OSART Good Practices
TECHNICAL SUPPORT
Plant modification system

Forsmark, Sweden

Mission Date; 12-28 Feb., 2008

The TIGER procedure ensures that HMI (Human-Machine-Interface) design can be incorporated in modernization projects in an appropriate manner. The TIGER procedure was developed in 1998. It has subsequently been well applied to about 30 modernization projects in this plant since the start of application.

- The TIGER procedure is based upon a number of norms and guides from the nuclear industry, e.g. NUREG, IEC and ISO.
- The TIGER procedure consists of a five step procedure, e.g. TIGER extent description, present description, HMI design review, HMI verification and HMI validation.
- At the stage of present description, all the operator work tasks that are affected by the modernization are identified and analyzed by the TIGER group. Each TIGER group consists of operators and different type experts.
- At the stage of HMI design review, a new HMI design developed by technical design department is reviewed and approved by the TIGER group.
- At the stage of HMI verification, the TIGER group can be complemented by an independent person that has not been involved in earlier steps in the TIGER process, in order to achieve a more independent verification.
- At the stage of HMI validation, it is always performed by operators that have not been earlier involved in the earlier steps of the TIGER process in order to show that the modernization is in accordance with the other systems and functions within the plant.

Flamanville, France

Mission Date; 6-23 Oct., 2014

Arrangements for reducing the impact of saline mist causing corrosion in Flamanville Unit 1 and 2 pumping stations.

The pumping stations are situated in the vicinity of the sea, and as a result the equipment is surrounded by saline mist, which causes corrosion of both stainless steel and carbon steel components.

During renovation of the pumping stations, the plant installed permanent shields and movable curtains in several locations to keep saline mist away from the equipment.

These shields and curtains are made of composite materials. The movable curtains allow easy access to equipment for operation and maintenance purposes.

This decision has reduced the level of humidity and salinity in the air in areas of the pumping station, thereby reducing the rate of corrosion significantly.

Flamanville, France

Mission Date; 6-23 Oct., 2014

System for management of temporary modifications (DMPs) specific to outages.

The plant has developed a system for managing a specific type of temporary modifications (DMPs - plugs, tools and other devices mostly used during maintenance, operations and testing activities).

The system developed includes stands with shelves. Racks of suitable size for small items are placed on the shelves. Each item has its own position, and positions are color-coded. The stands are separated by of a cage, and the door of the cage is locked. A catalogue with colored pictures is placed on the outside of the cage. Every page has its own plastic sleeve, and the sleeves are easy to browse. If any item is in use, a special tag is placed in this item's plastic sleeve.

The system allows all DMPs to be well controlled, enables the location of every DMP to be traced at all times, and reduces the probability of using inappropriate devices.

Paks, Hungary

Mission Date; 27 Oct.-13 Nov., 2014

Mobile battery plant

At Paks NPP the safety-related batteries have reached the end of their lifetime, therefore their replacement was necessary. To allow replacement of these batteries plants an alternative solution was provided during the time of the reconstruction.

The electrical technical section and the electrical maintenance section have set up a container size mobile battery unit that can be moved by crane.

This mobile battery unit fulfils all the parameters of the safety battery plant at the Units and it is an equivalent substitute.

The batteries are built into a container that has temperature control, ventilation and it is seismically reinforced.

The interior of the battery plant

Container battery plant

During the replacement of the unit safety batteries, the mobile battery unit was moved to the relevant Unit with a mobile crane and connected to the safety system through the connecting distributor cell of the safety battery plant. Following testing the safety system could fully operate without time limitation during which time the reconstruction works were successfully carried out.

The temporary cable

The mobile battery unit allowed the power plant to perform the reconstruction of all safety- related batteries on all Units without operational safety risks.

Reserve cables and quick connection points were installed for all Units for the mobile battery unit to power each safety-related battery at the designated container locations. The mobile battery unit is stored at the site of the electrical maintenance section, where periodic maintenance is provided on it. In any failure of a safety battery or in case of emergency the mobile battery unit can be set up to replace any damaged safety battery within 24 hours.

