OSART Good Practices
RADIATION PROTECTION
Control of occupational exposure

Ignalina, Lithuania

Mission Date; 5-21 Jun., 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 O_2)

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 (H_2 , H_2O_2 , O_2) during cooling down.

Process consists of the following stages:

1. Cooling down of primary circuit after shutdown till 180°C 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 150-110°C
3. Boiling mode of primary circuit at the temperature 95-100°C 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; 7-23 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; 7-23 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.

Khmelnitzky, Ukraine

Mission Date; 29 Oct.-14 Nov., 2007

Radiation warning and emergency (action) alarm levels at stationary Radiation Monitoring System (RMS) were voluntarily lowered by plant management in order to provide early alarms in case of anomalies.

Since KhNPP commissioning a huge amount of RMS output data has been accumulated in the database. In addition to legal limits and control levels, set by the Company, the plant took an independent decision to set in RMS for each radiation monitoring channel even lower levels of response to radiation parameters deviation. This decision was based on achieved levels of radiation parameter values for all previous operating period and the alarms were set according to the following principle:

- Warning (investigation) level: 150% from the average steady level.
- Emergency (action) level: 200 % from the average steady level.

Besides, a more sensitive warning system has been installed with light and audible signal in case of only 20% variation of measurement channel values up or down from the average daily value. This allows responding to changes in radiation environment on early basis before warning or emergency set-point is reached. Procedures exist to follow any anomaly, to log it, to investigate, to suggest and/or to perform corrective action.

The modification increased the radiation monitoring system sensitivity and attracts operators' attention to changes in process monitoring, status of safety barriers and in radiation environment.

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 Jun.-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; 20 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.

Doel, Belgium

Mission Date; 8-25 Mar., 2010

Staff have been trained to assist in the proper usage of protective clothing and equipment to prevent personal contamination and prevent spreading of contamination.

All radiation protection staff and selected radiation protection contractors are trained in appropriate dressing and undressing procedures for protective equipment. Training is conducted in facilities simulating the radiation controlled area, located at the plant's training centre. Training includes lectures to explain and highlight the importance and benefits of correct usage of personal protective equipment in the radiation controlled area. Demonstrations and practical rehearsals are carried out with all personal protective equipment used in the radiation controlled area. The examination to obtain the dresser certificate contains both written and practical sections. A refresher course is performed annually.

The plant has experienced some cases of group contamination in recent years. Analysis of these cases identified procedures for removing personal protective equipment as one of the reasons for contamination. The "trained dresser" practice has been integrated into the plant ALARA process and dose reduction program. Since the practice was introduced, the number of external contaminations has decreased. Evidence of the decrease in contamination cases is clear.

The use of trained dressers was found by the team to be quite unique and innovative. The practice would be relatively easy to implement in other installations. The benefit of the practice has been seen in the reduction in the number of cases of personnel contamination. When trained dressers are used, radiation protection staff can focus on their other activities.

Dukovany, Czech

Mission Date; 6-23 Jun., 2011

ALARA performance

The performance indicator for the Collective Effective Dose of Dukovany NPP has shown exceptionally good results in comparison with other PWRs and VVERs for many years. For the last three years, it was a value of less than 0.15 manSv per Unit.

Excellent ALARA performance at Dukovany NPP is a matter of a comprehensive approach which is based on the following technical and organizational aspects:

Initially, a low level of doses is in connection with selection of a low-cobalt material in the early design of primary system components, and its passivation before the Units start-up. During outages, reactor coolant components such as steam generators, pumps and hydroaccumulators are decontaminated when needed, and the ALARA principle regarding planning and following-up on a daily, weekly, monthly and yearly basis has been adhered to. The ALARA practice is supported and registered by an ALARA software module which is connected with all other relevant RP data.

In addition, the plant has defined criteria (in line with application of the ALARA principles) for work with a risk of radiation. In the case of a very high radiation risk, there are additional related criteria implemented and a special operating instruction (procedure) has to be developed which is called "Program of radiation protection safeguarding" (PRPS). Photo-documentation with actual measured radiation is developed for selected PRPS activities which allow the maintenance team to be familiar with the radiation situation before the work starts. In such a way, people involved in the activities are fully acquainted with the hot spots and sources of radiation. This PRPS is developed by both the RP department together with the contractor's technician, responsible for RP.

Precise RP planning has been done for significant modifications such as SG collectors change, modernization of equipment for CASTOR casks manipulations and layout and improvement of the Spent Fuel Temporary Storage.

There are also a selected number of managers from all NPP departments and contractors who are RP license holders – i.e. they are specifically trained and have passed state exams in radiation protection (at the state regulatory body office).

