NPP Mochovce Units 1 and 2 Diagnostic Systems

Introduction

Original detailed project of diagnostic systems for NPP Mochovce [1] was completed in the end of 80th by Skoda Enterprise, Plzen. Following subsystems for operational diagnostics of primary part were included:
- subsystem „V“ - for monitoring vibrations components, based on the Siemens KWU system SÜS
- „C“ - for monitoring loose and detached parts in reactor coolant system, based on Siemens KWU system KÜS
- „U“ - for leak detection, based on the Siemens KWU system ALÜS
- „A“ - acoustic emission, based on SKODA system AMS
- „Z“ - fatigue monitoring of steam generator and pressurizer, based on the VUEZ Brno measurement system

In the beginning of the 90th the list of diagnostic subsystems was completed with subsystem „H“ - reactor coolant pump (RCP) monitoring, based on the VUJE Trnava measuring and evaluating system.

After the NPP construction break upgrading of the diagnostic subsystems had to be performed as well as their expansion based on the present safety demands and importance of diagnostics itself. The NPP owner, SE EMO a.s. decided to process this modernizing using three Safety Measures (SM) improvements procedures - SM number 07, SM 08 and SM 06 - and their technical scope has been determined by the Technical Specification of Safety Measures (TSSM), related to each SM number. Afterwards responsible leader of SM’s 07 and 08 became ŠKODA Praha a.s. For SM 06 leadership of EUCOM has been established. Each SM is substructured into more detailed parts (for instance 06.1, 06.2 etc.), and for each of this part a documentation called Basic Design (BD) has been worked up and published by the leader, then commented by EGP, Skoda Prague, EUCOM, adapted and finally issued.

Based on the BD the general designer EGP Praha elaborated Basic Project which has been commented and agreed upon by SE EMO a.s., technology general supplier SKODA Praha and EGP. These basic projects [2,3] describe scope of diagnostic systems, their location, sensor numbers and interface to a Unit Information System (UIS), Siemens system MADAM-S.

Present scope of diagnostics systems

All of the designed diagnostic systems are PC based systems. Their measuring part is located partly near the monitored technological components and partly in the diagnostic control room. The evaluating software is located on PC’s utilizing different operating systems (DOS, Windows, UNIX).

Basis of some diagnostic subsystems, mentioned above, has remained, and these systems are being upgraded both hardwarewise, including sensors expansion where needed, and softwarewise. This concers Siemens systems KÜS, SÜS, ALÜS. Subsystem „H“ will be delivered suiting present demands.

New systems have been added into the design - systems HUMON, CSLBB (supplied by VUJE Trnava), DAKEL (supplied by ZAPA Sala), AKFLÜS, FAMOS, VIBROMETER (supplied by Siemens).

Diagnostic monitoring covers components of both the primary and the secondary part of the NPP (figure 1).
Primary circuit components diagnostic systems

Permanent diagnostics will be performed using following diagnostic methods and systems.

Leak detection monitoring

For this purpose several systems, using different physician principle have been designed. ALÜS uses acoustic emission principle and measures noise of the leaking media. Sensors (piezoelectric transducers) of the system are located on pipes, steam generators, pressurizer, main closing valves, RCP's and on upper part of the reactor pressure vessel (RPV). AKFLÜS uses radionuclides detection principle and humidity level monitoring. This system uses special flexible steel tube winded around monitored technology components below the thermal insulation. The tube is equipped with calibrated input holes and system periodically sucks (using fans) the tube air volume. The sucked air is fed through detectors for the presence of Nitrogen-13 and Fluor-18 nuclides and level of humidity. The system's tubes are located on coolant loop pipings and pressurizer. HUMON is based on humidity level measurement of the air. Input air is sucked by fans via measuring pipes located at the inputs of operational ventilation in hermetic boxes, round RCP's, main stop valves, pressurizers and on accumulator tank.

Each of these three mentioned systems suits the Leak Before Break (LBB) criterion detection sensitivity. To arrange integrated alarm generation of these three systems a CSLBB (Central System LBB) will serve. This PC based evaluating system is datalinked to the three LBB systems and to the UIS. Upon knowledge of the operational process parameters, messages from further datalinked systems (DAKEL, HUMON) and special algorithms, CSLBB will more preciously detect and qualify rising leaks.

DAKEL is a leak monitoring system, using acoustic emission principle, having it's sensors welded on high pressure steam pipes and feedwater pipes within and outside the hermetic zone. Some of the sensors are periodically switched to active mode and serve also as pulsers for calibration.

Vibration monitoring

SÜS, the well proven system, evaluating vibration behaviour of the reactor coolant system components and RPV enables early detection of changes in their vibration patterns. As input sensors special low frequency absolute vibration sensor are located on RPV, steam generators, RCP as well as dynamic pressure sensors inside the coolant pipings. For the vibration nominal patterns acquisition specialised measurements called Baseline Measurement with participation of Škoda Nuclear Machinery, VUJE Trnava and Siemens will be performed.

„H“ system monitors vibrations of the rotating RCP using accelerometres (housing) and ultrasonic sensors (seals).

Loose parts monitoring

KÜS system detects and measures noise of the detached parts in the reactor coolant system. Strike of the detached parts to other components generates noise measured by accelerometres located on the bottom of RPV, on the steam generator and on main coolant pipes. System is also equipped with testing stroke pulsers for calibration.

Fatigue monitoring

FAMOS system will serve for primary piping component fatigue monitoring. This evaluation is based on continuous measurement and storage of piping material temperatures and on offline data evaluation. Contact thermocouples are installed (below the thermal insulation) on the surface of pipings of RPV, steam generator, emergency coolant pipings. Medium temperature stratification is detected by installing more sensors distributed on one diameter.
Secondary circuit components diagnostics

Leak detection monitoring
The in primary circuit already mentioned system DAKEL detects leaks from the high pressure steam pipes and feedwater pipes within the secondary circuit.

Vibration monitoring
VIBROMETER system serves for vibration measurement and vibration spectra displaying of secondary circuit rotating machines. Turbosets 22OMW, main feedwater pumps, condensate pumps and coolant pumps are equipped with sensors for housing (accelerometers, velocity sensors) and rotor vibration measurement (proximity probes).

Diagnostic system integration with Unit Information System
The LBB systems (ALÜS, AKFLÜS, HUMON), DAKEL and „H“ systems acquire process parameters being datalinked to the Unit Information System (UIS) MADAM-S via the CSLBB system. Data for systems SÜS, KÜS, FAMOS and VIBROMETER are transferred from UIS via a Communication terminal (KT), supplied by SKODA Praha. Outputs from diagnostic systems are fed as binary outputs to the Main Control Room.

Conclusion
During the work on Basic Designs present diagnostic systems level and scope has been taken and transferred into the Basic Project. At present a working design for a substantial part of the mentioned diagnostic systems is being completed and in parallel, sensors are being located on technological components. Upon own proving procedures the diagnostic systems will bring important information about technology behaviour during physical and power startup time and then in permanent operation.

Literature
[1] NPP Mochovce, Working Design DPS 2.01.16, Ae 6886/Dok, Skoda Enterprise, Plzen
Fig. 1: EMO DIAGNOSTIC SYSTEMS OVERVIEW SCHEME