<u>Technical data:</u>

Measurements:

- length: 6000+400 mm
- width: 3600 mm
- height: 2700 mm
- weight: 22903 kg

Power source:

- network connection: 3x400/230 V 50 Hz
- built-in power: 8 kW

Batteries:

- type: VARTA Vb 2412
- nominal voltage: 220 V DC
- capacity: 1200 Ah

Kashiwazaki 6/7, Japan

Mission Date; 29 Jun.-13 Jul., 2015

Station protection measures against tsunami

The station has performed a comprehensive assessment of SSCs important to safety as well as those needed to cope with severe accidents to identify any necessary enhancement. The results of these investigations are compiled in a document that provides the list of safety related SSCs, the safety class and other relevant information on equipment characteristics. The result is either the demonstration of adequate margins in the design of the SSC or the need to perform reinforcement actions.

With respect to protection measures related to the tsunami risk, and based on experience and lessons learnt from the March 2011 Tohoku earthquake and Fukushima accident, the station decided to build a protection sea-wall around the safety-related area in order to keep a “dry” site. As a result, all safety-related SSCs, including those needed to cope with severe accidents, are protected against a tsunami. In addition, to cope with uncertainties in tsunami wave height evaluation, a conservative height of 15m above sea level was established for the design of the sea-wall (compared with 8.5m coming from the Tsunami Hazard Assessment).

Furthermore, based on the concept of Defence-in-Depth, additional measures were implemented such as flood barriers, water-tight doors and waterproofing penetrations around and/or inside the reactor building to protect safety-related SSCs in case of flooding.
These measures, implemented by the station in a pro-active way in order to improve the protection against tsunami, are an exemplary application of Defence-in-Depth and have a significant positive impact on the reduction of the risk arising from tsunamis.

Kashiwazaki 6/7, Japan

Mission Date; 29 Jun.-13 Jul., 2015

The flexibility and capability of alternate AC/DC electrical power systems to facilitate restoration of power in design extension conditions.

The alternate AC power systems consist of three mobile gas turbine units located at the +35 m elevation; seismically qualified emergency switchgear building with a preinstalled cable connection to the unit safety buses; two 500kW mobile generators per unit that can be connected to preinstalled outside, geographically diverse connection points at the +15 m elevation and water proof emergency switchgears, located in geographically diverse places in the reactor building. The gas turbine generator has almost the same capacity as the standby AC power source that allows powering the loads necessary for the core injection and heat removal function. The gas turbine generator can be started and manually aligned to a safety bus(es) within 70 minutes.

The alternate DC power systems consists of a permanent as well as transportable apparatus, preinstalled connections and portable batteries and chargers, that can be deployed to ensure continuous operation of DC powered systems during accident conditions.

Both the AC and DC alternate power systems can supply power to equipment and instrumentation required during accident conditions (design basis accident and design extension conditions). The combination of the alternate AC and DC power supply systems and a newly installed High Pressure Alternate Cooling provides the Units 6 and 7 with the capability to withstand simultaneous Loss Of Coolant Accidents (LOCAs) and Station Black-Out (SBO) events.

The alternate AC and DC power systems not only meet but exceed Requirement 68 of SSR 2/1, rev. 1, as well as recommendations in Section 8: Alternate AC power Supplies of IAEA safety guide SSG-39 Design of Electrical Power Systems for NPPs (both in preparation).

Cernavoda, Romania

Mission Date; 7-24 Nov., 2016

Development of an innovative solution to leak check individual cable penetrations, without the need to conduct a full scale Reactor Building Leak Rate Test (RBLRT).

CANDU NPP requirements necessitate a Reactor Building Leak Rate Test every time a new cable is pulled through a containment penetration. During the 2015 outage, new cabling was scheduled to be installed to improve Calandria level measurement during post-accident conditions. However, the next RBLRT was not scheduled until 2017. Rather than delay installation, the plant developed an innovative solution to test and verify only the affected penetrations. A mockup was designed and constructed to ensure leakage requirements could be adequately verified, as shown in the following figures.

