OSART Good Practices
RADIATION PROTECTION
Control of Occupational exposure

North Anna 1/2, USA

Mission Date; 24 Jan-11 Feb, 2000

The ALARA program is very well established and very well understood by everyone. Effective use of remote monitoring techniques and a central radiation protection control room have improved radiation protection monitoring of workers, reduced personnel dose and decreased the needed level of technician support. The system uses numerous video cameras, radio communications, and telemetric electronic dosimetry to monitor both worker and area dose rates during normal operation and outages.
In addition, work groups and individual workers exhibit strong awareness and ownership of their doses. Dose reduction is an integral part of work and outage planning. The program is especially effective, because all parts of an excellent program are in place and are of high quality:
- Adequate staffing and efforts from RP
- Source term reduction efforts have been continuous and successful;
- Extensive, well-prepared and high quality pre job briefings are conducted; Attendance at these briefings is recorded and mandatory before entering the RCA. Industry experience is systematically assessed during these briefings;
- Well-documented and high quality post job reviews are completed. Lessons learned are incorporated in the procedure or in the briefing for the next time;
- Mock-up training is extensively used before performing the work;
- Maintenance supervisors and workers, including contractors, are well aware of the importance of ALARA and of the lessons learned from previous outages for their own work;
- Graphs are widely distributed daily, showing actual versus predicted dose;
- Temporary shielding is put in place wherever required.

Mühleberg, Switzerland

Mission Date; 6-23 November, 2000

The plant has spent significant effort in installing hardware modifications to keep doses ALARA. In the past 20 years, the plant has had an extensive program to evaluate and trend the plant radiological conditions yearly. The results have been used to improve plant radiological conditions and reduce collective dose. Examples implemented during the last ten years to reduce dose rates in the plant include:
- fixed shielding installed in numerous places in the plant. During each outage, a large quantity of temporary shielding (approximately 90 tons) is installed, mainly in the drywell;
- in approximately 50 places, piping was modified in order to be able to clean the piping and to flush hot spots by means of high pressure cleaning;
- stellite containing ‘pins and rollers’ in the control rods have been replaced by low cobalt sliding pieces;
- zinc conditioning was introduced to reduce dose rates;
- chemical decontamination of the reactor water cleanup system;
- recently, application of noble metal to minimize the impact of hydrogen injection.

Nogent, France

Mission Date; 20 Jan.-6 Feb., 2003

The plant has developed several innovating ways to reduce dose for specific problems in plant areas and the actual doses in the plant are very low. Some of these are:

1. In order to reduce doses of the decontamination crew in the tasks of manual sump cleaning, this activity has been mechanized. Now, the operation is done with minimum time near the sump, by means of a mobile system that employs a pump to suck the water and a shielded filter to clean it. The results are a drop in the ambient dose rate with direct impact on the dosimetry of the operation and chemical teams. The collective dose has been reduced by a factor of two for the decontamination crew. Also, there have been gains in terms of dose reductions for operating and chemistry teams by means of eliminating hotspots and the reduction of area dose rate near the sump. Additionally, there is no production of prohibited waste (sludge) because particles are retained in the filters and these are treated as normal waste.
2. In order to reduce the doses around the concrete drums of high activity waste, an additional biological shielding has been designed as a big metal container drum, where the smaller drum can be introduced. The dose rate produced by these high activity drums inside and outside the waste treatment building has been reduced by a factor of 8.
3. Optimization of the cavity decontamination operation by reducing the dosimetry and the critical path. This was accomplished by changes in the cleaning method (no manual scrubbing) to low pressure water with cleaning foam, and an optimization of zones to decontaminate. The results are a reduction of outage critical path and collective dosimetry by a factor of 7 for decontamination after unloading the fuel and by a factor of 2 after refueling.

Civaux, France

Mission Date; 12-28 May, 2003

The plant developed a user-friendly software (called "EDP") to make dose estimations and provide experience feedback for ALARA purposes. This software is used by all departments for planning, monitoring and integrating radiation exposure operating experience for all work in the radiation controlled area.

For the planning of the plant's first outage, the management decided to introduce software designed to make optimised dose estimates for each job. Everyone can consult this user-friendly software on the computer network.

EDP is used by all departments for:

- The calculation of dose estimates which can go as far as the work order grid,
- The formalization of the ALARA approach used (ALARA check-list),
- The monitoring of the dose for the work site,
- Easy comparison between radiation exposure at the work site and the objectives for the work,
- Analyses by department, activity, work site, elementary system, etc. for monitoring, control and operating experience purposes,
- Reporting good practices or any unforeseen circumstances encountered,
- Benchmarking between units and outages,
- Optimisation through consideration of operating experience from previous work.