Smolensk, Russia

Mission Date; 5-22 Sep., 2011

Automated Thermo-luminescence Dosimeter (TLD) Issue System.

A new system has been developed by the plant in partnership with the equipment manufacturer that prevents the incorrect issue of a TLD dosimeter to an individual. This system is installed at the point of entry to the controlled area. The issue unit comprises the following components:

- Automatically opening drawers.
- A liquid crystal display to display relevant information or messages.
- A barcode reader for identification of individuals.
- A small chamber for contamination checking of the dosimeter when it is returned.

An individual approaches the unit and presents the barcode reader with their pass which has a barcode that contains the individual's identification. The system checks that the individual has sufficient authorization to enter the controlled area. If this authorization is in place, the drawer containing the dosimeter for the individual opens and the individual retrieves their dosimeter.

If the individual does not have the required authorization, a message is displayed on the screen.

On returning the dosimeter, the individual checks the TLD for contamination in the provided chamber if contamination is detected on the TLD, a message is displayed on the screen. The barcode on the individual's pass is presented to the barcode reader and the associated drawer opens automatically.

This equipment provides a novel solution to the problem of individuals using another person's dosimeter. Standard issue systems normally comprise a rack or shelving with individual compartments for each dosimeter. An individual can accidentally retrieve another person's dosimeter if they do not pay adequate attention. This system reduces the potential errors in each individual's legal dose record associated with persons wearing the incorrect dosimeter.

Smolensk, Russia

Mission Date; 5-22 Sep., 2011

Illuminated hot spot wire to identify enhanced radiation is used in the RCA to reduce exposures when working in the controlled area.

The site has developed a novel practise of using red illuminated cable to identify hotspots in areas with low lighting conditions. This cable supplements standard signs used to identify any localised areas of enhanced radiation.

The cable consists of frequently spaced red light emitting diodes and does not require an external mains power supply. It is powered by a standard 9 volt battery so it can be deployed at any area around the site. The cable can be threaded into clear rubber tubing to provide protection from radioactive contamination.

The illuminated cable can be mounted on any plant or equipment with elevated radiation levels. Examples of where it has been used are:

- Walls.
- Pipelines.
- Pumps.

This novel idea is primarily used during reactor outages to provide an effective visual aid to all staff and contractors, with the goal of minimising exposure to ionising radiation.

Cattenom, France

Mission Date; 14 Nov.-1 Dec., 2011

Dose reduction techniques for the storage, transport and handling of a high activity neutron source.

The plant has developed a technique to reduce radiation exposure during calibration work when using a high activity neutron calibration source.

The source itself is secured within a shrink wrapped coloured plastic net. This is applied by the plant. It has two advantages allowing it to be instantly seen and also enabling it to be easily picked up with remote tongs without any fear of slippage or loss. This enables a quick transfer to a shielded container for movement. Radiation exposure during the visual identification, handling and transfer of the source are minimized.

The movement container has wheels, allowing it to be easily moved to any area on the plant for the calibration of the installed nuclear neutron instrumentation. At the point of work, the source can easily be removed with the remote tongs on the netting to reduce the operator's exposure time during the calibration of the instrumentation.

This practice reduces the neutron radiation exposure to the operator during the use, transport and storage of this high activity neutron source.

Angra 1, Brazil

Mission Date; 20 Aug.-6 Sep., 2012

Accredited thermoluminescence dosimetry laboratory

In Angra 1 the assessment of individual doses from exposure to external radiation is done by using thermoluminescence dosimeter as personal dosimeters. The dosimetry laboratory is equipped with Panasonic measurement systems. The laboratory maintains a consequent and regular quality assurance and quality control on the national and international level.

The routine performance testing in individual monitoring for testing the accuracy and precision of the dosimetry system is conducted appropriately. Monthly, 4 TLDs are sent for comparison to the Instituto de Radioprotecao e Dosimetria (IRD). All results are recorded and have an acceptable uncertainty.

For their performance, the laboratory is accredited on national regulations.

Clinton, USA

Mission Date; 11-28 Aug., 2014

Use of remote-monitoring technology for radiation exposure reduction.

In 2013, CPS reduced the annual collective radiation exposure (CRE) by about 0.75 Sv (75 Rem) lower than the CRE during any year with an outage since 2000.

