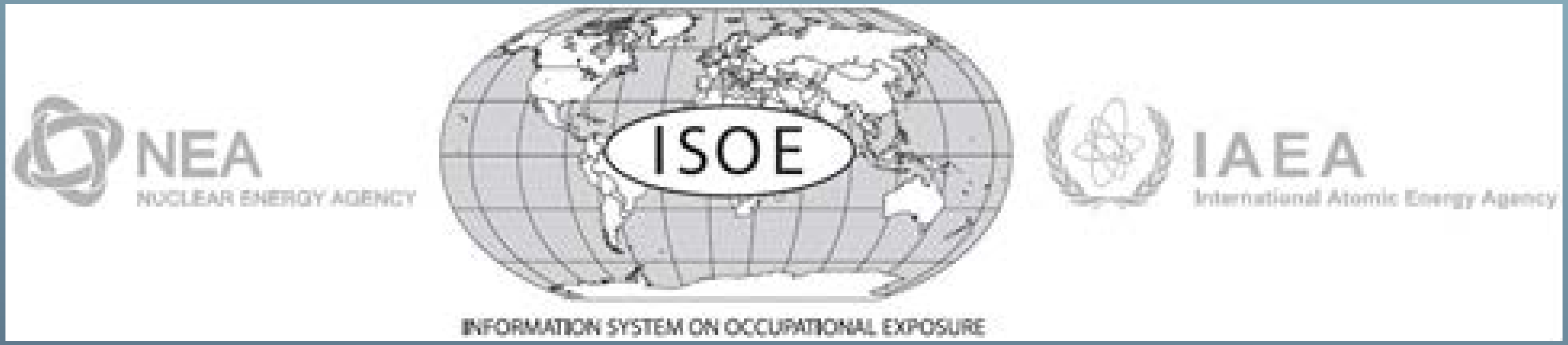
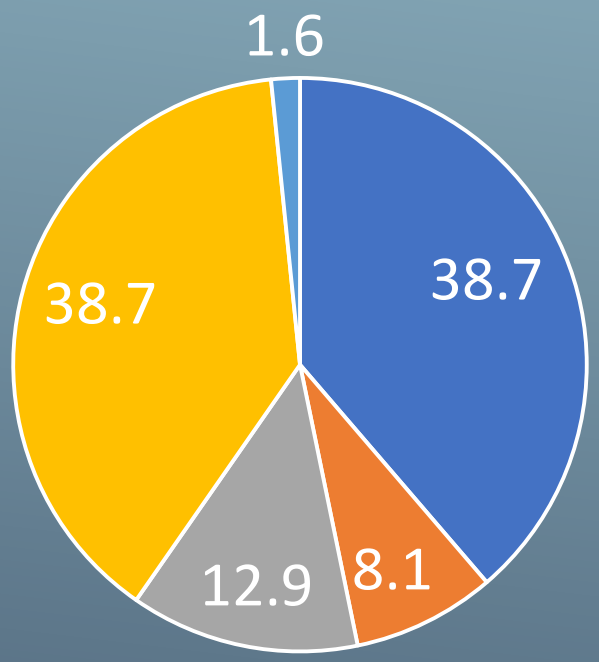


