OSART Good Practices

MAINTENANCE

Maintenance programmes

St. Laurent, France

Mission Date; 27 Nov.-14 Dec., 2006

As a part of main generator monitoring, a specific way to connect device called MIRAC has been introduced to measure insulation of main generator rotor by reducing risks.

The device measures rotor isolation during operation. Since it is not part of original design, no connection is available to fit the MIRAC to the main generator exciter system. Using the suggested way of connection, an interface box was installed permanently to connect the MIRAC device thereby minimizing the risks. Using the suggested connection, this measurement of rotor insulation was successfully implemented.

Benefit for the plant:
-- Reducing the turbine trip risk therefore reducing potential reactor scrams by creating an interface box (including a mounting panel with fuses and circuit-breakers) and also avoiding short-circuiting the ground rotor.
-- Increasing industrial safety: the interface box enables to minimise risk associated to a high-voltage connection (secured plug, anti-flash with reinforced insulation).
-- Implementation of a condition based maintenance programme; with a safe plugging activity, it is now possible to take a monthly measurement therefore allowing the early detection of potential defects.

St. Laurent, France

Mission Date; 27 Nov.-14 Dec., 2006

Risk assessment organization for urgent activities.

Risk analysis for urgent situation that have impact on safety and availability is started immediately by deputy shift supervisor, while the appropriate technicians from an on-call system travel to the plant. With this method, the plant reduces the unavailability of the equipment (thereby improving safety) and reduces the overall unavailability of the installation.

The overall aim of the risk analysis is the need to prompt and track a multidisciplinary risk analysis between maintenance and operations prior to an urgent activity.

While conducting urgent activities, this practice guarantees, that a risk analysis is conducted, and that a debate takes place between operators and maintenance crafts in the fields of nuclear and industrial safety, radiation protection, environment and availability prior to the activity.

The findings of the analysis and the activity are tracked.

This document illustrates the professionalism and safety culture applied by workers.

Benefit for the plant is to improve control of urgent work activities.

Operating experience sharing with other plant in the field risk analysis.

Loviisa, Finland

Mission Date; 5-21 Mar., 2007

Condition monitoring programme has been developed systematically at the plant.

The main objective has been to develop procedures and to utilize integrated technologies that enable the plant to use and combine all available information at plant, i.e. condition monitoring, process data, operational and maintenance history etc.

The condition monitoring programme is based on optimizing maintenance strategies (i.e. corrective, preventive and predictive) combined with properly trained personnel, application of technology, integrated analysis, effective decision making, and utilizing metrics to suggest changes (proactive maintenance).

To enable the programme the plant has purchased condition monitoring software and equipment produced by the CSI Company, AMS Machinery Manager, which integrates several predictive monitoring technologies. At present five integrated AMS condition monitoring technologies are applied at the plant: portable vibration analysis (since 1991), oil analysis, induction motor analysis, infrared thermography and ultrasonic analysis.

In addition an on-line monitoring system is installed to monitor vibration of turbines, generators and primary cooling pumps. The On-line system will be extended to monitor main sea water pumps later in 2007.

AMS Machinery Manager enables the recording of case histories of detected problems. When a deviation is detected in the trend data a case history is written into the AMS database. A case history can also be generated automatically. The case history includes information of the severity of the detected problem, observations, proposal for actions, figures of measured data and root cause of the problem. Fault types are classified to facilitate the use of stored information when planning proactive actions. Case histories have been collected at the Plant since 2002. In future case histories will be transferred to LOMAX.

Two examples of results showing the performance of the described system:

- High flow induced vibration in primary circuit caused high vibration levels on primary circulation pumps. These vibrations were delaying the startup of the plants. After analyzing comprehensive measurements it was found that the flow induced vibration was caused by back flow of water through pumps' seals. The seals' construction and materials were checked and the sealing faces were found degraded. The faces were machined and this vibration problem disappeared.
- Lubrication oil change intervals have been optimized. The change intervals have been extended or the change is carried out according the condition of the oil. Oil filteration has been improved for the diesel generators, turbine bypass valves, main seawater pumps.

Tihange, Belgium

Mission Date; 7-23 May, 2007

Document management database developed internally at the plant by the repair - replacement section.

