ABSTRACT

Assistance and cooperation programmes of the European Commission for Russian designed Nuclear Power Reactors have been established since 1991 through the TACIS and PHARE programmes. The TACIS and PHARE nuclear safety programme have been focused on reactor safety issues, contributing to the improvement in the safety of Russian designed reactors and providing technology and safety culture transfer.

The main parts of these programmes are related to the On-Site Assistance and to the Design Safety of VVER and RBMK Nuclear Power Plants where In-Service Inspection of the primary circuit components is addressed.

This paper gives an update of the TACIS and PHARE projects dealing with In-Service Inspection of VVER and RBMK Nuclear Power Plants, such as qualification of In-Service Inspection for Russian designed Nuclear Power Plants and In-Service Inspection upgraded equipment for RBMK fuel channels and VVER reactor pressure vessel. It details the main objectives and the results obtained.

INTRODUCTION

Nuclear safety assistance from the European Commission to Nuclear Power Plants of Russian design has been established through the TACIS and PHARE programmes, and has been focused on reactor safety issues, contributing to the improvement in the nuclear safety and providing technology and safety culture transfer.

The TACIS and PHARE projects dealing with the In-Service Inspection of VVER and RBMK Nuclear Power Plants comprise the Qualification of In-Service Inspection methods and the improvement of In-Service Inspection tools for primary circuit components.

IN-SERVICE INSPECTION QUALIFICATION

Several PHARE and TACIS projects had the objective to set up the basis for the qualification of the In-Service Inspection of Russian designed Power Reactors.

In-service Inspection Qualification in PHARE Nuclear Safety

An important effort was carried out to implement In-Service Inspection qualification through the PHARE nuclear safety programme in Central European Countries, concerning the In-service Inspection of the reactor pressure vessel and other primary circuit main welds.

The achievement of a level of quality and effectiveness of In-Service Inspection of VVER 440-213 primary circuit components equivalent to the level of European Union practice has been carried out in applying the ENIQ (European Network for Inspection Qualification) methodology.

The efficiency of NDT (Non Destructive Testing) procedure able to be used for In-Service Inspection of Reactor Pressure Vessel (RPV) components was evaluated based on an improved In-Service Inspection programme. This included identification and selection of the procedures to be evaluated and identification of the essential variables of those procedures. Samples representative of RPV areas subject to In-Service Inspection were defined as well as the rules to evaluate and later qualify NDT methods, materials and operators. Size and shape of the samples for each selected area were determined as well as number, type, location, size, orientation of the flaws to be implanted. Finally the test samples were procured after qualification of the suppliers of sample material and
flaws, and the personnel required for evaluation of the results underwent a qualification process. For evaluation, the rules consisted on the establishment of the data for the exercises (type of flaws, blind test and or technical justification), method of evaluation (ratio of detection, false calls), complete knowledge of the samples in determining the actual flaws by destructive tests or through partial investigation and non destructive testing.

The completion of the In-Service Inspection qualification programme for primary circuit components other than the reactor pressure vessel consisted in the improvement of In-Service Inspection for the following selected inspection areas: pressurizer pipe to main circulation pipe, safety cooling pipe to main circulation pipe, steam generator transition weld, steam generator: feed water nozzle transition weld, main circulation pump inlet circumferential weld, main circulation pump shell to elbow weld, longitudinal weld of the main circulation pump elbow, pressurizer nozzle to transition nozzle dissimilar weld. This included the following phases: comparison and evaluation of In-Service Inspection effectiveness, supply of test blocks, of inspection equipment and of inspection procedures, definition of training requirements, definition and performance of inspection qualification, evaluation of the improved In-Service Inspection.

The improvement of the In-Service Inspection programme of the steam generator collector has been based on a Round Robin Test (RRT) and the preparation of NDT qualification for this type of inspection. Corrosion cracks damage of VVER steam generator collectors occurs in the shell and especially threaded flange region. The scope of concerned In-Service Inspections was limited to the area of threaded flange and collector shell. The assessment of the methodology used to inspect the threaded flange and collector flange included the selection of available steam generator collector with real cracks, the performance of RRT with international participation, the assessment of RRT results and the elaboration of procedures for the In-Service Inspection qualification process for steam generator collector.

