OSART Good Practices
MAINTENANCE
Maintenance facilities and equipment

Ignalina, Lithuania

Mission Date; 5-21 Jun., 2006

The plant implemented a policy and wide programme to support usage of new equipment facilities/tools/stands and training mock-ups for mechanical maintenance. The main objectives are preparing and performing maintenance activities and implementing ALARA programme and practices.

There is a plant policy to enhance facilities/mock-ups for all mechanical maintenance workshops:

a) new equipment facilities/tools/stands:
- machine-tools in most workshops;
- hydraulic/pneumatic facilities;
- welding automats;
- new plasma-cutting facilities;
- full scope-test stand of Main Circulation Pump;

b) training mock-ups:
- mock-up for main circuits 300 mm tubes welding;
- removable insulation mock-up;
- cutting/welding/reinstallation full scope mock-up of fuel reactor tube-channels.

Size and arrangement of these maintenance facilities are appropriate for safe and efficient completion of work. Most of these maintenance facilities/mock-ups are used for maintenance training as well as for maintenance and maintenance tests to allow the improvement in the quality of works, industrial safety, skills, ALARA programme, qualification of personnel and interaction between managers and workers within maintenance staff.
In connection with the forthcoming plant decommissioning, the team evaluates this improvement as a good decision to enhance mechanical workshops and guaranty high-level safety requirements after Unit 2 shut down.

South Ukraine3, Ukraine

Mission Date; 9-25 Oct., 2006

Welding simulator

To train the welders in arc welding the plant equipped the Training centre with the computerized simulator named DTS-02.

The advantages of the DTS-02 simulator during welders' initial training are:

- simulation of welding with the help of low-amperage arc;
- limiting values and parameters of simulated welding (arc length, electrode displacement speed, etc.);
- saving welding materials;
- energy saving;
- no necessity to arrange"special" conditions in simulator premise,
- "WWSim" software tracks arc length, electrode angle of slope, values indication on the monitor;
- "WWSim" identifies deviation from prescribed parameters of training;
- trainees are able to see their errors on the monitor;
- after the training course the trainee makes a debriefing followed by a report;
- allows training welders in different positions, in different modes (simulates welding of different class steels).

This simulator provides an automatic assessment of trainees' performance.

Yonggwang, Korea, Rep. of

Mission Date; 16 Apr.-3 May, 2007

YGN 5&6 use a strong system of ownership for visual identification on maintenance of plant equipment. YGN 5&6 has developed ownership cards, with the name and picture of the responsible maintenance and contractor technicians, which are placed on the equipment being worked on.

This system of identification is designed to inspire responsibility and pride in technicians, assure the quality of maintenance being performed and improve the capability of identification of ownership on safety related equipment. The ultimate goal of the identification system is to ensure that materials are thoroughly checked for quality before maintenance begins, abide by the regulations and YGN 5&6 process and procedural requirements.

After maintenance is completed, there is a concerted effort to double check the quality of the work performed and to prevent human errors. This is accomplished by the responsible supervisor verifying that all information and corresponding joint cooperation of contractors is well coordinated and that the maintenance history and details of work performed are complete and documented. This system of visual accountability of technician's work practices and good maintenance practices is evaluated before the next plant overhaul and maintenance teams are awarded excellence status.

This good practice has resulted in no transient operation caused from maintenance work in 2006 on YGN 5&6, and has significantly motivated maintenance and contractor personnel to take pride in their work.

Metzamor, Armenia

Mission Date; 16 May-2 Jun., 2011

Safety upgrading implemented by own staff.
During last number of years the plant has implemented the upgrading of several important safety systems, including neutron flux measurement, radiation control and systems for early detection of emergencies. This upgrading was performed by the plant staff with the support of manufacturers and internal supporting organizations. Assembly and adjustment of novel systems was done by the plant. The upgrading was implemented on the following systems:

- Gas detection system at reactor vessel head.
- In-core temperature control systems including hard and software, sensors, uninterrupted power supply.
- Early primary leaks detection system
- Neutron flux measurement in source level (it is used in outage time during refueling and before start-up).
- Obsolete system of data acquisition and processing of neutron flux signals was replaced to meet requirements.
- Automatic regulator of the reactor power.

