

Radiation Protection Aspects of Articulated Master Slave Manipulator Maintenance at CORAL Facility

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Abstract

Nuclear facilities greatly rely upon Master Slave Manipulators (MSMs) to carry out various operations in hot cells in a safe and remote manner, minimizing dose to the workers. Over the years, various types of MSMs were introduced to meet the specific demands of various facilities and complexities of operations involved and hence it has become an indispensable part of the hot cells. While skilled manpower always enhances the efficiency of MSMs, build quality and materials used also adds to its reliability. Compact Reprocessing of Advanced fuels in Lead cell (CORAL) is a lead walled hot cell reprocessing pilot facility operated with the philosophy of remote operations and contact maintenance [1]. All the various day-to-day tasks are accomplished here with the help of 12 articulated MSMs (AMSM). Being a mechanical tool, AMSM is also prone to wear and tear even after careful design and material selection. This paper presents the summary of both preventive and breakdown maintenance carried out in AMSMs during the last 15 years at CORAL facility with a radiation protection perspective.

1. Role of MSM in process and related maintenance

CORAL was commissioned in the year 2003 as a pilot plant to benchmark the various process parameters and equipment needed for fast reactor reprocessing in India. The view of CORAL operating area is shown in Fig. 1. AMSMs are extensively used in CORAL facility as the whole reprocessing operation is carried out inside a single SS containment box shielded with external lead walls. Operations in CORAL facility may be classified into two categories, namely process related and maintenance related. Some of the process related operations utilizing AMSMs are transferring of fuel magazine inside containment box, loading of fuel magazine in the chopper, camera orientation for chopping operations, preparatory works for feed clarification and sampling from various aqueous or organic streams. And any maintenance during any of the above operation is also carried out by the AMSMs. All the equipment inside the cell is carefully engineered to be able to be maintained by the use of manipulators minimizing contact maintenance. Also, AMSMs are used for material movement inside the box, collection and segregation of high active waste and loading of alpha waste to transport cask.



Figure 1. View of installed MSM in CORAL facility.

2. Health physics surveillance for MSM maintenance

Since a lot is dependent upon manipulators for the smooth operations of the CORAL plant they also need maintenance in due course of time. AMSMs are unloaded from the hot cell for maintenance whenever performance degradation is observed and during preventive maintenance like greasing of gears and brazing or tightening of connected ropes. Generally encountered failures are rope cut, rope slip and yoke break. AMSM unloading operation starts only after clearance of radiological work permit (RWP) with erection of temporary tent around the AMSM. The anticipated external hazard from the MSM maintenance operation is minimal whereas cross contamination and air borne activity potential are relatively higher if there is a booting puncture. Hence, all the persons involved in the work are provided with personnel protective equipments like plant dress, lab coat, head cap and half face mask. Spot air sampling is done during unloading of AMSM and thorough contamination checking is carried out in AMSM port and floor area after unloading. The slave side is immediately covered with polythene up to the forearm area and moved to the area designated for AMSM decontamination. Radiation levels in the slave side are measured and tagged above the polythene cover. AMSM port hole is sealed with polythene cover till MSM is reloaded. Health physics personnel analyses the air samples and swipe samples and provides clearance for continuing works in the respective area. The mechanical crew takes the AMSM for maintenance after proper decontamination. Similarly, any cross contamination observed in port holes and floors are thoroughly decontaminated before reloading of the AMSM. Spot air sampling is also carried out during loading of AMSM and clearance for proceeding work is given only after analyzing the air sample. During the whole operation the containment box pressure is monitored by the control room personnel vigilantly.

3. Results and Discussion

During the period from 2003 – 2018, there have been 470 occasions wherein the AMSMs were unloaded for maintenance. The yearly frequency distribution of AMSM maintenance is shown in Fig.2. Thanks to the careful execution of job, there was no air activity due to any of the AMSM unloading and loading operations. The maximum dose rate observed in the slave side was 20 μ Sv/h in couple of occasions which was mainly due to damaged booting. There have been 85 decontamination operations probably due to pinholes in booting and the yearly distribution of the same is also shown in Fig.2. The maximum and minimum transferrable contamination levels observed on the AMSM and cross contamination levels observed in port holes and floors are represented in the Table 1. It is observed that high contamination levels exist in the tip and wrist portion of the manipulators for AMSMs unloaded from locations where head end operations like chopping, dissolution and centrifuge operations are carried out. The relatively low contamination levels are observed as one moves towards master side of the manipulator. The reason for contamination may be attributed to pinholes / punctures / tears emerged in the booting. It may be noted there was no transferrable and fixed contamination observed in AMSM master side during any of the maintenances.

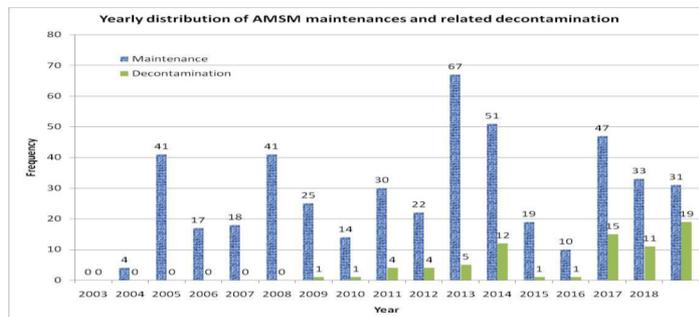


Figure 2. Yearly distribution of AMSM maintenances and related decontamination

Table 1 Maximum and Minimum Contamination levels observed on various sections of the AMSM

Type of contamination		Contamination (Bq) on various parts of the AMSM				MSM port (Bq/cm ²)	Floor (Bq/cm ²)
		Tip	Wrist	Forearm	Shoulder		
α	Minimum	15	33	12	10	0.20	0.37
	Maximum	138	78	45	30	1.00	0.98
$\beta\gamma$	Minimum	250	500	100	100	1.40	0.80
	Maximum	1550	100	650	300	3.80	2.50

4. Conclusion

It is concluded that all unloading, decontamination, maintenance and unloading operations were carried out in a safe manner with effective health physics surveillance and control measures. Total collective dose for the AMSM maintenance and decontamination operation combined is less than 1% of the total plant collective dose. All the workers involved in the AMSM maintenance and decontamination operations are regularly referred for internal contamination monitoring (whole body counting / lung counting and urinary analysis) and so far no internal exposure case was observed. To increase the safety measures further it is proposed to have hood type structures fitted with glove ports where AMSM can be parked which enables an easier way to decontaminate and perform maintenance operations [3] and an innovative retractable hood structure is planned while unloading/loading the manipulators.

References

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