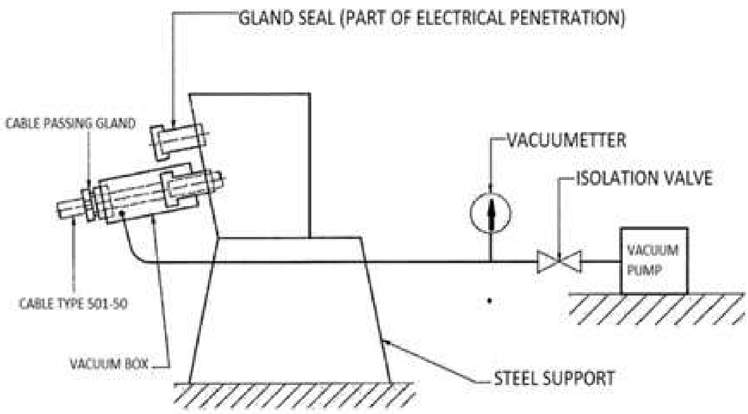


Figure 1 – Schematic of leak rate test rig

To verify the leak tightness of the penetration, a box is fitted around the penetration and a vacuum pump is used to establish a differential pressure of 38 kPa, simulating RBLRT pressure test.

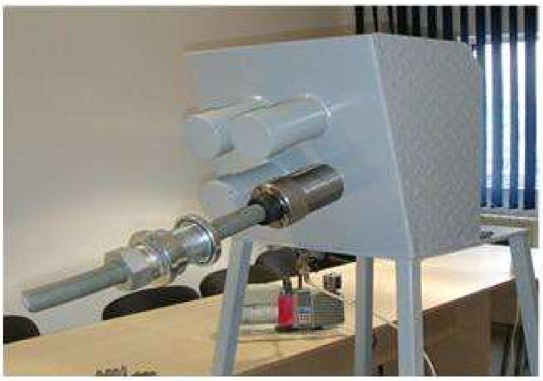


Figure 2 - Penetration mock-up

Figure 3 - Mock-up with vacuum box installed

While vacuum is maintained by a pump, leakage through the penetration is determined by measuring self-maintaining vacuum inside the box for a period of time.
This unique method of testing individual penetrations is the first of a kind for CANDU plants.

Taishan, China

Mission Date; 8-26 Jan, 2017

Extensive (large-scale) involvement alongside early involvement of the Operations Sector personnel in the design review.

More than 100 people from Operation Sector participated in Nuclear Island design review in AREVA Company during 3 weeks in 2014

A large group of plant personnel, representing different departments in the Operation Sector and Project Sector, organized in 10 topical working groups, conducted a three week workshop in the designer's premises to review in detail system designs from operations, maintenance and a commissioning perspective and to take into account first of a kind plant- specific conditions in operations and maintenance. The proactive approach predicted and resolved 529 issues, including some concerning a safety injection pump for hydraulic tests, devices for replacement of the SG's snubbers.

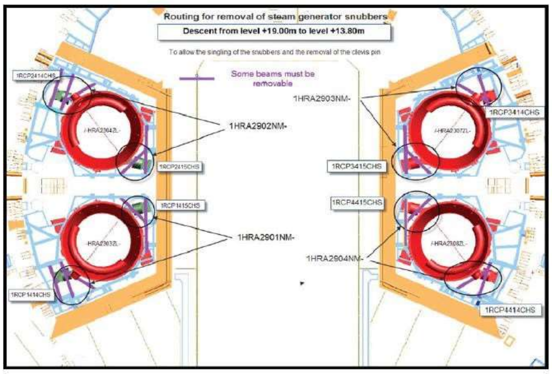
529 issues coming from reference plant feedback, design document, operation conditions were discussed and addressed. Through internal work in WGs and a series of meetings with the designer, a lot of technical issues were resolved, for example: upgrade of the function level of the instrument compressed air system valves to the fulfill safety requirement, designing of an additional flange in the pressure relief tank and the safety injection pump for implementation of the hydraulic test, installation of devises for the Steam Generator's (SG) snubbers replacement and others.