In-service Inspection Qualification in TACIS Nuclear Safety

Several TACIS projects were implemented to assess the In-Service Inspection of Russian and Ukrainian Nuclear Power Plants (NPPs), to provide NDT training and guidelines for In Service Inspection qualification.

An important project has been carried out to strengthen the Russian Regulator and its Technical Support Organization in the field of In-Service Inspection of NPPs and its qualification. It included the following activities: assessment of Russian In-Service Inspection concept for meeting structural integrity requirements for VVER and RBMK NPPs, identification and familiarisation with Western NDT equipment using digital flaw detection technology, and assistance to the Russian Regulatory Body in evaluating current inspection qualification systems by applying suitable features of the ENIQ (European Network for Inspection Qualification) approach.

Another important project was devoted in Ukraine for the implementation of a specialised Centre for training, qualification and certification of all personnel in charge of the In-Service Inspection of Nuclear Power Plants. This Centre has been organised in order to perform any activity related to training, qualification and certification, concerning all types of NDT methods applied in Nuclear Power Industry. This concerns not only basic theoretical and practical training, qualification and certification of personnel in NDT, but also qualifications related to the application at the NPPs of specific NDT procedures. This project defined the structure of the Centre and provided it with programmes, necessary documentation and basic equipment related to the most commonly applied NDT: Ultrasonic Testing, Eddy Current Testing, Radiography, Penetrant Testing, Magnetic Testing and Visual Testing. The training and qualification have focused on the In-Service Inspection of primary circuit equipment and piping.
SUPPLY OF NDT AND IN SERVICE INSPECTION EQUIPMENT IN TACIS NUCLEAR SAFETY

Several TACIS on-site assistance projects enabled Russian and Ukrainian NPPs to receive modern NDT and In-Service Inspection equipment to improve nuclear safety of operating VVER and RBMK NPPs.

Two TACIS projects were dedicated to the In-Service Inspection of RBMK fuel channels and primary circuit (steam drum separators, collectors and piping) for Smolensk NPP in Russia by developing dedicated NDT automated methods and equipment based on ultrasonic and eddy current techniques. A feasibility study was made with technical specifications for equipment, calibration blocks, test specimens and assessment manual to be applied to indications exceeding acceptable limits. Equipment fabrication with acceptance tests and definition of NDT procedures to be applied were carried out, followed by validation of the NDT procedures, training and qualification of NDT operating personnel with the objective to undertake the In-Service Inspection at Smolensk NPP using the equipment acquired and the procedures developed.

The SK-187 equipment used in Ukraine to perform the automatic ultrasonic inspection of the In Service Inspection of the reactor pressure vessel from external surfaces had serious limitations in terms of access to areas subject to inspection, reproducibility, accuracy and sensitivity. The SK-187 system has been developed in the seventies on the basis of components which existed at that time. Upgrading measures for this system were required because of deficiencies in the design options and other serious drawbacks. The main SK-187 system improvement measures concerned upgraded ultrasonic transducers for inspection of reactor vessel bottom, shell ring and nozzle-supporting shell ring, the upgrading of scanning devices for ultrasonic inspection, up-to-date ultrasonic flaw detector, control, display and inspection data processing equipment, video inspection, overall testing and metrological qualification of the system, operator training, and better sensitivity and reliability of ultrasonic inspection, especially for flaw detection in the welding area of the reactor vessel cladding and base metal.

The eddy-current equipment and technique are used in Ukraine for the inspection of threaded holes in the main flanges of reactor vessel, main coolant pumps and steam generator headers in order to detect cracks in thread and adjacent base metal. The inspection has been improved by adding a special device for thread preparation, an automatic computerized processing of inspection results and personnel training for the use of the inspection system.

CONCLUSIONS

The TACIS and PHARE programmes in Nuclear Safety have devoted important funding to support Non Destructive Testing and In-Service Inspection for VVER and RBMK NPPs, and the main achievements have been detailed in this paper. There is still the need to improve in-service inspection in VVER and RBMK reactors in relation to monitor the ageing phenomena. The main generic issue remains the improvement of the Qualification of the In-Service Inspection.