CEFDA05-1359

Task Title: TW5-TTMI-004a: PRELIMINARY REMOTE HANDLING HANDBOOK FOR IFMIF

INTRODUCTION

The International Fusion Material Irradiating Facility (IFMIF) will be built to test, define and select the materials for the next generation of fusion reactor (DEMO). The main requirement for this facility is to produce a neutron flux similar to fusion reactions that will take place in DEMO in a reasonable timescale.

The facility (see figure 1) will be composed of an irradiation source made of two linear accelerators focusing toward a liquid lithium target. Neutrons produced by the accelerated deuterons hitting the lithium target will damage target samples held in test assembly inside a test cell.

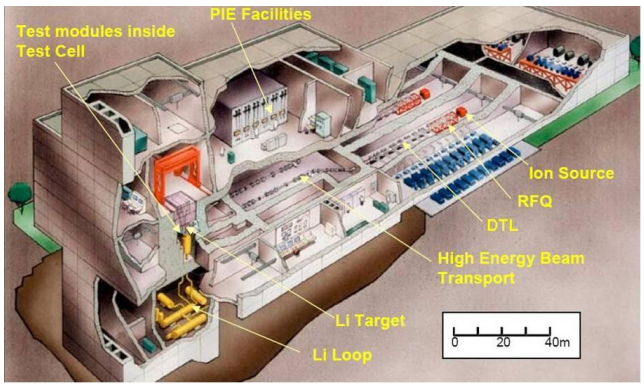


Figure 1: Facility layout

After disassembly of the test modules, examination of samples will take place in a post-irradiation examination laboratory.

High level radiations are expected in some areas of the facility. In some of these areas maintenance will not be possible with hand-workers and will require the use of Remote Handling equipment.

After a state of the art of the capabilities of standard Remote Handling equipment, the Preliminary Remote Handling Handbook for IFMIF compares the needs of the IFMIF facilities to similar existing facilities in Europe and in the USA. Through analyses of each large area of the facility (accelerator hall, conventional facilities, test cell, Li loop,...) according to preliminary studies available, this report identify where RH equipment will be necessary, proposes guidelines rules to designers and identify potential areas where R&D work would be necessary.

2006 ACTIVITIES

RH vs Hands-on operations

ICPR60 recommendations for any individual radiation worker are:
- The annual dose rate should not exceed 20mSv per year, averaged over 5 consecutive years.
- The dose rate in a single year should not exceed 50mSv.
- The dose rate for non-radiation workers should be kept below 1mSv/year.

For the IFMIF facility RH will be a necessity in all areas where the dose rate exceeds the 1mSv/hr dose rate. Between 10 µSv/hr and 1 mSv/h, it will be the result of ALARA considerations. Between these two values, past experience in nuclear facilities shows that using RH equipment has always been simply based on a balance between expected personnel dose and cost of the RH equipment.

Maintenance classification scheme

It is propose to follow the general maintenance classification scheme propose for ITER:
- RH class 1 = components requiring regular planned replacement.
- RH class 2 = components that are likely to require repair or replacement.
- RH class 3 = components that are not expected to require maintenance or replacement during the lifetime of the facility but would need to be replaced remotely should they fail.
- RH class 4 = components that do not require remote handling.

Examination of each piece of equipment in all areas of the facility will be made according to these criteria.

State of the art of telerobotic systems

Telerobotic systems are belonging to three large classes of systems:
- Mechanical master slave systems.
- Power manipulators.
- Servomanipulators.

They are either:
- Fixed: in that case the manipulator goes through a wall or a ceiling (generally the shield) and are operating in a space depending on the manipulator type. This configuration is generally limited to window workstation.

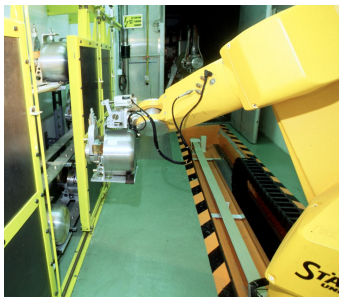
or
- Mobile: the manipulator is mounted on a carrier such as a gantry or jib crane, a telescopic mast... It's operating space is equivalent to that of the carrier and the manipulator itself.

Performance and capabilities, advantages and drawback for each family are discussed in the document.

RH in existing accelerator facilities

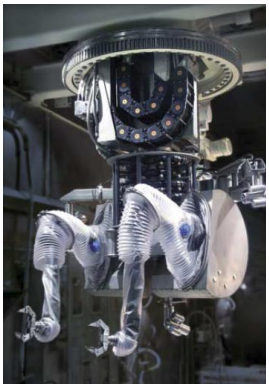
Although dose rate to personnel has always been considered for all existing accelerator facilities, it seems generally that the radiation level was low enough to allow radiation workers to perform all maintenance work hands-on a few days after the shutdown. During the last years the increase of power of the installation has changed the rule and the number of facilities operating or developing RH equipment is increasing.
Strategies and needs are different from one facility to another see (figure 2):

- Active handling with heavy shielding and semi automated transfer cask equipment for the Paul Scherrer Institute (PSI, Switzerland) and some beam line elements of the SNS facility (Oak ridge laboratory, Tennessee, USA).
- Advanced servomaniplators RH systems in the target cell of the SNS facility.
- Fully automatic procedures for a limited number of operations in the ISOLDE facility (CERN, Switzerland).



