Improvement of NDT Methodologies for in-service inspection (ISI) of NPP Safety Important Components based on advanced modern approaches and improved international practices

Description

Background
Ukraine operates 15 nuclear power units at four different sites: two units with VVER-440/V-213 reactors, the rest – with VVER-1000/V-320 reactors except for two earlier models (V-302 and V-338). These units were commissioned between 1981 and 2004, their installed capacity is 13,800 MW.

Currently the energy sector of Ukraine undergoes quick development. Ukraine has announced its intent to construct new units for replacement of those approaching the lifetime expiration, and to increase the nuclear power generation to 20 GW by 2030. The SE NNEGCEnergoatom has declared the following important objectives:

- Enhancement of the NPP safety;
- Lifetime management of the NPP units;
- Improvement of the NPP operational reliability and economic efficiency;
- Construction of new facilities;
- Preparation of the units for decommissioning and final disposal of radioactive waste;
- Development of social programmes.

Objectives
The overall objective of the project is the safety enhancement of Ukrainian NPPs by implementation of improved safety management practices in the area of non-destructive testing and preventive maintenance of the systems and components important to safety. The specific objectives of this project consist in development of recommendations and industry programmes for the improvement of quality and credibility of the non-destructive testing systems for the inspection of NPP systems and components important to safety, development of the industry documentation necessary for improvement of NDT of reactor pressure vessel welds, steam generator heat exchanger tubes, piping welds and predictive integrity assessment of pipelines containing two phase (steam water) medium as well as training and know how transfer to the Ukrainian NPP personnel.

Project Results
The project was launched, November 22, 2010 and ended November 21, 2013. The parties of the Consortium were: RE GmbH, RWE Power AG, Westinghouse Europe and NDEF. Rovno NPP was chosen as pilot plant for this project, whereas the remaining Ukrainian NPPs (Zaporozhye, South-Ukraine and Khmelnitsky) were involved actively in the project implementation. The regulator SNRIU was invited as observer to participate in the workshops
and project meetings.

The Kick-off meeting took place at Rovno NPP, February 09, 2011. Here, the arrangements of working groups and the plan of realization were accepted. The first workshop was performed at Rovno NPP, 3 months after the Kick-off meeting. The project realization was developed and performed in the following order (according to the ToR) within 3 years:

- Evaluation of the presented Ukrainian NDT/NDE status information;
- Comparison and presentation of Western NDT methods and derived recommendations for NDT/NDE improvements in the Ukraine;
- During 4 Study tours, presentation of Western NDT/NDE performances with hot knowledge tests;
- Development of procedures and its environment of NDT according to ENIQ;
- Presentation of the state-of-the-art NDT/NDE during a 14 days Workshop at RNPP;
- Presentation of the developed NDT procedures and final NDT Training manuals during the Dissemination meeting.

**Task 1: Organization of the NDT project;**
The project was well organized by the Consortium leader and well supported by the Rovno NPP and Energoatom.

In total, 120 documents (reports, presentations and procedures, training documents) were developed, translated and given to the End-User.

19 meetings/workshops took place including: 4 for the Consortium, 6 for the project working groups, 5 for Study/training tours, 2 for EC workshops and 2 for Kick-off/Dissemination.

**Task 2: Elaboration of recommendations for NDE improvements of Digital Radiography, Tightness Monitoring, Acoustic Emission Monitoring, Improved calculation of defect sizes, Ultrasonic testing (UT) and Eddy Current testing (ECT)**

This task has been divided into several sub tasks according to the branch of the applied NDT/NDE techniques and monitoring methods. All results and recommendations were discussed with Rovno NPP and applied during the development of procedures under the tasks 1 - 7.

**Task 3: Elaboration of recommendations for analysis of NDE results and calculation defect size**
The consultant performed a review of international methods and a comparative analysis of up-to-date International and Ukrainian good practices for the methods of calculations of the critical defect sizes, and crack growth rates depending on active degradation mechanism. How to perform analysis for critical defect sizes and the approach for continuous operation was presented and trained. The performances and ways of calculations were part of the tasks 4 – 6 (set into practice).