This unique approach was applied under the conditions of shortage of qualified manpower in the country only at the plant. The upgrading was implemented to high level of quality. Personnel involved were motivated to maintain upgrading in good condition because they were owners of the equipment. Personnel acquired deep knowledge and skills to successfully operate, maintain and repair deficiencies.

Seabrook, USA

Mission Date; 6-23 Jun., 2011

Dedicated channel test equipment and post calibrations.

In order to prevent a meter that potentially could have a flaw from causing the loss of function of safety related redundant trains or channels, a good practice was identified in the area of control of measuring and test equipment (M&TE) in combining the use of dedicated channel test equipment and the post calibration of M&TE as follows:

The use of dedicated channel test equipment: Dedicated Channel Equipment involves the use of specific instruments on specific trains or channels. The station has four safety related channels, the tags are colour coded red, white, blue, yellow. The station has four redundant sets of calibration equipment that are marked with the matching colour of the channels that they calibrate. This practice prevents a single piece of M&TE from causing a loss of functions on any more than one channel.

Post calibrations: Post calibrating M&TE when major work is performed provides assurance that the safety related equipment just calibrated is still in tolerance, so that any suspect readings can be evaluated immediately to ensure full operability and technical specification compliance.

Rajasthan, India

Mission Date; 29 Oct.-15 Nov., 2012

To avoid inadvertent contact with live electrical circuits, a pocket voltage detector was provided to all Electrical Maintenance section staff.

In Electrical Maintenance section, it is used by all departmental workers. These are small detectors with following features:

- Small Torch with white LED light.
- It detects the presence of voltages from 90V to 600VAC.
- LED light color changes from white to blue dependent on distance from source.
- (approximately 8 inch) and it changes to red light, closer to voltage source.

This helps the workers to avoid inadvertent contact with live components.

Rajasthan, India

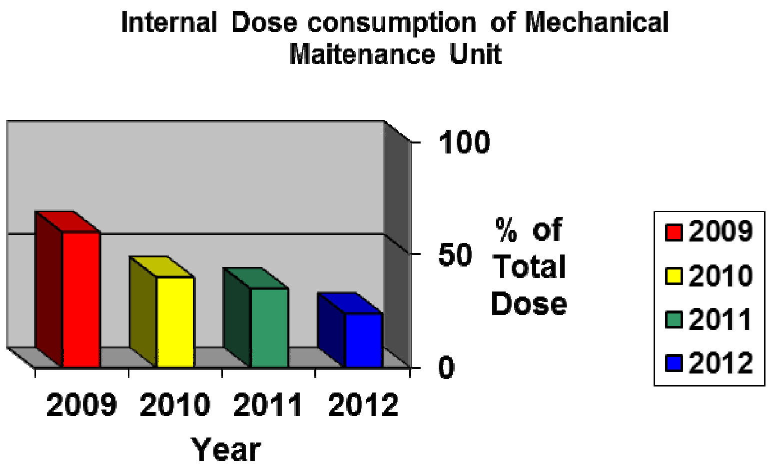
Mission Date; 29 Oct.-15 Nov., 2012

In order to reduce tritium uptake station developed a textile tailor made parachute balloon to seal off heat exchangers (HX) opening for drainage purpose and internal flushing of the 3211 HX moderator heat exchanger with non-tritiated D2O is performed before access.

In PHWR type of reactors, tritium uptake is of major concern. Sometimes, due to increase in area Derived Air Concentration (DAC), activities must be halted and this may increase equipment downtime, resource depletion and subsequently defeating the ALARA principles. On many occasions, during maintenance of heat exchangers (HX), spillage of D2O was reported which was a contributor to internal dose consumption by mechanical maintenance personnel.