The radiation protection department advises, approves and controls the different stages of the process. The radiation protection department analyses the results of previous outages with the other departments to optimise radiation exposure for the following outages.

The EDP file is printed out and placed in the work package file on the work site. The workers fill in the integrated doses, comparing them with dose objectives. At the end of the work, the doses which have been recorded and entered in the computer software by the workers are compared with the objectives and the file provides operating experience feedback on the work.

The introduction of this software has led to close involvement of each department in addressing radiation exposure at the planning stage and in monitoring their work sites.

It is a tool for operating experience feedback and progress which has resulted in better refuelling outage results for the fleet.

Penly, France

Mission Date; 29 Nov.-16 Dec., 2004

A well-defined approach has been set up to control and follow potential internal exposures. The approach takes into consideration both scientific and human performance aspects. The team acknowledged that this good practice is done in French plants, but wanted to bring to the attention of other nuclear plants

Contamination can be detected at the various plant portal monitors. Once informed of the problem, the nurse comes to get the person and takes them in the on-call vehicle to the medical centre decontamination room after they have put on clean coveralls. Inside the decontamination room, a complete detailed body examination is carried out. An examination report is drawn up on paper and external decontamination is carried out in compliance with the procedures.

At the end of this decontamination, a whole body count is carried out on the person dressed in protective paper clothing. The whole body count has two levels of identification involving medical actions. The level (D) corresponds to an internal contamination, which could result in an effective integrated dose of 0.5 mSv (threshold for reporting at EDF). In this case treatment is dispensed and complementary examinations (radio toxicology of urine and faeces) are requested.

The contaminated person is informed that during the time of the complementary examinations he cannot go into the controlled area and he receives temporarily the authorization to bypass the C3 monitors at the exit to the site. If needed care is also taken for psychological aspects, in order to alleviate any traumatic effect of the event. In order to do so, the medical team can rely on a system implemented by several site doctors and whose aim is to reply to the main questions posed by people who have been contaminated internally. A copy of the examinations is given to the contaminated person as well as to their company doctor if they are contractors.

On the days following the event, the person is invited to undergo whole body counts in order to monitor the elimination of contamination from their digestive tract. Radio-toxicological examinations (urine and faeces) are sent to the relevant EDF lab and to the Authorities for inter-comparison. Finally, should a dose above 0.5 mSv be registered, a report is sent to the employee's company doctor if a contractor is involved. For EDF staff it is inserted by the site doctor into the DOSIREG computer application.

Cernavoda, Romania

Mission Date; 22 Jan.-10 Feb, 2005

Apply Fading Correction Factor for TLDs

A fading correction factor is applied on a monthly basis by irradiating the control dosimeters with a predermined dose (e.g. 400-500mR) to correct the TLD readings.

For each in service batch of TLD's a control dosimeters (one TLD for 50 personnel TLDs) are irradiated (at a dose about 4-5 mSv), to control and apply fading correction factor for one month period. The control dosimeters are kept in the same place and in the same condition with the other personnel dosimeters.

Borssele, Netherland

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

Dose “lifetime graphs”; The plant strives to keep the individual maximum, 5 year average, dose lower than 3 mSv/year.

The RP department produces a dose "lifetime graph" every year in which a 5-year average line is inserted. In this way RP and workers have a simple overview of average dose for the last five years. These dose "lifetime graphs" support the plant policy to try and keep the individual maximum 5 year average dose lower than 3 mSv/year. The dose "lifetime graphs" are annually provided to the workers and if necessary, reviewed with the department managers. If during the year, a person is nearing 3 mSv, the department manager is consulted, in order to try to take measures to limit the dose in the rest of the year.

The individual dose was already a concern for the RP department and the NPP in the 80’s.

At that time the policy was to keep the individual dose for employees and regular contractors lower than an average of 10 mSv/year.

In the 80’s, a dose "lifetime graph" was made every year, to keep track of people with relatively high dose.

RP produces a dose "lifetime graph", every year, in which a 5-year average line is inserted. In this way, RP and workers have a simple overview of the average dose for the last five years.

These dose "lifetime graphs" support the plant policy to try and keep the individual maximum 5 year average dose lower than 3 mSv/year.

A dose "lifetime graph", with the 5-year average dose line, is produced every year.
The dose "lifetime graphs" are distributed to the nuclear workers.
The dose "lifetime graphs" are reviewed annually and whenever necessary with department managers.

If necessary, possible and desirable, measures are taken to lower the dose of an individual in the following year(s).

If, during the year, a person is nearing 3 mSv, the department manager is consulted in order to try to take measures to limit the dose in the rest of the year.