A document management database was created to meet deadline requirements for essential reports from the appointed organization enforcing ASME, for increased precision and completeness of the different documents issued, for more efficient management of operating experience (OPEX) and of the work records so as to plan future work.

Other areas for improvement in this database were:
-- To incorporate all information that is available at different times, for the purpose of work planning.
-- To allow technical specialists more time to go into the field.
-- To help new employees gain a faster understanding of the workings of ASME and of repair-replacement management.
-- To meet the QA requirements for repair organization.

This database was developed by the repair - replacement section which was recently reorganized as part of the main organizational change programme initiated in 2006. It includes ASME requirements as well as other relevant business codes and mandatory requirements. In addition to this, it also includes all preventive aspects associated with work package preparation such as foreign material exclusion (FME) programme, risk assessment, industrial safety, environment, radiation protection, and hot work in a cohesive manner from beginning to end.

With respect to increase in performance, the repair team looked at results from previous outages. In comparing results, performance was increased in the following areas;
- Improved output times for evaluation reports. Today, nearly 100% of reports are drafted in a very short term.
-- Improved output times for Nuclear In Service (NIS) 1 & 2 reports so that nearly 90% of these documents are issued within 90 days of start-up (ASME requirement).
-- Improved the efficacy of document management and the scheduling for outage repair and replacement programmes.

The repair team has been able to offer additional assistance in terms of expertise with the same number of staff at hand. The department has strengthened the repair technical presence in the field rather than invest time in management of technical documents. The department has made overall document management database much more solid and accessible to everyone.

Neckerwestheim, Germany

Mission Date; 8-24 Oct., 2007

Modification of obsolescent electronic equipment

Neckarwestheim Nuclear Power Plant has a very well structured and equipped I&C components workshop, where failed electronic assemblies can be repaired. In cases where a component is no longer available it is necessary to provide the modifications or redesign. These activities, resulting from non-availability of individual components, are clarified by updating the original documentation together with the sections concerned.

For assemblies used in safety systems, these modifications are adjusted with and approved by the independent expert (TÜV), and the relevant documentation is updated. Neckarwestheim NPP is able to provide support to all other German nuclear power plants in modifying equipment and to redesign some electronic cards in line with the quality requirements.

This good practice allows the plant to overcome the obsolescence of some electronic equipment.

Forsmark, Sweden

Mission Date; 12-28 Feb., 2008

The plant has electrical power monitoring for performance-based maintenance on isolation valves and control rod drives online, (SODEM).

An online computerized electrical power measuring system is optimal for monitoring performance of isolation valves and control rod drives. The electrical power measuring system can be used for tracking changes from a fingerprint curve or as an indicator of increased friction that may affect the operability of the valves.

The Plant uses such a system for measuring electrical power demand by motor-operated isolation valves. The computerized system is triggered at each individual operation of the valves or control rods.

In the valve monitoring system, the alarm levels are calculated for each individual valve. The alarm levels are based on the valve calculations in the SAR. The curves are analyzed on a regular basis and the maintenance engineers make recommendations for maintenance action during outage. Written procedures provide assistance with analysis and adjustment of alarm levels. The performance analyses also enable operability assessments for the motor operated isolation valves.

The valve monitoring system is used for troubleshooting on both valves and actuators. It also enables identification of mechanical errors, e.g. increased friction, bent stem and if the actuator is fitted off centre of the valve.

Alarms from the control rod monitoring system are used in combination with other monitoring systems to evaluate the status of the control rod drives and collect data for maintenance actions during outage.

Balakovo 4, Russia

Mission Date; 19 May-5 Jun., 2008

Testing control units.
Since 2003, plant has been using a computer aided test bench "Krona 706" to diagnose defects on electronic cards used for the controls of all systems in the plant. There are around 20,000 cards per unit and 28 types of cards. Cards are tested every four years during the refueling outage. It takes about twenty seconds to test a card.
The test bench allows detecting latent defects that have not caused the failure of a card but are likely to cause a deficiency during further operation. The types of defects identified by the test bench are the following:

- Short circuits,
- Differences in resistance values,
- Reduced insulation,
- High resistance of grounding,
- Unauthorized jumpers (by-passes),
- Spurious connections between separate circuits,
- Deviation of transistor performance,
- Anomalies of diodes and output transistors.