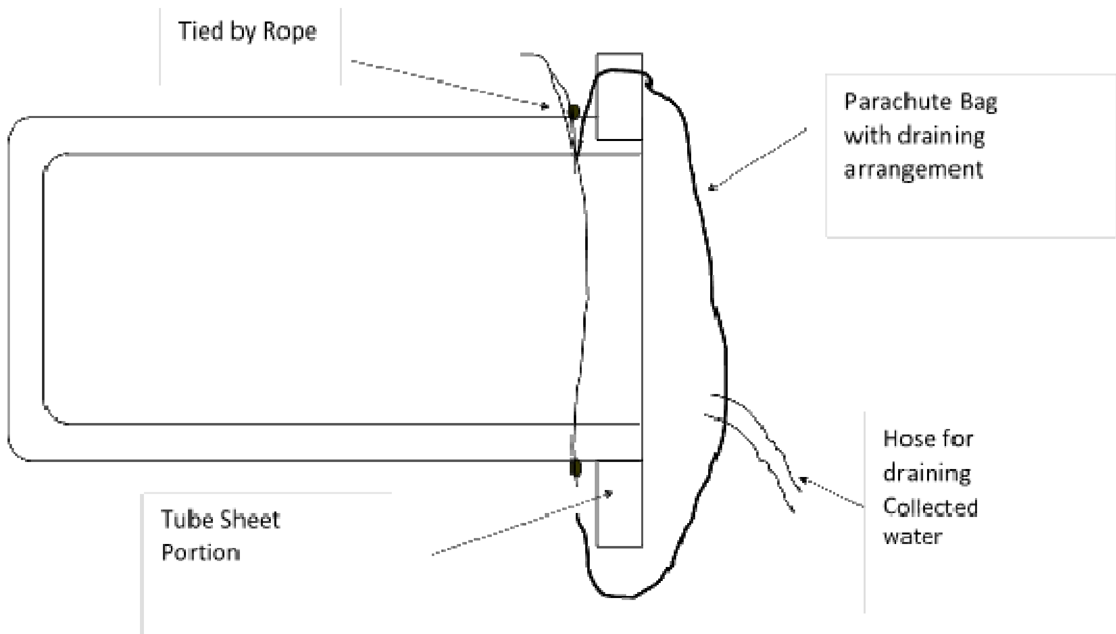
During maintenance activities carried out on D2O heat exchangers, various activities related to tube plugging and In Service Inspection by eddy current testing, it is necessary to drain D2O completely from the crevices of heat exchanger (HX). For this purpose, whenever a heat exchanger is opened, evaporation of D2O causes increase in Derive Air concentration (DAC) of that area. During D2O HX draining and collection practices, a small gap is created in-between the HX flange and cover and subsequently tailor made parachute balloon is inserted over the HX opening. The parachute balloon has one drain valve and a vent valve. The Heat exchanger is shifted backwards, later tilted up from the other end and residual tritiated D2O was collected from the drain point of the parachute bag. The bag is progressively drained into a drum using vacuum.

This technique is successful in draining of D2O heat exchangers like Shut Down HX, Regenerative Heat Exchanger, etc. This practice emulates ALARA principles by achieving reduction in internal dose. From dose data trend analysis, it is obvious that percentage of internal dose consumption for Mechanical Maintenance personal has been reduced from around 60 % in year 2009 to less than 30 % in year 2012.
Before work is performed at moderator HX an internal flushing with non-tritiated D2O is performed.



For moderator heat exchanger flushing, during bi-ennial outage period about 2 tons of non-tritiated heavy water is kept available. The “D2O addition station” is established inside the reactor building and all equipment required to carry out the operation is available. An established procedure (OTO No 21, rev.0, May 11, 2010) exists for the operation.

The experience shows that the air concentration of tritium at the work place is reduced from more than 1000 DAC to 10-50 DAC which substantially lowers the probability for uptake during the work. Ventilation with air does not give the same result since some hold-up water will always exist as the tritium activity of this water is of the order of 700 GBq per liter.



Schematic Sketch of HX and parachute balloon

Rajasthan, India

Mission Date; 29 Oct.-15 Nov., 2012

Use of testing facilities and mock-ups.

The station focuses on a philosophy “Do it right The First Time”. To achieve this, various test facilities and mock-ups are developed for enhancing the skill and competency of the maintenance personnel as well as improvement of system performance. It also validates spares before installation at actual location. The test facilities are extensively used for qualifying procedures and tools, training of the personnel etc. With electronic systems test facilities, it is possible to check electronic components of the systems for their health, fault identification and rectification, power supply tuning, etc. These test facilities contribute in reduction of down time, collective dose consumption, optimization of spare inventory and improve quality of work.

