHARE 4.1.2/93 September 1997	assumed in November 2002	open trials after TJ completion
Homogeneous circumferential weld of WWER 1000 primary piping of 850 mm diameter	PHARE 4.1.2/93 September 1997	assumed in May 2002	open trials assumed in August 2002
WWER 1000 RPV shell weld	Assumed in Summer 2002	assumed in November 2002	open trials after TJ completion
WWER 440 Primary Circuit Critical Inspection Areas Other than RPV (see [4], [5], [6])			
Inspection Area	Test Assembly Manufacture	TJ completion	Practical Trials simulation
WWER 440 245/500 mm diameter nozzle	PHARE 1.02/94 Spring 1998	PHARE 1.02/94 December 1998	PHARE 1.02/94 December 1998
WWER 440 108/500 mm diameter nozzle	PHARE 1.02/94 Spring 1998	PHARE 1.02/94 December 1998	PHARE 1.02/94 December 1998
WWER 440 steam generator collector dissimilar weld	PHARE 1.02/94 Summer 1998	PHARE 1.02/94 December 1998	PHARE 1.02/94 December 1998
WWER 440 MCP to reducer circumferential weld	PHARE 1.02/94 Autumn 1998	PHARE 1.02/94 December 1998	PHARE 1.02/94 December 1998
WWER 440 primary piping to reducer circumferential weld	PHARE 1.02/94 Autumn 1998	PHARE 1.02/94 December 1998	PHARE 1.02/94 December 1998
WWER 440 steam generator collector thread holes	PHARE 1.02/95 Spring 2001	PHARE 1.02/95 spring 2001 (for UT,ET)	PHARE 1.02/95 summer 2001 (for UT,ET)
WWER 440 steam generator collector thread holes	PHARE 1.02/95 Spring 2001	assumed in spring 2002 for ET	suggested in spring 2002 for ET
WWER 440 MCP elbow – longitudinal welds (intrados, extrados)	PHARE 1.07/97A Winter 2001	assumed in late spring 2002 for UT	suggested in late spring 2002 for UT
WWER 440 pressuriser dissimilar weld	PHARE 1.07/97A Winter 2001	assumed in late spring 2002 for UT	suggested in late spring 2002 for UT

WWER 1000 Primary Circuit Critical Inspection Areas other than RPV			
Inspection Area	Test Assembly Manufacture	TJ completion	Practical Trials Performance
WWER 1000 steam piping of 630 mm OD – circumferetial and fixing plates fillet welds	Autumn 2001	assumed in winter 2001	assumed in spring 2002
WWER 1000 water supply piping of 426 mm OD – circumferetial and fixing plates fillet welds	Autumn 2001	assumed in winter 2001	assumed in spring 2002

Progress in WWER 440 type RPV qualification

Role of the project PHARE 4.1.2/93

PHARE 93 regional project 4.1.2 "WWER 440-213 in service inspection" (1) focused on the reactor pressure vessel can be regarded as a basis for mechanized UT qualifications of WWER 440 type RPV inspection areas mentioned above.

In the frame of the PHARE project 4.1.2/93 three test assemblies were manufactured. This set of WWER type RPV blocks supplemented with test pieces representing RPV butt welds with cladding seems to be sufficient representatives of one of the most important components of NPP.

The mentioned three test assemblies with intended defects cover:

- WWER 440 RPV nozzle inner radius of 500 mm diameter with safe-end dissimilar weld.
- WWER 1000 nozzle inner radius of 850 mm diameter.
- Homogeneous weld of primary piping of 850 mm diameter.

The project based on the TOR was not focused on a detailed technical justification (TJ) for this specific WWER type RPV inspection area. The project covered the TJ parts as physical reasoning and experience gained in PISC and other international RRT projects with a special emphasis on necessary items for the design of the above three test assemblies. The data package covering the manufacturing process of the above test assemblies, technology and geometrical details including a full information about the defects is of a high value. The data package is expected to be applied as a part of TJ and appropriate qualification dossier.

WWER 440 Type RPV Butt Weld Test Assembly

As a part of the PHARE project 4.1.2/93 the first draft of test assemblies for WWER 440 and WWER 1000 type RPV butt welds with intended defects were designed. Based on this draft drawings of test assembly Nuclear Research Institute REZ, division of integrity and technical engineering and SKODA JS a.s. (SKODA Nuclear Machinery) developed a new test assembly with intended defects in the frame of national UT qualification project sponsored by the Czech Republic government and both companies. The intended defects designed and manufactured in the test assembly for mechanised UT in-service inspections of WWER 440 type RPV butt welds, parent base metal and cladding performed from inner and outer wall surface are summarised in the Table 1.

