CLEAN UP OF FUEL TRANSFER CANAL SUMP

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Abstract

The ALARA approach and radiation safety concerns are described in the case of manual cleaning of fuel transfer canal sump. A new cleaning device was designed based on air driven liquid pump and filter units. Its design allows different line-ups, shielding installation and easy transportation. Radiological engineering techniques were implemented in the design of filter assembly, its operation and manipulation. This device was efficiently used for removal of high radioactive dirt at the bottom of the sump. The activity took place before inspection of the sump liner and its repair.

Introduction

According to the plant design, a fuel transfer canal is used for fuel transport between the reactor cavity and spent fuel pit. Some controls or maintenance are required in this area, especially in its lowest part, i.e. in the sump. These include the fuel transport mechanism maintenance and stainless steel liner inspections. The latter triggered the action of radiation protection to reduce the dose rate in the sump. As some minor leakages were detected from the liner, inspection was expected to show the critical spots. There is a very inconvenient working area for removing residual radioactive contamination and preparing safe working conditions. It was difficult to access the area and to adequately protect decontaminators. The dose rate at some spots was from 1 to 2 Gy/h. The radiation protection (RP) supervision stopped all the works. It was impossible to easily remove the minor amount of high risk dirt and to assure a high level of protection.

Circumstances related to radiation safety

It is easy to believe that a very simple and cheap cleaning device might be a vacuum cleaner but due to a high dose rate the radiation risk of such cleaning is unacceptable. It was advised to collect high active dirt in the sump with a professional cleaning device designed to enable quick filter removal and shielding. This task requires a decontaminator to install and control the pump and adjust cleaning tool position. High radioactive dirt shall remain shielded by a layer of water.

The additional requirement of the RP was also to prevent pumping of the high active dirt from the first sump to the second one at another end of the canal. The intention was to remove high activity and facilitate any future tasks in this area.

The relocation of high active particles was however the major concern.

Water pumping from such locations is usually performed by electric submersible pump. In the case of radioactive dirt, this was not practical. The dirt in the sump had no affinity to be dispersed and diluted in water. The Figure 1 shows vertical cross-section of the canal.

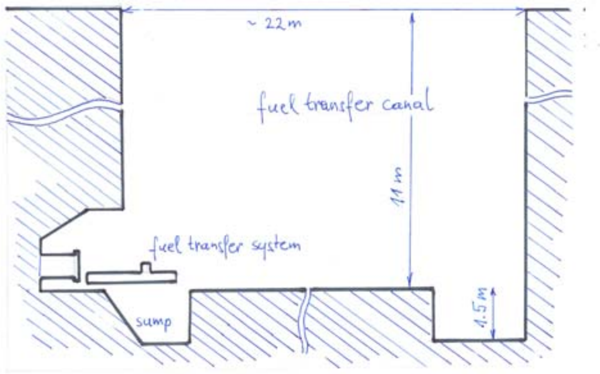

Figure 1: Vertical cross-section of the fuel transfer canal with the sump.

The plant staff tried to buy a pump assembly on the world nuclear industry market but there were only high-flow and large volumetric capacity solutions available. They were not designed to be positioned and operated in confined spaces or at difficult accessible locations.

Design of a new cleaning device

Plant decontamination and RP engineers designed a new pumping skid with the help of mechanical engineers of a specialized company for similar industry applications.
An air operated double diaphragm pump was selected as appropriate for the new skid. It offers reliable operation and smooth flow, and the ability to pump the sludge. It uses simple valves and flexible diaphragms. It is widely used in industry applications. Water and sludge mixture together with some air can be easily pumped by this type of pumps. Only air supply is necessary for their operation.

The skid is designed in a way that the filters are positioned in front of the pump. This approach removes contamination before water flows through the pump. Filter covers are sealed by pressurized seals and they are released after the pump is switched off. The filter unit operates in negative pressure on the pump suction side; therefore leakage from this unit is not possible. There is no manual action required to either disconnect or open the filter housing. The dose rate probe can be fixed on the support between two filter housings near the covers.

Figure2: Cleaning skid with rolled reinforced tubes prepared for transportation

Two stages of water filtering were required to be taken into the design. The first filter cartridge uses the bag with a 200 micron pores and the second with a 25 microns pore. The filters are optimized in a way to maintain stable flow conditions and collect the sludge up to the maximum of a few hundreds grams.

Flexible tubes are connected to the skid with couplings designed to avoid collection of contamination at their joints. They use venturi effect to accelerate the flow. These plastic reinforced tubes serve as an extension of a suction duct and for either recirculation or water transfer to another location.

Two types of suction nozzles were proved to be efficient, one offers cleaning of the corners or gaps and the other the flat sump area. The nozzle is attached to a telescopic stick extendable to 2.5 meters. The plastic suction tube is attached to the nozzle at the end thus enabling the distance between the operator and the tube during radioactive sludge suctioning.

Figure 3: Testing of gap and flat area cleaning tool.

The skid is composed of stainless steel frame on wheels. The frame supports temporary flexible shield around the filter assembly. The skid dimensions are 1250 x 515 x 980 mm. Its mass is 115 kg (or 145 kg together with plastic tubes on the three wheels). This assembly can also be dismantled and transported manually.

The valves installed in the assembly offer different modes of operation:

- Water recirculation through the filters
- Water transfer by pumping through the filters or by-passing the filters
- Internal water recirculation to clean assembly components.