Ignalina, Lithuania

Mission Date; 5-21 June, 2006

Non-reagent decontamination of primary circuit
Reactor RBMK-1500 has a number of peculiarities:
-large number of channels
-branched pipeline network
-special thermal treatment of fuel channels from Zr-Nb alloy which provides certain limitation to the acid application for decontamination
-condensate-feed circuit operates in a neutral oxygen mode (200ppb O2)

The INPP together with VNIPIET and NIKIET has developed non-reagent decontamination process of primary circuit. This methodology is based on the change of behaviour of radiolysis products (H2 , H2O2 , O2) during cooling down.

Process consists of the following stages:
1.Cooling down of primary circuit after shutdown till 1800C with running MCP and by-pass purification system of primary circuit. Concentration of corrosion products in the water during this period is not very high.
2.Circulation cleaning of primary circuit in order to remove corrosion products which have appeared during cooling down. At this stage the iron corrosion products appear within the temperature range 150-1100C
3.Boiling mode of primary circuit at the temperature 95-1000C during 11 -1 6hours, Cooling Down Pumps are used and by-pass purification system of primary circuit is in operation. Concentration of corrosion products increases 2-4 ppm.
4.Main Circulation Pumps are switched on in order to remove corrosion products from the surface to water during this previous stage
5.Corrosion products are removed from stagnated zones by means of water speed acceleration
6.Flushing of equalizing pipelines between separator drums
7.Flushing of drain pipes from the main pipelines.

Gamma-sensor installed at the inlet pipe to the by-pass purification system of primary circuit provides monitoring of efficiency of different flushing stages. These sensor indications are displayed by the computer of local information system. On the basis of sensor readings the corrections of each stage are performed.
As a result of annual flushing the stable gamma level is maintained. During flushing the corrosion products in amount from 20 to 70 kg with activity from 70 to 200 TBq are removed.

Tihange, Belgium

Mission Date; 5-23 May, 2007

Integrated Detection of Internal and External Contamination.

The plant has equipped all exits of its radiological controlled area with sensitive exit gate monitors "IPM9" that are equipped with beta and gamma detectors. Beta detectors monitor worker skin contamination at the level of legal requirement.

The purpose of the gamma channel is to monitor worker internal contamination and detector sensitivity is sufficient to detect internal contamination of the monitored worker lower than or equal to 1% of the annual limit of intake of the most important radioisotopes of interest.

An internal contamination is recognized from external contamination if, after decontamination of the worker's body, the monitor detects only gamma contamination or if the whole body contamination monitor indicates contamination of the respiratory and digestive traces. In this way, all radiation workers at the plant are systematically checked after every visit to the RCA for external as well as internal contamination. The short monitoring interval makes it possible to detect intakes of radioactivity promptly at acceptable detection levels.

Additionally all external radiation workers arriving on site are controlled at the entrance by 2 IPM9 monitors.

The practice is performed independently from internal contamination monitoring of radiation workers performed twice a year by the authorized medical services using whole body counter with a germanium detector.

This practice enables worker intake of internal contamination to be well detected at an early stage.

Tihange, Belgium

Mission Date; 5-23 May, 2007

Fixed structures for non permanent lead shielding blankets.

The plant has designed and installed seismically qualified fixed structures on which blankets of lead shielding can be quickly installed and dismantled for high dose rate worksites in places where workers go to carry out systematic maintenance activities.

As a result, there is a considerable saving in individual and collective radiation exposure at each outage, resulting in the following advantages. There is no longer any need to bring, install, accept, dismantle and remove scaffolding to install shielding on these worksites. The fixed structures allow shielding to be installed earlier in an outage. It is quicker to install and remove shielding thanks to the geometry of the specifically designed structures. Since the radiation exposure incurred by the installation of this shielding is low, it is worthwhile applying even for short jobs as implementation of ALARA.

An additional advantage is that very little investment is required for these fixed structures. This practical approach is easily applicable even in seismic qualified plants because of its ergonomic design and savings in terms of dose and investment.

Chinon, France

Mission Date; 27 Nov. - 14 Dec, 2007

Use of the boric acid valve lineup display has reduced operator occupational exposure due to performing manual valve lineup operations on the boron and water make up system. Previously, the plant experienced numerous operational, safety significant events concerning boron and water make up system valve lineup errors, which resulted in a loss of functionality of the system. Each valve lineup configuration of this system required field operators to check and manipulate over 50 separate manual valves located in numerous areas of the plant, some with elevated ambient radiation levels. A field operator proposed the idea of using a dynamic display to check valve lineups on this system.
The online monitoring system does not actuate individual valves, but displays the position of each valve in the system relative to specific lineup configurations. In this way, the field operator only needs to manipulate the valves required to be repositioned for the lineup and does not need to check the position of the remaining valves in the system. The display, in addition to valve position indications, provides positive indication of main voltage supply, voltage supply to each channel, voltage supply to valve position sensors, and sensor faults. As a result of installing the valve lineup display in each of the four units, the plant has reduced the exposures of operators by a total of 5 millisieverts each year. The display system is unique to the plant.