Staubli robots used for target exchange and storage in ISOLDE

Transfer cask system of PSI



Servomanipulators of SNS' target cell

Figure 2: RH in existing accelerator facilities

Design guidelines to the IFMIF equipment

Analyses of all situations help to draw general recommendations to designers of the facility:

- Sectionalize large apparatus.
- Design to be readily replaceable and preferably arranged so that it can be lifted vertically.
- Modularize all auxiliary equipment.
- Use of quick disconnect fasteners instead of bolted joint.
- Connections to the unit from main headers (water, air vacuum...) should be designed to provide minimum connections.
- The section of the equipment should include guides to fit on supports that require a minimum of alignment.
- If alignment is necessary, it is better to include them in the support base and not onto the movable equipment.
- Every effort should be made to make all sections look identical and define standards.
- Standardization helps to define a spare part policy and allows the use of spare units while the repair work can be done in external facility without prolonging the downtime of the facility.

And more dedicated to the accelerator design we can quote:

- Design magnets and diagnostics to give simple cooling and power connections.
- Limit the length of straight sections to improve stability of mechanisms due to the shorter mechanical moment.
- Modularize diagnostics, detectors, positioners. It means: provide all these kind of devices within the same packaging containing all driving and servoing systems.
- Assembly of this package to the machine has to be made with simple clamping system after self alignment of the system.
- The module can be handle with help of an overhead crane with very few manipulation.
- Services connections must be grouped to provide a simple plug-in operation.

IFMIF Accelerator facility

Activation of structures in the beam line of accelerators is driven by the beam loss in each piece of equipment and the energy level where the beam loss occurs. As a matter of fact elements such as beam collimators, scrappers, or beam dumps will certainly reach activation levels that prevent any hands on maintenance in a timescale compatible with the 70% availability target of the facility for beam-on operations.

On the other hand, the choice is still open for big elements such as Radio Frequency Quadrupoles and it seems like the real activation of these components will be known at the end of the Engineering Validation and Engineering Design Activity (EVEDA) phase. According to the proposed classification, a fist attempt to write a list for element needing maintenance was issued:

According to this list and the design guidelines defined in the upper sections concepts are proposed to handle some piece of equipment within the accelerator facility (see figure 3).

Zone	Element	Maintenance type	Maintenance classification
RFQ	Diagnostics	Maybe activated. Issue at the end of EVEDA phase	
	Cavity		III
	coupling loops		III maybe II due to number
	vacuum pumps		II or I (due to number)
MS	Buncher, quadrupoles, coupling loop	Maybe activated. Issue at the end of EVEDA phase	
DTL	Steerers, diagnostics,	Maybe activated. Issue at the end of EVEDA phase	
	Cavity		III
	Coupling loops?		III maybe II due to number
	Vacuum ion pumps		II or I (due to number)
Drift tubes & quadru-poles	Diagnostics, steerers	Maybe activated. Issue at the end of EVEDA phase	
	Drift Tube in DTL cavity		III
	Quadrupole magnet in DTL cavity		III
HEBT		RH or limited hands-on access	
	Quadrupole chain (cooling, power supply,coil)		III
	Dipole chain (cooling, power supply,coil)		III
	Octupole chain (cooling, power supply,coil)		III
	Ion pump chain for beam tube vacuum systems		
	9 degree achromatic lens		
	Neutron shield		
	Drift tube		
Beam Monitoring Station	Dump, diagnostics		

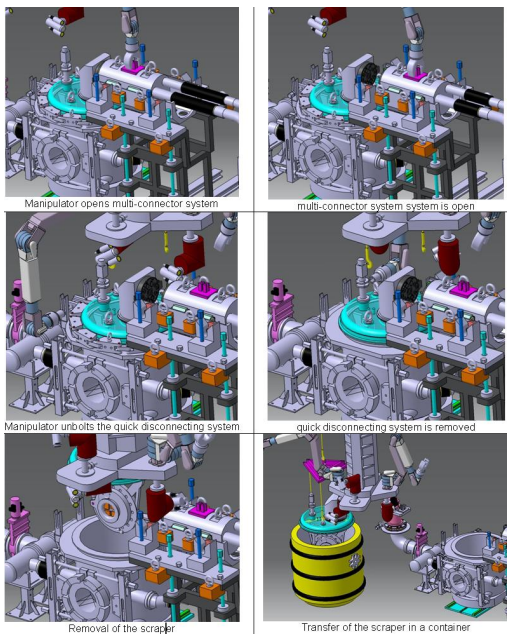


Figure 3: Example of sequences for scraper removal

Conventional facilities

Post-irradiation examination of irradiated samples is one of the main areas needing remote handling in conventional facilities.

According to data of the CDR, activity of samples seems to be in the range of what is currently handled in labs such as LCMI in CEA saclay and that no special R&D will be needed.

Figure 4: Tensile test machine in LCMI hot cell in Saclay

CONCLUSIONS

Redaction of the Preliminary Remote Handling Handbook for IFMIF is in progress. It aims at providing rules and elements to help designers to integrate Remote Handling since the beginning of the design of the machine to simplify maintenance operations and minimize downtime of the facility.

TASK LEADER

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