

RADIATION SAFETY SYSTEM FOR INDUS ACCELERATOR COMPLEX

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Abstract

Ionizing radiation emitted from the accelerators of Indus facility and similar facilities is a major occupational hazard. Therefore, a Radiation Safety System (RSS) is installed at Indus facility as a mandatory feature. The essential constituents of the RSS are: Shielding structure, erected as a part of the building, for protecting the personnel from ionizing radiation; Protection system for ensuring that nobody is inside the shielded area when the facility is in operation and detection and monitoring of the radiation levels inside & outside the shielded area. This paper deals mainly with the later two parts. The Protection and Monitoring systems were set-up in stages, first, for microtron and booster synchrotron, followed by that for Indus-1 ring. For Indus-2, it was commissioned in July 2005. These systems were then integrated and have been performing as intended. This paper presents the integrated radiation safety system of Indus Accelerator Complex with emphasis to the features of Indus-2 RSS.

INTRODUCTION

Indus Accelerator Complex is the first synchrotron radiation facility in India, located at Raja Ramanna Centre for Advanced Technology, Indore. It consists of a 450 MeV electron storage ring Indus-1 and 550-2500 MeV booster-cum-storage ring Indus-2. A common injector system that feeds these rings consists of a 20 MeV microtron & a 450-600 MeV booster synchrotron. All these accelerators produce intense ionizing radiation due to gradual or accidental loss of high-energy electrons in these machines. A Radiation Safety System (RSS) has been installed at this Complex to protect the personnel from this harmful radiation as a mandatory pre-requisite. Shielding structures made of thick concrete walls and roofs, form part of the Complex-building and enclose these four machines to contain the harmful radiation. The objectives of RSS are to:

- Prohibit any radiation producing activity in a shielded area till it is accessible;
- Prompt and ensure evacuation of shielded areas;
- Permit operation of accelerator / systems only after the respective area is searched and locked;
- Terminate the operation if trapping of a person is annunciated from a locked shielded area or access to such an area is attempted;
- Display the status of operation and access restrictions;
- Monitor, regulate and record the access of personnel to machine areas;
- Monitor, record and display radiation fields in the Complex and annunciate high radiation levels.

The RSS mainly consists of a hard-wired, relay-logic based Protection System and Ion-chamber-based Radiation Monitoring System to achieve these objectives.

DESCRIPTION OF RSS

The shielding structures around the machines mark the boundaries in reference to which we have set-up our RSS. The entire Complex has been divided into three zones as follows:

ZONE#1: Normal occupancy area, e.g. Foyer, offices, sitting rooms, labs – Without any monitoring of radiation field/ dose to personnel,

ZONE#2: Controlled / Restricted entry area, e.g. Experimental Areas, RF system areas, Magnet P/S areas. – With continuous monitoring of radiation field and dose to the personnel,

ZONE#3: Shielded Areas, inaccessible during operation / entry-restricted during shutdown, e.g. Microtron and Booster hall, Indus-1 hall, Indus-2 tunnel, Transport line tunnel – with continuous monitoring of radiation field & dose to personnel.

The main constituents of RSS are

- Protection System
- Radiation Monitoring System
- Access Control System
- Closed Circuit TV Surveillance System
- Moving Message Display System
- Public Address System

Protection System

This is a relay-based system and operates with 24 V dc supply. It has three parts, one for each of the three machine areas namely, Microtron & Booster, Indus-1 ring and Indus-2 ring. Each part is comprised of Search & Scram switches, door interlocks, flashing lamps, siren, key-interlocks and a central Safety Interlock Unit. Search switches are located around the machine in each of these areas. Search of each area is carried out while actuating these switches sequentially. Along with the search switches, scram switches are also provided which can be actuated to stop machine operation if needed. All access doors of these areas are fitted with limit switches interlocked with the search logic. Flashing lamps and siren are provided for audio-visual annunciation of access prohibition for machine areas. These field devices are connected to the Safety Interlock Unit of the respective machine area, which ensures that machine operation is allowed only when all the device interlocks are cleared. For Microtron and Booster ring area this system was commissioned in 1994 and for Indus-1, in 1999. These have been modified and improved since then. The system for Indus-2 is more spread-out and therefore more