Most of the test facilities are developed in house over a period of time. The following are some of the test facilities developed at the station:

- **Primary Shutdown System (PSS) drive test facility:** PSS drive test facility tests the PSS drive at various simulated operating conditions at wet station. This facility is used for testing and qualification of PSS rods drive mechanisms before installing in field after maintenance. This facility is useful in reducing man-hours and collective dose consumption.
- **Reactivity Mechanism drive test facility:** This facility is for testing of Reactivity Mechanism Drive. Also the maintenance activities to be performed on the drive can be practiced and refined on these mock ups. This facility has resulted in the reduction in the Man rem and man hour consumption for the replacement of adjuster drives in situ. The collective dose consumption for Adjustor Rod Drive Mechanism maintenance has reduced from 5000 man millirem in Year 2002 to 250 man millirem in Year 2011.
- **Low Tension Motor Test facility:** This test facility contains provisions for testing motors like Moderator Pump Motor, Active Low Pressure Pump Motor, Active High Pressure Pump Motor, Active Process Water Cooling Pump Motor. All these motors are tested after maintenance on the facility before field installation.
- **Active & Non-active valve testing facility:** A separate valve testing facility exists for active & non active valves. All relief valves are also tested in this facility.
- **Dual Processor Hot Standby (DPHS) Card Test Facility:** This is a prototype of actual system and is used for testing of all types of input, output and logic cards installed in DPHS/DCHS systems. The test facility facilitates offline diagnosis, identification of problems at component level and quick rectification of the fault.
- **Channel Temperature Monitor Card Test Facility:** This facility is used for testing of all type of Channel Temperature Monitor cards. The test facility facilitates offline diagnosis, identification of problems at component level and quick rectification of the fault.
- **Programmable Digital Comparator System Card Test Facility:** This is a prototype of actual system and is used for testing of all types cards of Programmable Digital Comparator System.
- **Dew Point Probe Calibration Facility:** This facility is used for calibration & testing of dew point probes. It is useful for training & practical exposure to dew point sensors handling and calibration.
- **Control Valve Test Facility:** This facility is used for testing of CV instrumentation and training of the personnel. In-house maintenance capacity can be developed by giving hands on training to maintenance personnel without any intervention in the main.

- **Beetle Monitoring System Test Simulator:** This facility is used for testing of all types of moisture detectors monitoring system cards. The test facility facilitates offline diagnosis, identification of problems at component level and quick rectification of the fault.
- **Ram assembly test facility:** The Ram assembly drives performance check is done using this facility. By carrying out all the functional checks at this test facility, improvement in the reliability of Ram assembly before installation in field is achieved and does not consume any dose. This has led to dose reduction of 500 millirem for each replacement and a total dose reduction of 2000millirem in a year.
- **Oil equipment test facility:** The facility is used for leak test and performance checking of various oil equipment at the desired operating pressure, after maintenance.
- **Water equipment test facility:** The facility is used for leak test and performance checking of various light water equipment at the desired operating pressure, after maintenance.
- **Separator test facility:** The facility helps in calibration of the separator assembly consisting of feelers, retractors and side stops. This facility can generate and measure the very fine movements in the assembly. It is helpful in checking that the desired feed backs are generated at proper values.
- **MT-1 calibration facility:** The facility is used for testing and calibration of leak detector transmitter MT-1. This facility gives the volume as input to the transmitter to test over a full range of the transmitter.
- **Relay Testing Lab:** Relay testing lab has been set up for testing and calibration of all kinds of protection relays installed at the station. The Lab also has computerized program and facility for calibration of test and measuring instruments used in the section.
- **Card Testing Shop:** Electronic circuit card testing facility developed within the station houses tailor made test jigs for checking the health and settings of electronic cards as well as for trouble shooting of defective cards of plant safety related Power and Control uninterrupted power supplies(Power UPS and Control UPS), Inverters , Battery chargers, Rectifier systems and Main generator excitation system.
- **Valve Test Facility:** Motorized valve test facility has been developed at the station for testing and monitoring the performance of various types of motorized valves installed at the station before installation in field.
- **Universal Process Loop:** This facility is developed in-house for training new entrants and plan personnel for various C&I related task by simulating field like conditions.
- **Mini Power Station:** It is a working model of conventional process in a system consisting of steam generator, turbine, condenser, hot-well, CEP, dearator, feed pump, CCW pump & NDCT to train new entrants.