Table 1: Defects in the Test Assembly for Open Practical Trials for WWER 440 Type RPV Shell Welds Qualification

Defect Description	Number of defects	TWE defect height (mm)	Defect Length	Defect Simulation Type
Underclad Crack Simulations Outside the Weld	6	5-15	15-36	PISC type A
Simulations of Crack in the Weld Central Line	9	5-15	15-30	PISC type A and LOF
Simulation of Lack of Fusion	4	5-15	30	LOF
Simulation of Other Crack	2	5	15	PISC type A
Technological notches	2	15	20	LOF

The dimensions of the test assembly for open practical trials for WWER 440 type RPV butt welds qualification are 1450 x 790 x 140 mm. A phase of the manufacture of PISC type A defects at NRI REZ and a mechanised UT examination of the test assembly can be seen on photos (see Fig.l and Fig. 2).

Fig. 1 - A phase of the manufacture of PISC type A defects into the WER 440 type RPV butt weld test assembly for open UT practical qualification trials

Fig. 2 - WWER 440 type RPV butt weld test assembly for open practical trials for UT qualification (dimensions 1450 x 790 x 140 mm)

Within the above mentioned national project:

- the test assembly for WWER 440 type RPV shell weld with intended defects was manufactured,
- inspection procedures were optimised during open laboratory trials on the test assembly
- major part of technical justification for pulse echo and TOFD techniques were written.

Progress in WWER 440 type SG collector thread holes qualification

The projects devoted to SG collector thread holes qualification are closely connected with the latest PHARE project named „In service inspection of Steam Generator tubes/collector junction". Objectives of the project can be shortly outlined as fabrication of calibration and qualification test assemblies with intended defects (see Fig.3 and Fig.4), Round Robin Test for EC and UT techniques performed on the above blind test assemblies with realistic SCC

and PISC type defects and qualification of appropriate EC and UT mechanized inspection procedures

Fig. 3 - WWER 440 type SG collector thread holes test assembly with intended IGSCC type defects and EDM notches for open practical trials for UT and ET qualification

Fig. 4 – Simulation of qualification for WWER 440 type SG collector thread holes ET examinations performed on test assembly with intended IGSCC and EDM type defects

The project PHARE 1.02/95 is concentrated on the area of upper part of steam generator collector with the thread holes zone. The qualification simulation of EC and UT procedures was based on technical justification and laboratory optimisation and practical trials supplemented with destructive examinations as a part of required evidence. Transfer of SCC type defects manufacturing know how should be a substantial advantage for the fabrication of test blocks with SCC type of defects. The project was finished in June 2001.

Conclusions

Czech Nuclear Power Plants Dukovany and Temelin face a challenge to improve and optimise their in-service inspection programmes based on NDT qualification programmes in compliance with requirements of the Czech law No. 18/97 and the Decree 214/97.
Priorities for the improvement and optimisation of inspection programmes are:

- Inspection intervals prolonged from four to eight years for selected inspections of primary circuit components as RPV (UT inspections from inner wall surface), steam generator, pressurizer a selected piping systems.
- To justify inspection areas not covered by the current ISI programmes.
- To complete in compliance with requirements of the Decree 214/97 substantial part of UT qualification for mechanized inspection procedures for selected RPV inspection areas as nozzle inner radii, safe-end (or nozzle to MCP homogenous weld) and circumferential RPV shell welds till the end of 2002.

REFERENCES

[1] European methodology for qualification of non-destructive tests: second issue, Lemaitre P., Editor, published by the European Commission, Brussels-Luxembourg, EUR 17299 EN, 1997

[2] Methodology for Qualification of In-Service Inspection Systems for WWER Nuiclear Power Plants, IAEA-EBP-WWER-11, March 1998

[3] PHARE 93/4.1.2 VVER 440-213 In-Service Inspection, completed July 1997

[4] PHARE 1.02/94, "Technical justification for the 5 inspection areas of PH 1.02/94", February 1998

[5] PHARE 1.02/95, “In service inspection of Steam Generator tubes/collector junction", completed June 2001

[6] PHARE 1.07/97A, “In service inspection of In-service Inspection of Primary Components”, started in January 2001