

# OSART Good Practices

## MAINTENANCE

### Maintenance Programmes

#### Sta. M. Garona, Spain

Mission Date; 18 Feb.-2 Mar., 2002

The plant has been innovative in the development of new designs, tools, and technical processes. Much of this innovation has been focused on the reactor vessel and reactor vessel internals.

To ensure that the innovation works properly the first time, the plant has made extensive use of mock-ups to verify the design, test the tooling and validate the new processes.

A comprehensive variety of reactor vessel mock-ups and remote handling tools are available for testing the performance of equipment and also for training maintenance personnel in reactor vessel inspection and repair activities. Mock-ups can be flooded with water and include realistic flaws to simulate similar conditions to what will be met on the plant.

Employee rehearsals of such activities create the conditions where repairs and inspections can be carried out more efficiently anticipating potential problems and shortening critical path time that otherwise would not be possible.

Examples of these are:

1. Equipment development and mock-up training for inspection and repair of control rod drive penetrations and jet pump restrain restrainer brackets.
2. Tooling developed for core spray piping as-built measurements prior to replacement, material surveillance test specimens insertion and removal, recirculation nozzle and jet pump nozzle plugging for decontamination purposes, etc.
3. Mock-up development and personnel training for feedwater spargers replacement, core shroud repair and core spray piping replacement.
4. Blind testing of contractors' ultrasonic inspection equipment prior to use for vessel inspection during outages.

## Zaporozhe, Ukraine

Mission Date; 6-23 Sept, 2004

The plant keeps records in logbooks of maintenance already done and follows relevant performance indicators and reviews the background for poor performance or failure. Thirty days after each outage, all defects and mal functions noted in the logbooks are reviewed, analyzed and categorized in different groups of components with the possibility to compare the different units as well as different years. Based on the information achieved the maintenance manager together with his section heads issue a plan for corrective actions. During the OSART Mission, it was demonstrated how these performance indicators give management the ability to take corrective measures based on the trends given by the indicators. During the operating period 2003-2004 units 2-6 were running continuously between the outage periods, and unit 1 had a 6hour stop. Tours in turbine buildings 3, 4 and 6 also confirmed the high level of maintenance and no leaks could be found, bearing in mind that unit 3 was in the end of the operating period with 292 days of continues operation. The way this process is developed and used in the Maintenance Division is seen as a good practice for the industry.

## Cernavoda, Romania

Mission Date; 22 Jan.-10 Feb, 2005

Maintenance Department is in the process of developing "Maintenance Enhancement Programme". The true strength of this practice is the involvement of operations in this activity.

This is a complex optimization of preventive and predictive programme based on best international practice developed by EPRI Preventive Maintenance Database.

Experts panels of maintenance preventive and predictive group, system engineers from technical support, licensed operators evaluate the failure mode of active equipments recommended by EPRI compared with manufacture manual, plant experience and Romanian regulation. After this comprehensive evaluation the maintenance templates are issued.

The added value in this systematic approach is the integration of engineering process, preventive maintenance programme preparation, spare parts identification and the identification of training requirements. The plant started with a project of 24 preventive maintenance programmes on important equipment and 11 of them are finalized.

## Blayais, France

Mission Date; 2-19 May, 2005

Effective risk assessment methodology of maintenance activities has been developed and implemented by the plant. This methodology is based on software application of questioning approach to encompassing the areas of nuclear safety, radiation protection, industrial safety, plant availability and environmental protection. The use of a common tool facilitates collation of risk assessments. The tool is cross-functional and adaptable. It encourages a questioning attitude and provides a reminder of basic reference standards. The deployment plan calls for the joint involvement of a network of representatives as well as management and training staff.

Qualitative and quantitative arguments to support risk assessment methodology as a good practice:

- Extension of the risk assessment method to areas other than nuclear safety helps to minimise risks and improve site performance in the areas of radiation protection, industrial safety, plant availability and environmental protection.

- The tool promotes a questioning attitude and provides a reminder of applicable expectations. It facilitates analyses and promotes in-depth investigation. It is an effective means of grouping together risk assessments performed during previous similar activities. It promotes cross-functional links between crafts. Its ability to include new topics makes it an efficient vehicle of site expectations and obviates multiple tools: It has evolved since it was first introduced, taking into account the specific features of risk assessments pertaining to temporary modifications and fuel pool safety areas. It is tracked by a dedicated task force.

- The decision to deploy the "new" risk assessment methodology by involving a network of representatives as well as management and training staff has helped to send out clear and consistent messages concerning the site's objectives. This has created momentum in the assimilation of this methodology (see performance indicators) and worker support.

## Brunswick, USA

Mission Date; 9-26 May, 2005

Programmes developed to track, prioritize and schedule coatings.

Environmental conditions and normal wear contributes to degraded conditions of components and structures. To maintain structural integrity of these components, a 'Maintenance Coatings Programme' was developed and implemented. The objective of this programme is to provide logical and timely preservation of components which aids in inhibiting accelerated breakdown of the components while promoting equipment reliability. The maintenance coatings programme manager has the responsibility to ensure compliance with the requirements of the coatings programme. This includes surveying areas or zones throughout the station and entering the surface quality, environmental grade, and digital photographs of the zones in the database. An Electronic coatings program database was developed internally within maintenance and has become instrumental in establishing priorities, frequencies, budget, and resource requirements. Calculations are performed and reports are generated to provide accurate information. The results of the programme and electronic database are key elements to perform improvements in the condition of areas, components, and equipment and to have an efficient recording system.

## Borssele, Netherland

Mission Date; 8 Nov.-7 Dec., 2005

Valve condition monitoring on systems important to safety.

The plant has developed a powerful process for condition monitoring of valves on systems important for safety. Detailed drawings of these valves have been entered into a computerized drawing system. The drawings contain key dimensions of the valve components. When maintenance is performed on such a valve, up to 20 important dimensions are measured and compared to the values stored in the computer. The software checks as found and as-left values and highlights dimensions which are out of pre-determined acceptance criteria. The results are entered into the maintenance system to ensure that the valve is not returned to service before out of tolerance components have been replaced and all values are within specification.

The valves are categorized by complexity; importance for safety and importance for reliable production and those in higher categories have more dimensions recorded than those in lower categories.

The system has been used for maintenance of many valves since 1996 and the measured values have been used for trending and planning of maintenance.

## 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.

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.

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 filtration has been improved for the diesel generators, turbine bypass valves, main seawater pumps.

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.

## Neckarwestheim, 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.

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.

### 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.