General Overview of International Radiation Protection at World NPPs

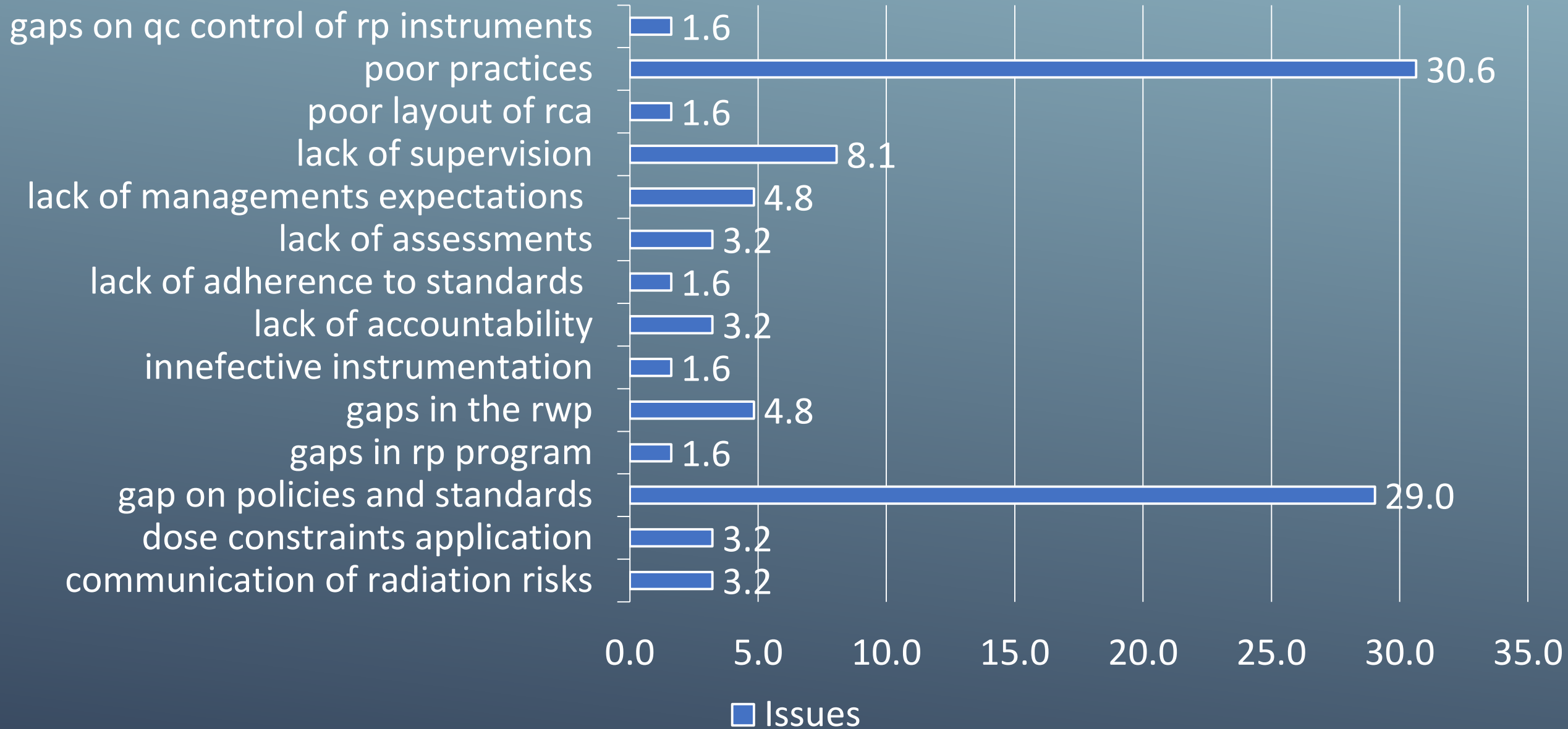
Marcos Antonio DO AMARAL, ISOE Chair

Main Issues (%)



- Control of occupational exposure
- Radiation protection instrumentation, protective clothing and facilities
- Radiation protection policy
- Radiation work control
- Radioactive waste management and discharges

Main Drivers (%)



Dose Index

Team	10	Persons	10	Persons	10	Persons
Total hours	**100**	**Hours**	**110**	**Hours**	**60**	**Hours**
CRE	15	Person.Rem	16	Person.Rem	9	Person.Rem
Index	**150**	**mRem/person.hour**	**145,45**	**mRem/person.hour**	**150**	**mRem/person.hour**

Important Points

- Use of OE
- PJB
- LLE
- Coaching
- Questioning atitude
- Effective supervision
- Managers in the field
- RMT
- Layout
- Use of indicators in the field
- Mixing error & violation

Good Practices

- **Radiation protection instrumentation, protective clothing and facilities**
  - The plant developed an innovative system to remove contaminated particles with rotating brushes coupled to a HEPA filtered vacuum unit.
    - A shoe brush has been developed featuring a suction system to contain radioactive particles. Without causing damage to the shoe, this brush removes contaminated particles that might have stuck to the sole.
    - Benefits:
      - Prevents contamination from spreading outside contaminated work areas or outside the radiological controlled area.
      - Contaminated shoes no longer have to be laundered, thus reducing the volume of liquid waste.
      - Reduces the number of loaned shoes.
      - Simplifies the shoe decontamination process
    - This shoe brush has proved very useful in improving radiation protection performance. The current result shows a reduction of contamination events picked up by C2 monitors and caused by shoe contamination.