complex. It has an intermediate stage, namely RSS station, for local integration of logic. Indus-2 machine area is divided in four parts and field devices of each part are connected to an RSS station. These four RSS stations are in turn connected to Indus-2 Safety Interlock Unit kept in Indus Control room. In addition to the devices listed earlier, in Indus-2, a PULL CORD is also provided along the outer wall as a scram device, which, if pulled down, stops beam transport to Indus-2. The status of Protection system is indicated in the Control Room on the Safety Interlock Units. For Indus-2, the status is also sent to control room via a data acquisition system for display on a computer console. The block-diagram shows this.

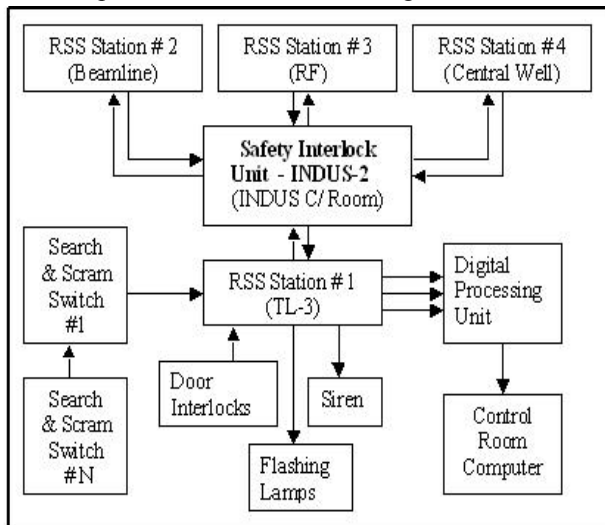


Figure 1: Block-diagram of INDUS-2 Protection System.

The Protection System also integrates features of these three parts and facilitates selection of operation modes for switching the electron beam injection between Indus-1 and Indus-2. It controls a switching magnet and a Beam-Shutter provided in the beam transport line that leads electron beam to the storage rings for ensuring radiation safety in an occupied machine area, while the other machine is in operation.

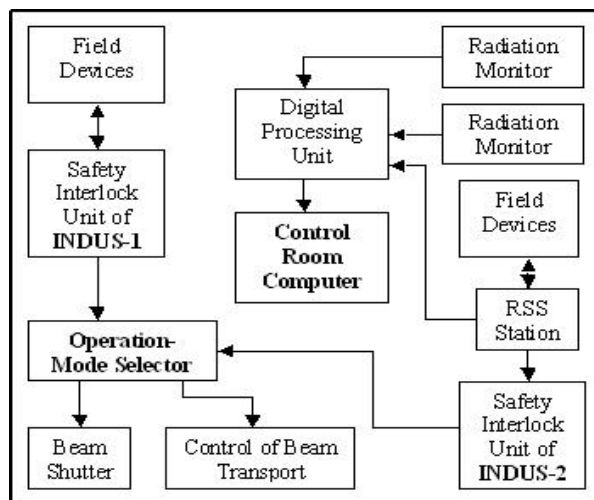


Figure 2: Block-diagram of Protection & Radiation Monitoring System.

Radiation Monitoring System

The unwanted hazardous radiation around electron accelerators is mainly bremsstrahlung radiation. Its high energy and pulsed nature make its detection and estimation difficult. However, in the experimental area around a storage ring, it is possible to measure this radiation using integrating detectors, because the beam storage and shielding structure smoothens the pulsed nature and reduce its energy. We have installed Ion-chamber-based radiation monitors at Indus Complex. High-range monitors having small SS ion-chambers are used as Beam-Loss Monitors near the machines (Zone#3), while low-range monitors having large SS and Al ion-chambers are used in the experimental halls and other occupied areas (Zone#2). Few high-sensitivity Environment monitors are placed in Zone#1 and around the complex. Neutron monitors are also installed to estimate of photo-neutron radiation. These monitors have been supplied by ECIL, Hyderabad and Electronic Division, BARC, Mumbai. All these monitors are provided with local high-radiation alarm and are connected to a computer in the control room, as shown, via a data acquisition system developed by Control Section of RRCAT.