Early identification of latent defects has significantly improved the reliability of the plant controls. The yearly number of defects has been divided by ten between 2002 (last year without test bench) and 2005. Since 2005, the number of defects per year is one to two per unit.

The defects are automatically diagnosed and archived by the computer.

Balakovo 4, Russia

Mission Date; 19 May-5 Jun., 2008

Improvement of equipment seal tightness

Low-pressure turbines:
Plant has been using Teflon based sealant stripe since the year 2000 to seal the horizontal flanges of the low pressure turbines. Use of Teflon based (Gore-tex) sealant has reduced the number of leaks from 15 to 20 down to 2 to 3 per cycle with a possibility of elimination. By reducing the number of leaks, this technique has contributed to improve the condenser vacuum and reduce the oxygen concentration in the condensate water. At present, there are practically no leaks in the low pressure turbines.
Until 2000, plant had used multi-component mastic on the horizontal joints of the low pressure turbines. During on-line operation, there were permanent problems of air leaks into the condenser that affected the condenser vacuum. In addition, it used to take one day to prepare the sealant of the low pressure turbine. Now it takes one technician two hours to put the sealant stripe in place.
Teflon based (Gore-tex) can be used on equipment working under a pressure up to 64 bars and a temperature up to 270°C. It is chemically stable within pH = 0 and pH = 14. It does not pose any health problem (it is used in the food industry).
Equipment subjected to temperature cycling:

Plant is using graphite gaskets on the reactor vessel head penetration flanges (in-core temperature and neutron flux measurement channels) and on the control rod drive mechanisms. Originally, plant was using nickel gaskets that did not provide appropriate seal-tightness during the hydro-test or later during plant operation because of thermo-cycling.
Based on the good performance of these spiral graphite gaskets on the reactor vessel head penetrations, plant has extended the use of these gaskets on a growing number of key systems on the primary side (e.g., reactor coolant, spent fuel pool cooling), the secondary side (high and low pressure steam lines, condensate water, low pressure heaters, main feedwater), and other important systems such as essential service water and instrument air supply. No defect has been identified on these gaskets since 1997.

Oskarshamn, Sweden

Mission Date; 16 Feb.-5 Mar., 2009

Comprehensive In-Service Inspection (ISI) programme

The plant implemented comprehensive ISI program which includes the following tasks:
- A tailor-made computer system has been developed for keeping track of all ISI-related data. All ISI-affected tasks are stored in a database, together with relevant information such as material composition, drawings, testing intervals, historic testing protocols, relevant testing methods, photographs, room location, environmental data etc. Excellent search-functions make it easy to find, for example, components with the same material composition in cases of generic problems. Also related structural verification reports are easily accessible through direct links. The database is also used by and in interaction with the third party control organization, and as a special feature the outage testing plan is locked, not able to alter, once it is electronically checked and signed by the third party control organization. By using the program, the ISI-officer always has a good overview over both the upcoming inspections (the program knows the required testing intervals of all objects and can by that easily produce an outage testing plan) as well as historical testing data for trending of results.

- ISI database is used as one of the bases for OKG Ageing Management Program.

- All welds and inspection areas are given indexes for "probability of defects" and "consequences of defects". Qualified inspection techniques are used.

- Well in advance (> 3 years) the plant evaluates all ISI activities during the upcoming outages, and decides if there are any needs to establish a repair method for a certain area. The judgment is made by an expert panel with representatives from different parts of the company. The recommendations are presented for the plant manager for final decision. By this, the plant has a proper time to develop a repair technique. If a crack is found during the ISI, the repair can start immediately during the outage. The impact on the outage length can then be minimized.

Mühleberg, Switzerland

Mission Date; 8-25 Oct., 2012

Long-term comparison of dynamic measuring circuit performance

The first research projects in the USA began in the 1980s to investigate the noise characteristics of various measuring transducers used in nuclear power stations. Noise characteristics maps the authentic performance of physical factors with slight variations (and is not merely interference in this context). It investigates the dynamic behaviour of transducers or measuring circuits. This dynamic behaviour can also be used to generate additional important information about measuring transducers or circuits. Any deviations can be identified earlier, whereas conventional calibration based on static behaviour would not show up any difference. The method is thus of great value for nuclear power plant safety systems.