DPHS Card Test Facility

Separator Test Facility

Electrical Card Testing Shop

Active Valve Test Facility

Universal Process Loop

Mini Power Station

Clinton, USA

Mission Date; 11-28 Aug., 2014

Maintenance Learning Centre

The station has developed multiple scenario based mock-ups with mannequins simulating various in-plant activities to improve station personnel and outage contractor performance related to industrial, radiological, nuclear and environmental safety. Scenarios challenge employees to identify and take appropriate action when presented with faulted situations, worker behavior errors, and procedural compliance gaps.

The station reviewed contractor performance over multiple years to identify outage performance trends. From this review, the station developed seven mockup stations with mannequins that simulate errors. The course is named Fundamentals Alley.

- The Fundamentals Alley begins with a lecture on the Generic Error Model System. It examines the three mental models that people use to make decisions (skill based, knowledge based and rule based) and the error rate associated with each model. The emphasis is to remain in rule based activity, the importance of procedure compliance and the need to stop work and involve management before getting out of process.

- Employees are then split into small groups (3 to 5 students) and each group is given a clipboard with a written description of the work activity the mannequins are performing at each of the seven stations. Students have five minutes to identify all of the errors at each station before moving to the next station.

Once all seven stations have been observed, the students return to the classroom and the instructor reviews their findings and adds additional details to support the importance of each safety topic

This training utilizes a novel and effective approach to reinforce key industrial, radiological, nuclear and environmental safety expectations for station and refueling outage contract personnel and builds confidence in new workers ability to identify safety concerns prior to performing work.

Borssele, Netherlands

Mission Date; 1-18 Sep., 2014

Manipulator used for ultrasonic testing of reactor control rod drive tubes.

The plant has introduced and developed a specific manipulator for the ultrasonic test of several welds located on reactor head control rod drive tubes.

More inspections are required on the reactor control rod drive tubes, due to the latest version of the ASME code and the enhanced requirements of the ageing management program. An assessment of the material properties and behaviours has been made for all reactor control rods tube welds with and without the thermal sleeve with the new ultrasonic inspection tool, to ensure that the mechanisms and changes in material properties are known and there are no internal changes or degradation on the inside of the tubes.

The lower welds of the reactor vessel tubes are located under the thermal insulation and can only normally be reached by removing the insulation. This would give high radiation exposures and so welds were not inspected. Previously, the upper welds have been inspected several times with radiographic and penetrant method.

With the use of this new manipulator, ultrasonic inspections can be carried out for lower welds, as the manipulator is placed below the head and the probes can reach all welds on all the tubes. The manipulator includes two manipulators reaching both required diameters of 147.2 mm and 55 mm.

The inspection method was fully qualified using blind and open calibration blocks on basis of European Network for Inspection Qualification (ENIQ) requirements.

Using this new inspection manipulator the inspection time and radiation exposures received are significantly reduced.

Paks, Hungary

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

Slab/block turning equipment – Lifting equipment for hermetic slab/block covering in reactor hall

At MVM Paks NPP during the maintenance works of an outage it is necessary to remove the hermetical slab coverings in the reactor hall. These slabs cover the maintenance openings over the steam generators and are part of the hermetical wall. On each unit in every outage at least 3 slabs need to be removed – for the structural tests of the steam generators, for installing ladders, and for scaffold and insulation works. After the removal of the slabs the silicone sealing profiles need to be inspected. To replace damaged sealing profiles the slabs need to be turned over. For this purpose the so-called slab turning equipment was developed. The lifting beam is connected to the crane hook with a hanger bar. The holders of the hanger bar are welded to a reinforced, hot-rolled profile that is capable of bearing the 28 t load, with four joints installed at the underside. The turning beams are powered through a connector on the lifting beam. This connector also ensures the synchronous movement of the turning beams.

To safely secure the slabs adjustable grips are needed. The grips are welded structures that can be opened to easily attach to the slabs. When the grips are tightened fixing pins ensure that the grips cannot accidentally open. The sides of the grips that are in connection with the surface of the slab are covered with non-slip material to ensure that the slabs cannot move during manipulation.