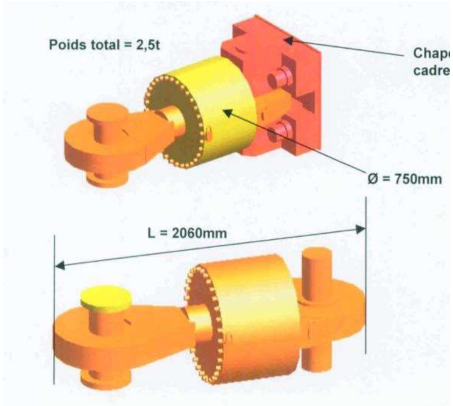
Benefits

- Plant specific requirements from maintenance and operation were taken into account in the study and implementation of the modifications;
- Plant personnel improved understanding of the plant's design;
- Acceleration of the review of modification by the Project team by reducing the interfaces between Project Sector and Operation Sector;
- Reducing the number of modifications.

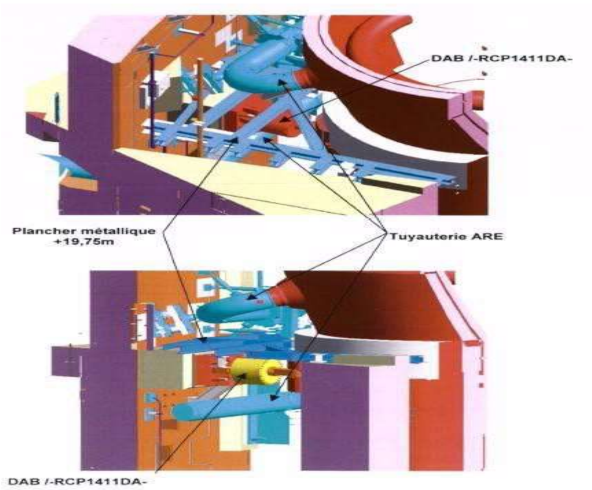
SG snubbers replacement

Steam Generator snubbers (weight: 2.5t, length: 2m) have to be maintained every 20 years. This maintenance is not possible at the location on the Steam Generators, and the designer didn't take into account the maintenance requirements for the future. The main difficulties came from the lack of lifting devices (polar crane hook cannot access to snubbers) for handling snubbers outside the reactor building, from the transportation in areas where there are many pipes and where metal floors are not designed to support the weight of a snubber.



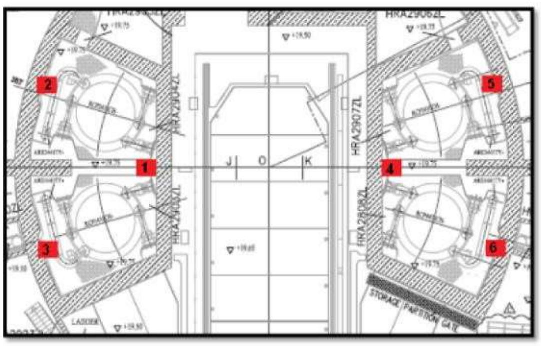


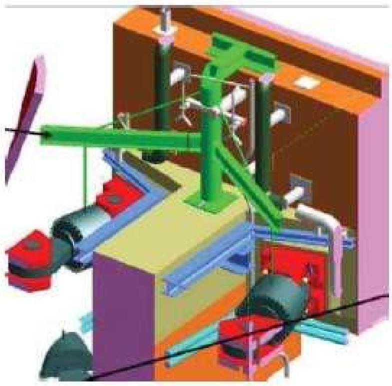
Location of 8 snubbers   snubbers' size : 2.5t, 2000mm



This issue was discussed and both parties finally agreed on the proposal presented below:

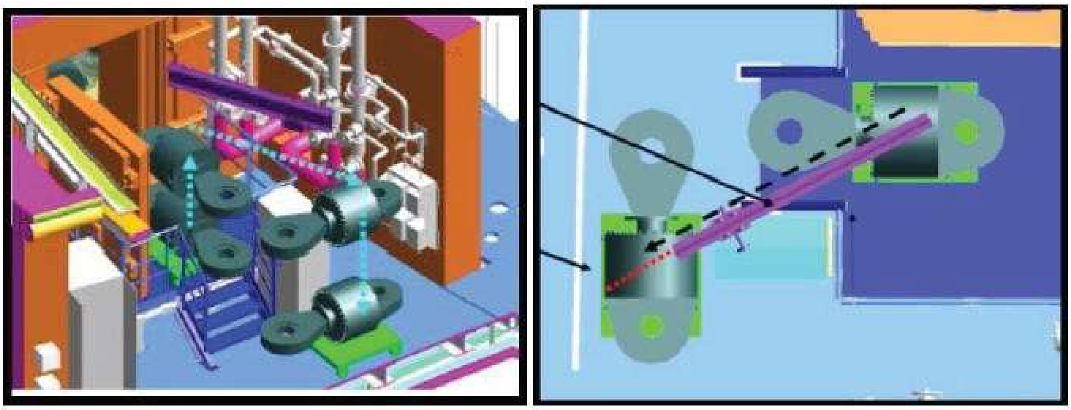
Step1： Install additional 6 cranes, remove some beams and re-route pipes of DER SAR SAT RES system to handle down the snubbers inside the SG compartment from level +19.00m to the platform at +9,38m





Location of additional 6 cranes,   Design for cranes 1 and 4

Step2： Transport the snubber from the SG compartment to the annular space via 2additionally installed monorails



This monorail needs to be enlarged and increased the capacity in order to handle the snubber.

Step3： Transport the snubber on the annular space and to the handling opening in the south east part of Reactor Building

Step4： Handle the snubber from level +8.70m up to the service floor at +19.50m through the opening

Step5： Evacuation on service floor to HK set down area via Equipment Hatch The modification was implemented soon after NI design review.

Almaraz 2, Spain

Mission Date; 5-22 Feb., 2018

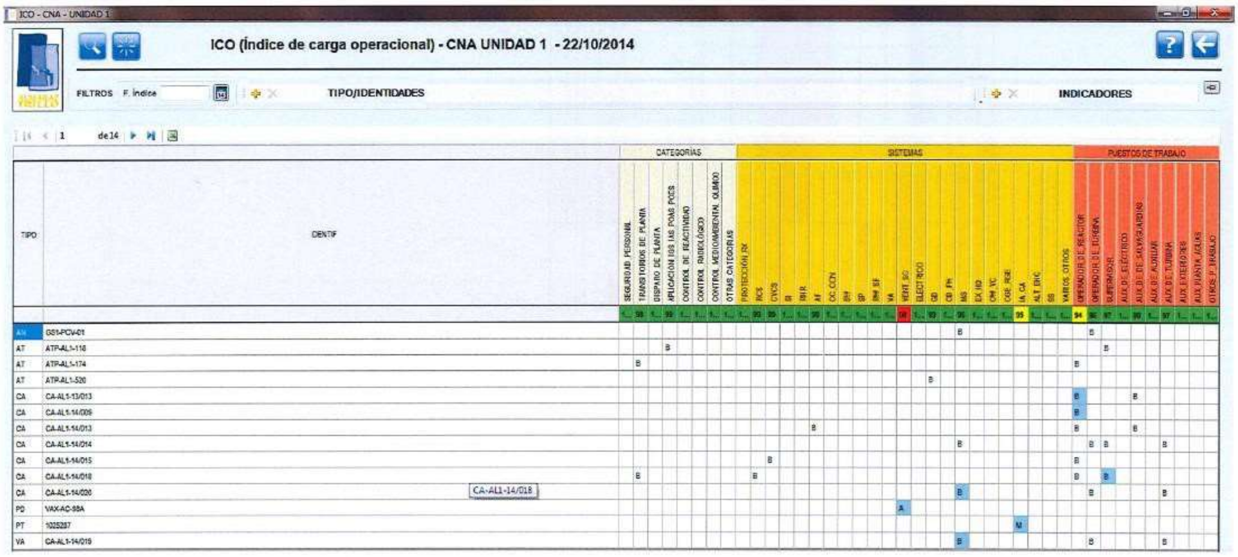
Control of risks associated with Plant activities:

Use of a plant configuration control indicator to evaluate and inform the plant on the status of daily operational focus.