Arkansas, USA

Mission Date; 15 June. 2 Jul, 2008

Information technology to support radiation data acquisition and field display results in improved radiological performance.

A software system called the Radiation Data System (RADS) provides the ability to monitor radiation and airborne radioactivity levels throughout the plant and also outside areas. This system has been developed by the plant to allow workers to obtain radiological information prior to entering radiation fields and provides a method for radiological surveys to be documented and retrieved. Over 80 monitoring devices are used to provide dose rate information every 4 seconds from the field where they are located. During the outage period the number of devices is increased to over 140. The system provides alarms to alert the plant staff if radiation or airborne conditions are changing. Trending of dose rate data allows for accurate evaluations of dose reduction strategies.

Display computer monitors are located at the radiation controlled area boundary and throughout the plant for the workers to access. All hard wired computers also have access so any permanent plant staff can review radiological data before leaving the office. The data displayed provides live time information from the detectors located on plant and also imported data from recent radiological surveys completed by radiation protection technicians. Other information includes details of hotspot and any lead shielding.

The RADS system also allows a worker exposure to be monitored in the field by telemetry of information back to a central station. If conditions change in the field an alarm will occur locally with the worker and at the central monitoring station or also locally to any wireless laptop computers. The system can be used during outage, non-outage and emergency conditions. Telemetry data can be used up to 0.65 miles from the plant during emergency situations.

A RADS simulator has also been developed that provides scenario training to the radiation protection technicians. The process provides instruction for the response to alarms or any changing conditions in a control environment by providing radiological data in a real life setting. The required training scenario can be selected for a multitude of situations such as under vessel repair to diving in contaminated water. The system also has a scenario for emergency planning exercises to provide data that would be seen under emergency conditions. The simulator can also be used as a process to validate procedures against any of the scenario situations.

The plant also uses an electronic message board to communicate radiation dose rate information and instructions to workers. The system called MDRD measures the radiation dose rates in the area and displays the dose rate information on a large marquee sign, which can be visible from at least 30m. If the dose rates increase in the area then the display changes colors and will also provide additional instructions to the workers in the field. The dose rate information can be displayed locally at the sign and by telemetry at other monitoring stations across the site. When conditions are normal the sign displays the information in green. When the dose rates increase to a preset limit the sign color changes to yellow and if a higher limit is reached the color changes to red. Each change in condition is reflected in a new written instruction that is displayed on the marquee sign to instruct nearby workers.

The plant has implemented the use of the marquee sign, particularly in areas where dose rates are subject to change. An example of such an activity would be radiography where it is used to enhance radiological controls. A MDRD sign is placed close to the radiography source and will provide an indication that the source is in a shielded position. Once the source is out of the shield the sign color changes to red, providing additional warning instruction to workers. In another example of source term reduction and trending, the detector can be placed directly on a radiation hotspot and the trend displayed on the MDRD at a safe distance.

Cruas, France

Mission Date; 24 Nov -11 Dec., 2008

Mobile optimized flushing and filtering system for contamination and hot spots removal (ORFO).

The plant has developed and uses a specific system for crud (activated particles in the primary coolant and auxiliary systems) removal from connected and circulating system. It is inexpensive and effective. ORFO is mobile and easy to operate. It consists of a filtration unit with a filter, pump for circulation and hoses with flexible connecting flanges. Lead shielding around the filtration unit protects the operator from radiation.

As it is a mobile system, it can be connected as close as possible to a hot spot area and the membrane pump ensures circulation and removal of radioactivity by filtration of particles. An additional benefit is that it can reduce time of drainage of the cleaned system, or reduce radioactive waste production by re-injection of the cleaned water to the boron recycle system.

As example of the ORFO performance is its use in the ten years outage at unit 4. As results from dose rate measurements of hot spots indicate , the dose rate reduction of processed hot spots was 7,78 Sv/h and total dose rate on spent filter bags reached 6,4 Sv/h.

Mihama 3, Japan

Mission Date; 15 Jan.- 5 Feb., 2009

The personal dosimeters worn by workers at the MIHAMA NPP are of the glass badge type (GB) which displays better performance than thermo luminescence dosimeters or dosimeters of film badge type and are easy to manage and use.

The personal dosimeter GB, used at the MIHAMA NPP, has wider energy range, 10keV - 10MeV, and dose measurement range, 0.1mSv - 10Sv, than other types of personal dosimeters, and offers better energy characteristics, margin of error, and directional characteristics.

It is a stable unit with minimal variability between different units, better resilience to heat and moisture, and almost no phasing.

The use of GB enables accurate measurements of workers' personal dose, thereby providing effective radiation protection.