This structure made the whole process a lot safer and easier. Before these slabs could only be moved with the parallel use of two cranes. Then the swinging of the slab was unavoidable and could only be stopped with the rigging cord. With the use of the new equipment the slabs are evenly turned, not swinging over the vertical position - which was the riskiest part of the process. The new equipment reduced the risks of personal injury and equipment failure due to dropping.

Slab turning equipment

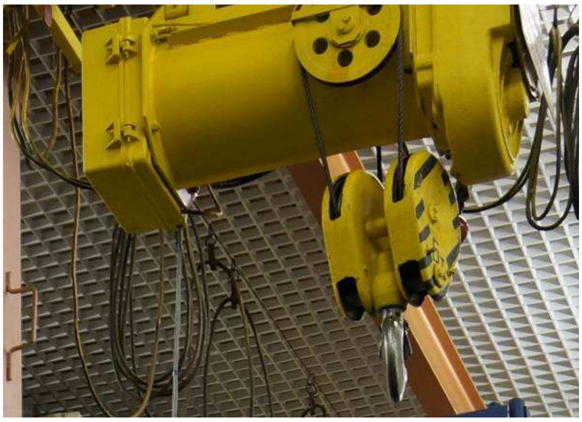
Kola, Russia

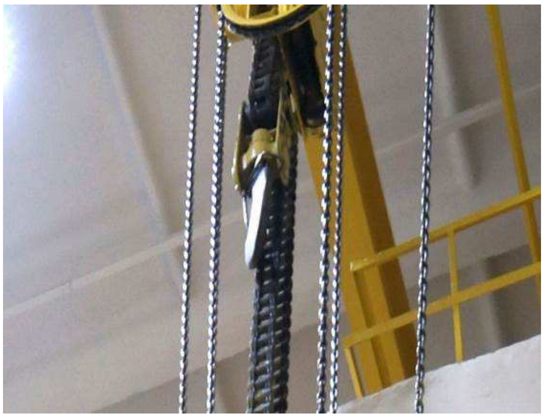
Mission Date; 10-27 Nov., 2014

The operation of lifting equipment is very well controlled to ensure its safe use.

The safe operation of load-lifting mechanisms is managed in the following way:

- Upon termination of work, the hook of the lifting equipment rises fully to its top position.

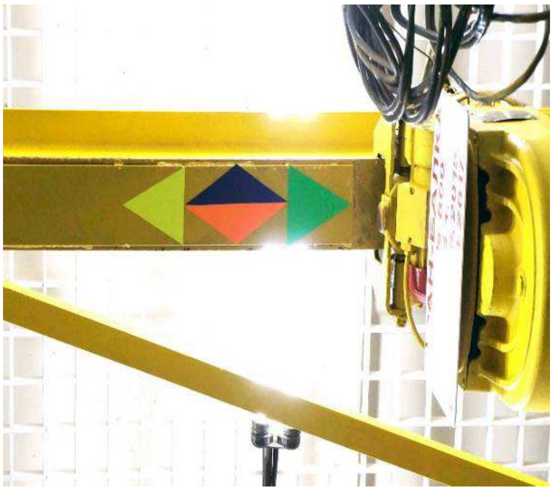




- The lifting equipment moves to the parking position indicated by a visual alarm.
- The control panel and drive chain are retained in special housings.

- The housing containing the operational control is locked, keys for the control panel and its housing are retained by the responsible person.

- The bridge (beam) of the lifting equipment has colour markings showing the direction of movement, each colour specifies the direction of travel corresponding to marks on the control panel.



- The control panel of the load-lifting mechanism also has colour markings, each color specifies the direction of travel corresponding to the marks on the bridge (beam) of the load-lifting mechanism.

These measures provide the following advantages:

- The possibility of unauthorized access to the control panel and drive chain circuits is prevented.
- The possibility of human error is minimized when selecting the direction of movement of the lifting equipment.

Following the implementation of this approach, the safety of operation of the lifting equipment has been significantly enhanced.

Sizewell B, UK

Mission Date; 5-22 Oct., 2015

Use of a mechanical key interlock scheme to prevent unauthorized access to the Reactor Protection System

The station Reactor Protection System [RPS] comprises of 2-off diverse 4-train independent protection systems. The Primary Protection System [PPS] and the Secondary Protection System [SPS] provide both diverse Reactor Trip [Scram] and post-trip Engineered Safeguards Features [ESF].