The plant has developed a cross-functional indicator to show the cumulative impact of planned and emergent equipment outages, system health, system alterations, temporary modifications, surveillance and maintenance activities, abnormal conditions, and plant operator work load, to name a few, on the overall plant risk. This indicator gives the shift manager and plant management a global context of plant status and the impact of plant activities on a daily basis. This larger vision of plant status provides for improved resource prioritization and optimization and/or possible contingency actions required for the plant's daily activities.

Benefits:

- Provides a global impact context of overall plant status including equipment and activities
- Provides an overall plant view for robust operational decision making
- Provides a global impact context of the impact of emergent work activities
- Provides a cumulative impact of temporary modifications and long-term equipment outages
- Provides a cumulative assessment of plant operator work load and the effect of emergent work activities



Loviisa, Finland

Mission Date; 5-22 Mar., 2018

Use of process simulation to test and improve plant engineering process during design of modifications and upgrades.

Process simulation is extensively used in the plant to support safe and economical implementation of process and automation system modifications and upgrades. Simulation is used in the design process as early as possible to detect and correct design errors.
Planned modifications are modelled in simulator environment and a number of test scenarios (transient conditions and accidents) are simulated to check that plans meet requirements.
The plant has several people in-house who can do simulations which makes it efficient to co-operate iteratively with designers to improve proposed designs. These in-house simulation experts can provide analysis studies at short notice if required to study and help understand observations in design or in plant operation. Simulation helps to validate design, reduce errors and reduce the scope of dynamic system tests needed on site.

Use of simulation can also identify issues early before site acceptance testing of new digital automation systems. It has been possible to do comprehensive integrated testing on a newly produced I&C cabinet immediately after production is complete without waiting for all cabinets to be manufactured. It was possible because the cabinets that were not yet manufactured were represented by software emulation and the already produced cabinets were connected to emulated cabinets for integrated system testing.

The plant has invested in development of simulation competence within the organization and developed specific simulation software used in several applications:

- assist engineering of plant modifications and upgrades by testing new plans in simulator during design phase
- conduct safety analyses needed for plant licensing
- develop, test and validate emergency operating procedures
- test and validate new digital I&C systems in closed loop with simulated process models
- test and validate new human-machine interface systems
- train plant personnel.

Tihange, Belgium

Mission Date; 17 Apr. - 4 May., 2023

Permanent design modifications were integrated into a structured project management system, ensuring that the plant's resources and requirements were all aligned and followed a graded approach based on safety and complexity.

Purpose

Development of a process for enabling permanent modifications to be integrated into a structured project management system which ensures that:

- The plant configuration is controlled at all times;
- A graded approach is taken so that resources are concentrated where necessary, and scheduling is optimized;
- Identified risks are controlled (for example, commissioning risks, scope, resources, quality, etc.);
- The project portfolio is managed in terms of scope, resources, scheduling, budget and risks;
- The system is sufficiently agile to control changes imposed by external factors (for example, new Safety Authority requirements, procurement issue, weather, etc.);
- All modifications are ranked by importance to safety.

Description

The following factors enabled the objective to be reached:

- A robust and effective process to manage permanent modifications using monitoring software (Synapse) that tracks updates to documents affected by the modification;
- An efficient process to identify, challenge and track minor modifications and maintain the design basis;
- A project management system based on international best practices, complying with the Project Management Institute's (PMI) standards;
- Permanent modifications integrated into the project process to ensure robust and rigorous control and monitoring based on a periodically updated dashboard (Project Health Report), and on a set of Key Performance Indicators (scope, scheduling, risk, resources, etc.). The dashboard can be used to update senior management on permanent modification progress;
- A system for prioritizing site projects to align departments and resources;
- The use of a single IT project management system common to the entire fleet.

Benefits

The system implemented at the Tihange plant resulted in the following benefits:

- has operational and design documentation that always reflects the plant configuration;
- manages and reduces the lifetime of permanent modifications from initiation to completion;
- prioritizes the list of projects dynamically and periodically in order to align the entire organization (including resources);
- anticipates risks effectively and manages their mitigation plans.