

## Successful work in the area of water chemistry improvement

Nuclear power plant	Kalinin NPP
Project reference	R1.03/92A and R1.03/94A1, R1.03/94A2
Project name	92A - Secondary side water chemistry treatment, 94A1 - On-line measurement equipment for the secondary side water chemistry. 94A2 - Additional equipment, make up water preparation and capillary electrophoresis analyser.
IAEA safety issue	CI 4 Steam generator collector integrity
Safety rank	III
Additional IAEA safety issue	CI-5 Steam generator tubing integrity
Safety rank	II
Additional IAEA safety issue	I&C 11 Water chemistry and monitoring equipment
Safety rank	I
Budget years	1992-94
Contract amount, Euro	For 92A 415 876 + for 94A1 324,949.00, + for 94A2 174,621
Working order	For 94A2 - 15/04/96
Contracting date	For 92A - 01/04/94, for 94A2 - 30/06/98
Supplier	For 92A: CITA, Millipore, Maihak For 94A1: CITA, for 94A2: Waters and Seres
Current status of the project	Completed. 92A on 18/05/96, 94A1 on 25/03/97, 94A2 on 14/10/02

### 1. Background: safety significance of water chemistry control

An accurate and preferably on-line chemical monitoring system is important to enable the operator to respond in time to deviations in the primary and secondary coolant water chemical condition indices. The specified water chemical conditions must be continuously maintained to avoid corrosion problems in the main equipment.

At the time of starting the TACIS programme the chemical monitoring systems in WWER 1000 NPPs were more than 10 years old and a great deal of maintenance effort was required to ensure reliable and accurate results. It was also increasingly difficult to obtain spare parts.

The analysis of failures of primary circuit header in the steam generator and also of heat exchange tubing in steam generator showed that these failures are connected with deviations from the secondary water chemistry. The IAEA issue book stated that the chemical monitoring system is essential to keep coolant parameters within prescribed limits. If these limits are exceeded, the integrity of physical barriers can be endangered. The necessity of continuous maintaining the specified water chemistry to avoid corrosion problems in the main equipment was specified as IAEA safety issue I&C 11 and assigned safety rank I, and the influence of water chemistry on SG integrity was recognized in safety issue CI 4 of safety rank III and CI5 of safety rank II.

### 2. Projects on water chemistry control in Kalinin NPP.

Already in the initial OSA contract at Kalinin NPP a strategy was defined to minimise the corrosion risk in the secondary side and more particularly in the steam generators. Part of

the approach was to install on-line monitoring systems on the secondary side in order to detect rapidly deviations in the chemical parameters and hence allow for appropriate corrective actions.

In the frame of TACIS 96 the following pending issue concerning the SGs tubes integrity was addressed: how to avoid further degradation of the condensers tubes affected by pitting corrosion and leading to quasi continuous large ingress of impurities ( ionic, organic ) via the condenser circulation water in-leakages?

Based on the western experience, which had shown that chemical cleaning and passivation of the condensers tubes is a necessary complementary means to the mechanical cleaning in order to limit the corrosion progress, a feasibility study of such a chemical cleaning and associated passivation was fulfilled.

Several TACIS projects were undertaken in Kalinin NPP in order to solve the problems of water chemistry control.

### R1.03/92A SECONDARY SIDE WATER CHEMISTRY TREATMENT

The goal of the project was to improve the existing system for in-service diagnostics of corrosion conditions of secondary circuit equipment and to elaborate computer calculation codes for resource estimation in the following areas:

- improvement of performance of automatic water chemistry control systems and increase of diagnostics reliability by considering the abnormal water chemistry cases,
- elaboration of methods for resource estimation based upon actual water chemistry conditions and deviations from prescribed values,
- scientific substantiation from water chemistry point of view of safety limits for both planned and operating NPP of WWER type.

On-Site activities of Tractebel which was OSA consultant at Kalinin NPP focused on three main items:

- a) characterisation of the chemistry in the crevices between the tubes and the tube sheet of the SG,
- b) survey of existing codes
- c) survey of analytical techniques to monitor the corrosion erosion phenomenon in the secondary side.