The control panel on the skid provides pressure indicators to control pressure in different parts of the cleaning device and to show filter saturation.

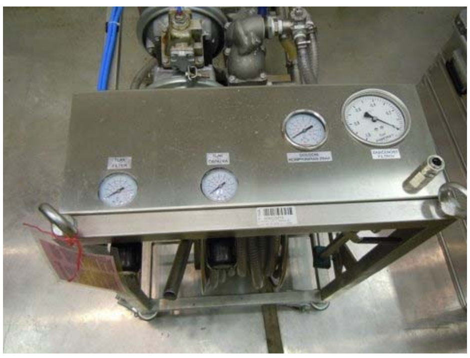

Figure 4: Control panel with pressure indicators

ALARA work planning and performance

The fuel transfer canal is 11 m deep and only 1,2 m wide. It is positioned parallel to the spent fuel pit. The sump is positioned close to the fuel transfer tube and it is 1,5 m deep. The sump horizontal area is 2 m x 4 m. The fuel transport mechanism is above the sump. In case of maintenance work on the fuel transport mechanism, the sump remains flooded and radioactive dirt or crud collected at its bottom is efficiently shielded by a layer of water.

The decontamination staff usually uses a special long stainless steel pipes with an electric booster pump hanging on the crane to remove some dirt or debris form fuel pools. It is a robust design provided by Gradel company, however impossible to be used in this location.

Figure 5: Fuel element transport mechanism above the fuel transfer canal sump

Water in the sump together with crud and dirt should be pumped out. Radiation survey with underwater probe indicated one location with dose rate of 1 to 2 Gy/h. Water mixing was not efficient enough to disperse the dirt which was barely visible.

The new sump cleaning device was tested in an area with non radioactive dirt first. Decontaminators and RP technicians were trained to manipulate this device and its tools. For the transportation of filter cartridge, a light open container was designed to be pulled up from the canal and disposed in a shielded drum. Two layers of flexible shields with total shielding factor of ½ were planned to shield the filter assembly. Filter housings were made of 2.4 cm steel. The long tools offered the distance of about 2 m from the source. Additional shields were provided at the location in case flexible tubes or filter assembly needed to be shielded. The dose rates in different locations were predicted easily.

During removing of radioactive particles, the water layer was left at 30 cm. The distance between the sump and the cleaning device was at least 10 meters.

The crew on the top of the canal was monitoring the dose rate in the sump to locate high radioactive spot; its duty was also to arrange vertical transports of two decontaminators and one RP technician into the canal, to transport the cleaning device and the radioactive filters to the drum. The RP technician in the canal had control over dose rate of the filter assembly and over dose rate in the sump. He was using the dose rate probe and a telescopic detector. The both groups had an audio link.

There were some safety precautions planned related to area dose rate and received dose as well as industry safety measures. First contingency actions were planned to be performed by the crew in the canal. The workers were equipped with positive pressure full-face masks, cooling jackets and protected against contamination.

Radiation survey data: the surface beta contamination of the transfer canal liner measured by smears ranged from 500 Bq to 20 kBq per 100 cm^2 and from 10 to 50 Bq of alpha contamination. The dose rate was 1 mSv/h in front of the spent fuel pit gate but only 0.4 mSv/h in the canal.

After removing the first radioactive spot the dose rate was still 15 mSv/h above the water and another spot of the same high radiation level was located by the RP technician. Having removed the second one, the sump was cleaned with water. The background radiation was then from 2 to 3 mSv/h.

The smears in the cleaned sump showed contamination from 5 up to 500 kBq/100 cm^2 beta and from 20 to 1500 Bq/100 cm^2 alpha.

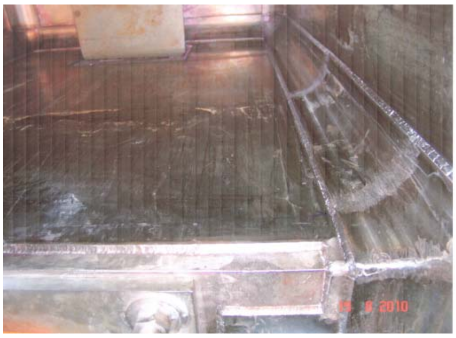

Figure 6: Detail of the sump. Top to bottom view after the cleaning.

The ALARA planning indicated 6 man-mSv of collective dose. The task resulted in 3 man-mSv.

The total activity together with preparations and waste manipulation took 3 working days. The sump work was performed in two days in about 5 hours. The first-line decontaminator's electronic dosimetry data showed the maximum dose rate of 36 mSv/h and the received dose 1,2 mSv. The maximum dose rate for the RP technician in the canal was 14 mSv/h and the received dose was 0,45 mSv. Dose rate measured at the top of the filter assembly was about 200 mSv/h.

Later on, gamma spectrometry of the drum with radioactive filters showed that cobalt Co-60 was the source of radiation. Subsequent inspections of the liner inside the sump and its repair with welding resulted in 3 man-mSv.

It would be recommended in designing fuel transfer system of a new facility to facilitate potential inspections and maintenance activities.

Conclusion

Cleaning up of the fuel transfer canal sump is a rarely performed activity which needs special preparations and cleaning devices to protect radiation workers. The dedicated designed filter assembly proved to be efficient and could also be used for other applications.

Acknowledgement

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