Both systems are designed to allow authorized access at power to only one train per system at a time for normal maintenance and testing. All cubicles and transmitter racks are accessed via hinged doors fitted with a mechanical lock and key system.

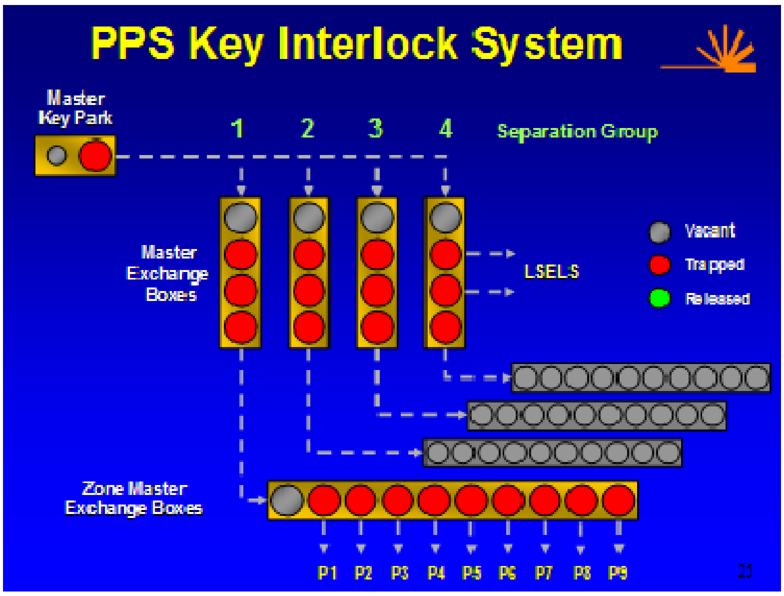
The master key [one per system] gives access to a Separation Group [Train] Master key box that releases keys in cascading order to further key exchange boxes, located in the Plant adjacent to the related cubicles and transmitter racks. Keys from the slave boxes are then released to open the doors to the cubicles for testing and maintenance.

Each key is unique, and the release of a key from the master box prevents the release of a key from another Separation Group until the first released key is returned. The slave boxes also retain their sub-master key which can only be released when all of the individual door keys are returned.

Thus the key system allows maximum access for testing and maintenance while preventing inadvertent trip or actuation due to testing or maintenance activities.

This supplements Human Performance and administrative controls to give an additional layer of defense during Nuclear Safety related equipment work.

There have been no cases of unauthorized access to the Reactor Protection System as a result of this interlock scheme.



Bruce B, Canada

Mission Date; 30 Nov.-17 Dec., 2015

The plant has installed mechanical torque wrench verification stations used to perform testing of torque wrenches before and after use in the field. This is done in addition to the regular calibration checks prescribed by the equipment manufacturer and allows for functional traceability on a job-by-job basis. This practice ensures the torque wrench is working properly before and after each job, eliminating extensive reviews and additional rework if a torque wrench becomes lost or otherwise damaged.

Examples of benefits:

- Physical verification of proper performance before starting work;
- When results are documented, it prevents extensive review for tool usage if torque wrench is found damaged or lost;
- When results are documented, it prevents additional rework in potentially hazardous or difficult access areas to verify conditions when a torque wrench is found broken or lost.

Bruce B, Canada

Mission Date; 30 Nov.-17 Dec., 2015

Use of a pure Deuterium Oxide (D2O) pump up tool to prevent venting and draining of Tritiated D2O during instrument calibration.

Operation of a CANDU reactor creates Tritium as a radionuclide when Deuterium Oxide is irradiated.   This is an inhalation/wetting hazard for workers and a source of contamination that is easily spread and made airborne. The plant uses a special purpose, pure deuterium oxide (D2O) pump up cart to backfill instruments and instrument lines when performing calibration of instrumentation loops.   The cart is equipped with a tank of pure D2O, a closed loop regulated pump system, and over pressure protection to ensure that the process system the cart is connected to cannot be over pressurized.   By backfilling instrument lines with pure D2O instead of draining or venting process fluid during calibration, the tritium hazard is mitigated thus reducing the risk to workers and preventing loose contamination.