**Task 4: Improvement of the RNPP-VVER-1000 RPV ISI using the automated inspection systems.**
The consultant and the End-user had agreed in a separate document the appropriate testing areas, achievable detection targets, testing techniques and calculation of critical defect size. The development of the task 4 and 6 procedures, etc., annexes and appendices followed those agreements. The task 4 report closed with a guideline for continuous operation with NDT results based on task 3 results.

**Task 5: Improvement of the inspection of the RNPP Steam generator heat exchanger tubes of the VVER-1000 using the automated inspection systems;**
The consultant performed laboratory research on eddy current inspection of VVER SG tubes
using analyse probes and prepared the draft Inspection Procedure and Technical Justification for the improvement of NDT with the Analysis Probes. The task 5 report closed with a guideline how to deal with the results of analysis probes and examination for continuous operation with NDT results.

**Task 6: Improvement of the manual RNPP UT of a dissimilar metal weld and austenite weld;**

The appropriate testing areas, etc. were defined as mentioned under task 4. The general way of the development of procedures is the same as done under task 4. The task 6 report also closed with a guideline for continuous operation with NDT results based on task 3 results.

**Task 7: NDE Study tours and Training**

According to the NDT-Contract, four Study tours in the EC Country had been performed, and a 14 days training workshop took place with the nominated Beneficiary and Authority experts as planned. At the end of each session a “hot knowledge test” was performed and certificates were issued to the participants.

**Task 8: Final workshop, dissemination of NDT project results**

During the performances of meetings and workshops with participation of non-key plant experts, the consultant could conclude that an effective experience exchange (dissemination of project results) had been established.

The Consultant presented the essential results of the NDT-project to the End-user and to the non-key plant experts in final dissemination meeting.

According to Energoatom’s presentation during the Dissemination meeting, all objectives established in the ToR and subsequently ascertained at the meetings, have been achieved. In the following, the SNRIU representative stated, as an observer in the project and in related workshops with active participation, the study tours were seen as very positive and enhance the information exchange between plant, Energoatom and SNRIU in this matter.

Also, a very good feedback was given by the participants of the study tours regarding the written test at the end of the training/study tour sessions.

The Beneficiary underlined that

- results of laboratory research made on heat exchanger tubes using analysis probes and rotating probes, had never been available for Ukrainian NPP specialists, except for short presentations. But now an excellent information basis exists;
- meanwhile, defect calculations have been made for detection purposes and for detected defect assessment curves, and now the calculation results have been used for the development of procedures;
- other implementation of NDT project results are in place or in progress:
  - ToR for additional qualification of a UT system for RPV - SAPHIRplus-ADVANCED has been developed and endorsed by SNRIU (calculation results were used);
  - Technical requirements (TR) for blind RPV specimens have been developed and endorsed by Attestation Authority;
  - Methodology of UT with sizing (on analysis at the Swedish RA) has been developed;
  - TR for blind test specimens (for the Attestation Authority) are being developed;
  - The Terms of Reference, for modernisation of the RNPP Steam generator heat exchanger tubes eddy current testing system, has been revised based on recommendations of the Consortium experts and approved by NNEGC.
  - The Technical justification has been prepared for equipment selection for the tightness
monitoring and humidity measurement in the inspection of a container for spent nuclear fuel (the selected equipment is proposed for inclusion in the request for 2013 – no funding is available);

- Many NDT data and documents are being collected for the development of NDT instructions for detection and sizing of discontinuity flaws in NPP equipment components and pipelines;
- Also, mechanisation of the manual ultrasound testing has started, and a model of manipulator is under development. The conceptual software has been developed and also, the analytical software is under development (to date: data presentation, construction of A, B, C scans).

On 7 December 2013, all agreed and produced deliveries by the consultant were handed over on CD ROMs to RNPP.
The objectives of the project, enhancement of nuclear safety and transfer of knowledge were fully achieved.

Appendix 1: Main components which were chosen for the development of NDT procedures according to ENIQ (see attachment)