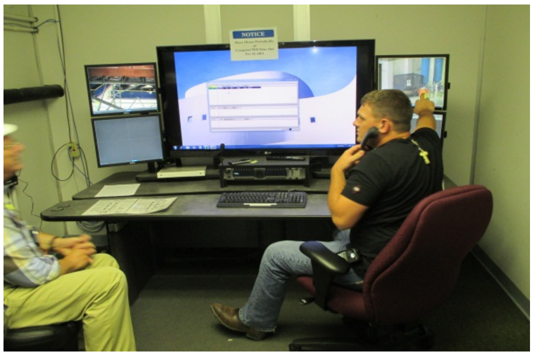
CPS have effectively reduced personnel exposure through implementation of an aggregate approach that uses technology and innovative dose reduction methods. This includes the use of remote-monitoring technology to monitor areas in which high dose rates exists, reducing the dose that station personnel would normally receive to perform tours and troubleshooting.

There are 90 cameras positioned throughout the station that are used by Operations, Engineering and Maintenance personnel in the conduct of tours and troubleshooting.

The station uses a remote operated robot to investigate leaks including steam, water and vacuum leaks in high radiation areas. This has effectively reduced the man-hours that personnel would have to be in the high radiation area doing this investigation.

The station utilizes technology to communicate and guide station workers in high radiation areas, to move them to lower dose rate areas or coach on body positioning to optimize ALARA practices.

Additionally, the station uses a reward programme that encourages station personnel and contractors to provide suggestions on ways to reduce collective radiation exposure. From these types of inputs, ideas have evolved such as removing the peripheral fuel bundles from the core during a refuelling outage to reduce the dose rates in the bio-shield closest to the reactor. This was estimated to reduce dose in the last outage by 77 mSv (7.7 Rem).



Through a combination of both the use of advanced technology and strong engagement of the work force, the station has reduced historically high exposure to be the best in the US fleet for on-line dose in BWR's and among the top five for the world.

The dose savings due to remote-monitoring are predicted to amount to 60 mSv (6 Rem) per year.

Bruce B, Canada

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

The plant uses an advanced Gamma camera to promote radiation area identification and shielding opportunities

The Gamma camera is a new type of gamma detector that combines gamma spectroscopy, high resolution photos and directional gamma imaging. It produces a ‘heat map’ of the radiation source superimposed over the camera image, which has numerous applications, and potential applications, and benefits such as:

- Fast, portable and easy to use imaging spectrometer
- Rapidly identifies and locates primary source terms
- Real-time spectroscopy, ID and imaging
- Quickly identifies multiple radionuclides and overlays the radiation ‘heat map’ over a high resolution photo
- Energy range covers isotopes of interest up to 3 MeV
- Quick set up time – less than two minutes
- Preliminary imaging in about a minute, high resolution five to 10 minutes, depends on dose rate

This camera allows for the posting of ‘heat map’ photos near key radiation work areas to provide workers with a better understanding of the primary source in the area. This helps develop the workers’ mental models about where the source is and gives them the opportunity to avoid it.

The camera can be incorporated into a plants routine survey program to track hot spots. The camera can also be used to evaluate the use of shielding to identify if there is any streaming, and also used to help in decontamination of rooms/components and long term investigation into plant degragation due to ambient dose rates

Taishan, China

Mission Date; 8-26 Jan, 2017

The optimisation of equipment for high doserate probe calibration

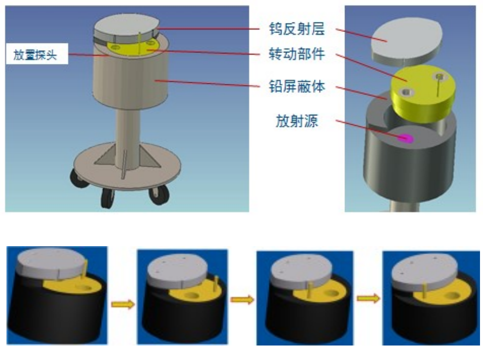
By redesigning the shielding onsite, improving the shielding design of the calibration device for high doserate probes (AMS system), the radiation dose of the staff is greatly reduced and the accidental exposure risk is controlled.

AMS (Aeroball Measurement System) is a special system which uses small metal balls to make a profile of the core. They are highly radioactive after leaving the core and are measured by high doserate probes. There are 360 probes needed to be regularly calibrated with 1.3GBq Co60 source in the system. The calibration cycle is 18-month. The Co60 source is stored in a shielding container. During calibration, the cover of the shielding container needs to be opened, and each probe held by the operator's hand needs to be placed inside the shielding device. The operator’s hand position dose rate is calculated to be 42.3mSv/h and the dose to the operator would be about 17mSv for all 360 probes. Additionally, incorrect operation will lead to accidental exposure. The new equipment design decreases the dose rate and the risk. New equipment uses a labyrinth design, in order to avoid direct source exposure and a new shielding material (tungsten alloy) is applied in the device. After evaluation, the maximum dose rate of the new equipment is 32uSv/h, and the operator dose is only 6uSv for the calibration of all the 360 probes. In addition, the new equipment will be more convenient to use. The optimization of radiation protection is realized. The dose rate is verified.