Tractebel confirmed that there are no major obstacles to supply EPRI-MULTE-Q code to the Russian side, estimated the price and devined the scope of supply.

The total supply of the laboratory equipment and on-line chemical monitors for both Kalinin units would cost about 600 000 €. This includes the cost of equipment installation supervision and Kalinin chemistry staff training. The supply of this equipment was considered as the first priority for KNPP TACIS 92 projects. The total supply of equipment having the first priority would amount to about 330 000 € . The supply of equipment of the second unit will take place later, depending on budget availability. The project has been completed.

#### *Achieved results:*

- Introduction of new methods for SG water corrosion aggressiveness evaluation and inclusion of the necessary apparatus in the existing chemical monitoring system
- Evaluation of SG crevice environment by analysing hideout return data during plant shut down

- Enhancing reliability of metal corrosion behaviour evaluation
- Possibility for evaluation of residual equipment resource and probable damage depending on maintenance conditions
- Water chemistry guidelines substantiation for new generation of NPPs.

### R1.03/94A KALININ SECONDARY WATER CHEMISTRY

It comprised two subprojects, 94A1 and 94A2.

#### R1.03/94A1. ON-LINE MEASUREMENT EQUIPMENT FOR THE SECONDARY SIDE WATER CHEMISTRY

This subproject supplied for Unit 2 a second set of equipment which had been installed on line in Unit 1 as part of Project R 1.03/92A. The on-line equipment for Unit 2 was the same as for Unit 1, and there was no need for the laboratory equipment which was used for both units.

The project provided for implementation of the experience gained with project TACIS R 1.03/92A.

#### R1.03/94A2. ADDITIONAL EQUIPMENT, MAKE UP WATER PREPARATION AND CAPILLARY ELECTROPHORESIS ANALYSER. TWO LOTS, I AND II.

In addition to A1, delivery of monitoring equipment for the plant make up water station which supplies demineralised water to the primary and secondary circuits as well as delivery of two capillary electrophoresis analysers for the laboratory in addition to the one supplied under Tacis 92. The analysers enabled the detection of impurities at trace levels in the different liquid streams of the plant.

There were no problems before tender but a delay of 8 months occurred between technical and financial evaluation due to problem of origin of goods. Another 8 months delay was needed to obtain approval of EC about the conclusions of the evaluation.

During the implementation there was a delay in customs clearance.

### 3. Equipment supplied:

On-line monitoring system on the secondary side was supplied in order to rapidly detect deviations in the chemical parameters and hence allow for appropriate corrective actions. Under the TACIS 92, unit 2 has been equipped with a monitoring system comprising:

- 11 sodium in-line monitors for condenser hotwell and SG blowdown
- 4 cation conductivity in-line monitors for the SG blowdown
- 3 dissolved oxygen in-line monitors for extraction and feedwater
- 2 chlorine analysers for the laboratory

In addition to this monitoring equipment, the following equipment was supplied in order to allow the proceeding with analyses in the laboratory:

- 2 water purification systems intended to produce ultra-pure water in order to prepare blank solutions for analytical purposes.
- 1 capillary electrophoresis analyser which enables the detection of impurities at trace levels in the different liquid streams of the plant.
- 1 total organic carbon analyser

Under the TACIS 93 the same monitoring equipment was supplied for unit 1. Additionally, the following equipment has been included in the scope of supply of this programme:

- Monitoring equipment for the plant make-up water station which supplies demineralized water to the primary and secondary circuits. This equipment consists of 2 SiO<sub>2</sub> in-line monitors and 1 Ca<sup>2+</sup> in-line monitor.
- Two capillary electrophoresis analysers for the laboratory in addition to the one supplied under the TACIS 92 programme.

#### 4. Main results obtained and reasons of success

Improvement of the secondary water chemistry by adapted specifications and enhanced control thanks to in-line monitoring means and accurate laboratory analyses are the most visible result obtained at Kalinin NPP, confirmed by the good state of the steam generators.

This result was obtained through a very close collaboration between experts of the EU-utility, REA, KNPP and VNIIAES. This is certainly to be considered as a positive lesson learned and the most important reason for success.



Analysers for chemical laboratory in Kalinin NPP



Анализаторы для химической лаборатории