At the plant neutron noise analyses were done in 1992/93. Using the same set of analysis tools, the first noise analyses from instrumentation signals were carried out in the reactor protection system. The same analysis instrumentation was used for the first time to carry out noise analyses of the reaction protection system's signal instrumentation as sensor tests. Since 1994, these tests have been conducted regularly as part of the annual KKM periodic testing programme. At present, approx. 400 instrumentation signals are recorded, analysed and evaluated every year.

After recording the data, they are sent to a contractor for evaluation. The evaluated data is recorded in a report and saved in the Sensbase data base which was specifically developed by the contractor for KKM. Analyses have been saved in the Sensbase database since 1996 where they are available for trending. This data base, for example, allows for a comparison of certain measuring circuits over a number of years which are preventively checked for dynamic out-of-tolerance deviations. Measuring circuits can then be corrected in advance.The plant presented examples of problems detected with pressure transmitters, electronic filters and partial flow blockage or cracking in an instrument sensing line.

Clinton, USA

Mission Date; 11-28 Aug., 2014

Fuel failure prevention policy including a strong Foreign Material Exclusion programme.

A robust Foreign Material Exclusion Programme reduces the likelihood of fuel failure, thereby reducing the dose received by workers and further protecting the health and safety of the public.
The station has achieved zero fuel failures throughout the life of the plant. Several items can be learned from the performance. The station has been able to achieve zero fuel failures by a strategic approach to Foreign Material Exclusion (FME). The following areas are key focus areas that are unique to the industry;

- During the original design and build of the station, extremely high standards were maintained regarding FME controls. During initial build and systems startup, the station developed a specific procedure for flushing all systems prior to putting them into service. Additionally the station has maintained that same standard that was developed from the start, each time a system is breeched. This site specific procedure establishes uniform inspection criteria for internal system component cleanliness. This prescribes a high focus on prevention of foreign material which is a cornerstone for FME.
- In the early 2000's, the industry changed the types of fuel and stated that it was acceptable to increase power ramp rates higher than ever before to shorten durations of outages. The station made a strategic decision to not follow the industry and follow a more conservative approach to fuel ramp rates. This led to a guideline document for the station called Fuel Integrity Guidelines (FIG's) for fuel ramp rates. The station continues to follow the conservative fuel ramp rates to this day, which is also unique to the industry.
- The station is also a part of a large nuclear power plant fleet and has a very strict programme for FME controls. This fleet provides all maintenance and plant personnel with very specific training on the FME programme. The station takes that one step further with their use of the maintenance learning centre to train on the fundamentals of FME. Specific qualifications are required as well for developing a project FME plan which provides a clear command and control for FME.

Sequoyah, USA

Mission Date; 14 Aug 1 Sep, 2017

Use of Preventive Maintenance (PM) 360 Feedback System

The plant uses an asset database system to control and track assets, materials, condition reports, and work orders. This database system contains a function known as PM 360 feedback. PM 360 feedback is a system function that automatically sends update emails to the originator of the Condition Report (CR) or Work Order (WO) feedback. This enables the originator to know when their concern or input has been addressed.

- On the CR side of the database system, an e-mail is sent informing the originator when the CR has been closed, allowing the originator to review the actions taken to address their concern.

- On the WO side of the database system, several different things occur when the originator provides feedback on the WO or PM.

  - Several additional fields open up to allow the originator the option to input whether or not the PM is still valid and needed; the frequency correct; and to input a number rating for the condition of the equipment. This feedback system also allows the technicians to provide a numerical grading system to the work, which is then used to determine if the work scope and frequency is adequate or needs to be changed. Additionally, there is a narrative field to add comments.

  - When the feedback issue is closed, an e-mail is sent to the originator informing them that their feedback has been addressed. The originator is then able to review the actions taken to determine if they have met their concern.

By adopting this feedback system, around 7000 feedback requests were received and resulted in 190 items being updated during the previous two years. During a recent PM review, about 100 PM frequency and scope of work changes were made based on the technicians' feedback.