This new design of shielding container could be used to optimise doses during any calibration of any high doserate probes with large sources.

Before:

After:



Taishan, China

Mission Date; 8-26 Jan, 2017

Display of recent personal dose history information on entry to the RCA.

At the RCA entrance turnstile, after personal identification, on a screen beside the turnstile a display will appear which gives the worker his record of this dose for the past 12 months and his recent dose received for on the current RWP (along with the relevant dose and doserate limits for his entry). This enables individuals to maintain a good awareness of their individual dose received to date and will remind them on every entry to minimise their dose.

Bugey, France

Mission Date; 2 -19 Oct., 2017

Effective management of radioactive source movements with a dedicated computer system.

A computer system equipped with badge recognition is used to control radioactive sources present on the site. This system controls access to the building, to the source store room, and to the security safe that contains the sources. This system allows radioactive sources to be obtained without RP having to monitor the movement of the source.

Benefits:

- Only authorized workers can obtain the source that they need.
- Duration of access to the sources can also be limited in time.
- Computer monitoring of source withdrawals makes it possible to track and record any source movement, while limiting potential loss/theft.
- Autonomous worker, no need for an RP technician to open the safe which allows RP technicians to focus on their core activities

Access to the source building

Identification of the authorized user

Keys box

Access to the authorized keys (source room and source locker)

Access to the authorized source

Almaraz 2, Spain

Mission Date; 5-22 Feb., 2018

Centralized Decontamination Unit to optimize the cleaning and decontamination in reactor buildings (UCA).

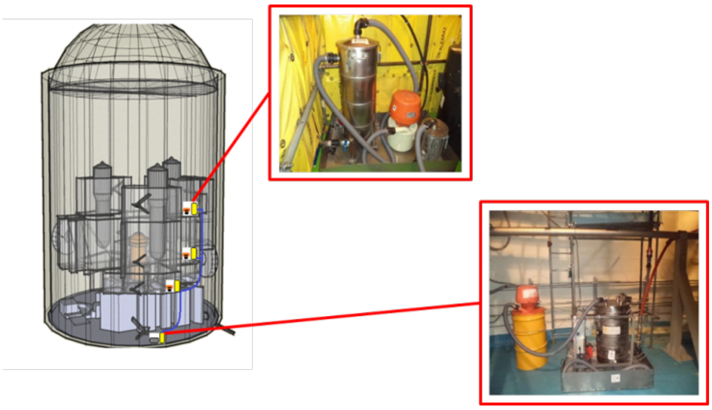
The centralized system is installed at all the levels of the reactor buildings with the aim to clean, decontaminate and discharge the liquid waste into the liquid waste disposal system (WDL).

The use of a closed and watertight system avoids the movement of cleaning devices inside the plant and also the pouring of waste from one container to another, thereby reducing contamination.

Its versatility enables access to all work areas and widely reduces the reaction times to respond to cleaning and decontamination needs in the plant.

Finally, it avoids direct contact of cleaning and decontamination staff with portable equipment and reduces doses received by such staff, as the system is confined in a particular area, far from operators. It is possible to shield the area where the system is, which would be impossible with portable equipment.

The system is composed of:
- Pneumatic extractor with an aspiration flow rate of 500m3/h.
- Stainless steel housing containing the filter.
- Drum for recovering the aspirated elements including a retention valve.
- Hose circuit.



The pneumatic extractor is connected to the plant's air system and the extractor's inlet is connected to the upper part of the drum and used for vacuum. A retention valve facing the opposite direction at the drum's outlet is used to achieve vacuum. In other words, the valve closes due to vacuum during aspiration and then opens up when the aspiration is stopped, making the drum dewater by the effect of gravity. The aspirated liquid or solid enters the drum passing through a filter sieve in the case of solids.

The equipment is designed and constructed in stainless steel to avoid build-up of waste and pipes are free of roughness and elbows. Since it has been in operation, no hot spots caused by accumulation have been detected.

The interior surface is completely smooth and allows easy decontamination. All the parts of the system are easily accessible and connected by means of quick couplings that make dismantling easier.

The equipment features an autonomous shielding system and keeps a water level that reduces the dose rate while in use. Besides, if the system is to be used in a highly contaminated area, the filter can be easily shielded or manipulated in the mobile shielding equipment.

When it comes to disposal, the equipment is designed to fit in a 220-litre drum without any further manipulation and then be treated as waste.