Good Practices

- **Radiation protection instrumentation, protective clothing and facilities**
  - The plant developed an innovative system with anemometer and small window with feathers to monitor the airflow coming from outside to inside a confined room or tent. This allows ensuring the working areas under negative pressure inside tents, preventing the contamination spread and complying with regulatory minimum airflow, by visual information on the anemometer and by checking the position of the feathers.
    - Main Benefits:
      - Radiation protection:
        - Airborne contamination contained in vented tent.
        - Very low costs involved to recreate this innovation.
        - Time required for sustainable implementation: less than a month.
      - Industrial safety:
        - Can be used to calculate the allowable exposure time for heat stressing temperatures and control the inherent risks for working on environment at hot temperatures.
      - 20 devices installed on tents for the 2 units.
      - Approximately 300 kits have been ordered by French power plants.

Good Practices

- **Radiation protection policy**
  - Automatic transfer of dose data from the operative and legal dosimetry between NPPs.
  - Use of remotely controlled radiofrequency technology to simulate radiation environments in dynamic learning activities, including gamma and contamination hazards and detector response, without the need for radioactive sources.
- **Radiation work control**
  - In-situ gamma spectroscopy to determine surface activity concentrations on internal surfaces of plant systems.

Good Practices

- **Radiation work control**
  - Index cards are available describing radiation protection measures as well as the protective clothing and equipment needed for a variety of activities.
  - Provision of portable radiation monitors to non-Radiation Protection personnel to allow them to confirm the radiological conditions in their work area and assist in dose reduction..

Good Practices

- **Radiation work control**
  - To ensure timely dissemination of radiation protection information, plant has developed a unique display system consisting of a TV-screen and White Board outside of the rp shift office, which results in rapid and accurate information to all staff on radiological and other related data. This is well visible to all personnel prior to entry into the inner controlled areas. Unique numbering is attached to jobs performed in controlled area.
    - On the TV-screen are displayed:
      - The photos and names of shift health physicists and technicians;
      - Information on accessible and non-accessible areas of the reactor building and other relevant rooms;
      - The dose rates, contamination levels and air concentration of tritium in various rooms and areas.
    - On dedicated white boards are displayed:
      - Information on the relevant “hot spots” in the station;
      - The collective dose targets and the incurred doses for the present year and for some years back.

Good Practices

- **Radiation work control**
  - Enhancements to standard identification of orange zones.
    - Orange zones are areas of elevated dose rates that require specific authorization for people to enter. In order to prevent inadvertent access without the appropriate authorization the plant has established enhanced warnings at the entry to all orange zones.
    - Where an orange zone is accessed through a door, as well as the standard warnings posted on the door, the plant have placed fixed extendable barriers at chest height.
    - Where there is a partial orange zone (term used when only part of the room is classified as an orange zone) the plant apply the standard barrier tape which is supplemented with a visible and audible sign that has motion sensors that activate the flashing lights and audible warning.
    - Since the implementation of both practices in 2009, the plant has not had a significant reportable event of persons entering and orange area without appropriate authorization.

Good Practices

- **Radiation work control**
  - Stickers for radiation protection work areas
    - In the past, access conditions for RP work areas were listed in written form on sheets, parts of which had to be completed by hand depending on the area's classification.
    - These sheets have been replaced by stickers, which correspond to the different types of predefined working conditions: the sticker is affixed to the worksite identification sign and stipulates prerequisite conditions for entering the work area.
    - Clearly legible stickers provide a simple illustration of the equipment to be worn for entering the area (PPE + other appropriate equipment).
    - This stand-alone worksite identification sign eliminates potential errors and omissions associated with handwritten information. It also promotes consistent work practices.

Good Practices

- **Radiation work control**
  - Preventing access to very high risk radiation areas
    - Some rooms containing primary circuit demineralizers are classified as red areas (very high risk radiation areas) as they contain active resins. As it is not possible to physically lock the shielding providing access to these red areas, the plant has developed a system using 2 plates secured by tamper-proof screws that are fixed on the bunker slab, thereby preventing access to embedded lifting rings.
    - Appropriate control of access to the red area is thus guaranteed The first key is managed by senior management and the second is managed by the RP department with 2 different tamper-proof screws.
    - This practice eliminates the risk of unauthorized opening of the resin bunker without having required authorization and without using the red area access process.

Good Practices

- **Control of occupational exposure**
  - 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.
  - 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.

Good Practices

- **Control of occupational exposure**
  - ALARA performance
    - The performance indicator for the Collective Effective Dose of 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.
  - 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.

Good Practices

- **Control of occupational exposure**
  - Use of remote-monitoring technology for radiation exposure reduction.
  - The plant uses an advanced Gamma camera to promote radiation area identification and shielding opportunities.
  - 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 dose rate 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 minimize their dose.

Good Practices

- **Control of occupational exposure**
  - The optimisation of equipment for high dose rate probe calibration
    - By redesigning the shielding onsite, improving the shielding design of the calibration device for high dose rate 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 dose rate probes. There are 360 probes needed to be regularly calibrated with 1.3GBq Co60 source in the system. 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. New equipment uses a labyrinth design, in order to avoid direct source exposure and a new shielding material 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.

Good Practices

- **Control of occupational exposure**
  - 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

Good Practices

- **Radiation protection instrumentation, protective clothing and facilities**
  - Use of low-power mobile telephones in the controlled area - Mobile telephones are used to improve communications during work activities. The system is also used to automatically alert personnel in the event of a building evacuation alarm.

Good Practices

- **Radiation protection instrumentation, protective clothing and facilities**
  - A sophisticated key cabinet allows specific users to access only keys which unlock areas containing radioactive sources which they have authorization to handle.
  - The plant uses a “Keymaster” system which is a locked cabinet containing keys to discrete locations where radioactive sources are stored. The keys inside the cabinet are electronically locked such that when the cabinet is open it is not possible to access all of the keys. In order to unlock a key for use, the user must enter a user code and also a key code which he has been provided to allow him access to a specific source location. When the user enters both these codes, then the key to the specific source location is released for use. The source location then only contains sources which he is authorized to use.
  - This system enables the plant to authorize individuals to use only specific sources that they are authorized to use and then restricts them physically from being able to access any other sources or any other areas containing sources which he is not authorized to use. This is a simple, but practical system which allows effective, physical control over access to radioactive sources.

Good Practices

- **Radiation protection instrumentation, protective clothing and facilities**
  - The plant uses a system which ensures that dose rate measurements are carried out at a precise distance from the source.
    - The usual practice is that RP technicians in charge of dose rate monitoring estimate the distance from the source to the radiometer by mean of personal judgment. his addresses situations where the measurement is carried out at 0.4 or 0.6 metres, for instance, and not at 0.5 metres.
    - Dose rate frequently has to be monitored at a precise distance from the radioactive source. This is the case for:
      - sensitive measurements, like radioactive material transport off the site.
      - measurements used for further calculation, such as activity assessment based on dose rate in a radioactive waste package.
      - or measurements that have to be cross-compared and therefore have to be reproducible measurements, such as for the assessment of hotspot changes under reduction treatment.
    - The plant has set up a mechanical system which connects a dose rate meter to a remote laser reader for accurate positioning of the device measuring the source. The mechanical system is easy to manufacture and laser meters are currently inexpensive.
    - This system was put in place for the transportation of radioactive materials and since its implementation, the plant has not experienced any transport events.

Good Practices

- **Radiation protection instrumentation, protective clothing and facilities**
  - Automatic radiation instrumentation dispensers
    - The plant has installed dispensers called "Radiabox" for small objects in dedicated places. The dispensers provide dose rate meters to the workers even outside the radiation controlled areas (RCA) that save the working time for the workers. Workers are not obliged to go to the RCA to pick up the RP instruments or return them if the work is performed out of the RCA. The other advantage is that radiation instruments are available 24 hours a day. Oxygen analysers and other small items of equipment will eventually also be available.
    - The plant assessed saving in time of around 15% to 25%. Interviews with the workers confirmed their satisfaction concerning the added value of this system.

Good Practices

- **Radiation protection instrumentation, protective clothing and facilities**
  - Accurate heavy water leak rate determination through the use of the Tritium in Air Monitoring System (TAM)
    - The Tritium in Air Monitoring (TAM) System has multiple, distributed sample points, including many in inaccessible areas.
    - Long term monitoring of noble gas activity have been performed to provide the most appropriate correction factor for noble gas compensation, which results in the ability to accurately correlate radiation levels to Tritiated water leak rates. This allows for a quick and accurate leak rate determination, and with the Radiation Monitoring System (RMS), the location of the leak can also be more rapidly identified.