Table 1: Details of Radiation Monitors.

Parameters	Indus-1 Area radiation monitor	Indus-2 Area radiation monitor	Indus-2 Environ. radiation monitor	Indus-2 Beam Loss monitor
Detector	Ion chamber	Ion chamber	Ion chamber	Ion chamber
Gamma sensitivity	4 pA / mR/hr	12 pA/ mR/hr	18 pA/ mR/hr	25 pA/ R/hr
Sensitive volume	5 litre	25 litre	7 litre	20 cc
Energy range	300 keV -3 MeV	100 keV -3 MeV	100 keV -3 MeV	300keV -3 MeV
Chamber wall	SS (2 mm)	Al (4 mm)	SS (4 mm)	SS 304L (1.5 mm)
Detector gas	Argon	Nitrogen	Argon	Argon
Pressure	150 psi	85 psi	100 psi	300 psi
Dose range	100 µR/h to 10 R/h	20 µR/h to 100mR/h	5 to 100 µR/h to 10 mR/h	0.1 to 10 R/h to 1000 R/h

Access Control System

Motorised tube-stile and turnstile gates are installed at all the entrances to Zone#3 of Indus-2 and at the entrance of Indus-1 hall. These gates are operated with electronic I-cards. These cards are issued to personnel authorised by the Operation-in-charge. The information of I-cards is recorded in a computer at control room when the gates are operated. The recorded data indicates the presence of personnel in the restricted zones. In the event of a fire accident, all these gates are released automatically for manual opening.

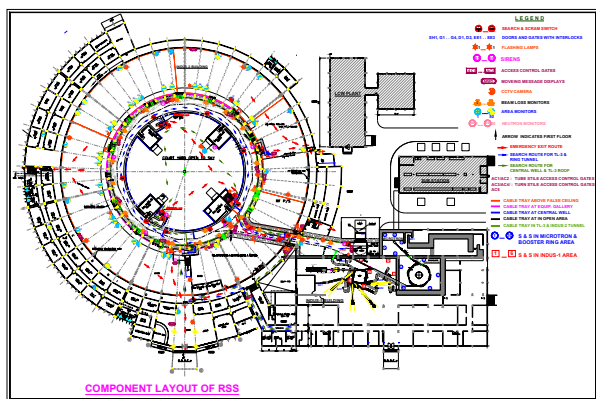


Figure 3: Layout of Radiation Safety System components in INDUS Accelerator Complex.

CCTV, Message Display and PA Systems

These systems are provided as a link between the operation staff and other personnel and aid greatly to the radiation safety in the complex. The CCTV system has colour-CCD cameras with motorized zoom lens and pan and tilt units connected to video monitors at control room and security post. The operation crew at Control Room visually monitors all the Zone #3 and Zone #2 areas before and during machine operation to detect any entrapment of personnel and accident in the machine areas. The Public Address System is used extensively for announcement before start-up of operation and also during testing of various systems to avoid accidents. Moving Message displays are provided in the machine areas and experimental areas to inform the personnel about the machine status and emergencies.

MODIFICATIONS AND PERFORMANCE

The radiation safety system of Indus has been modified and upgraded during past years. For the Injector system, trapped-key type kori-lock system was added. At Indus-1, changes were done to take care of the alterations done in the shielding while setting-up beam lines and to segment the search process. Kori-lock system and turnstile gate were also added. For Indus-2, distributed architecture was employed for the Protection system. It is segmented to quickly locate the place of breach of any interlock and failure of any field device.

A radiation safety system is a statutory requirement as per the regulatory rules and we were required to install this system for each machine before the commissioning trials could commence. Very reliable and consistent performance of RSS has played key role in the commissioning and regular operation of microtron, booster ring, Indus-1 and Indus-2. Provision has been made for bypassing the interlocks if the system fails (partly or completely) and an administrative procedure is also defined for this. However, such situations have arisen rarely during the past years.

CONCLUDING REMARKS AND FUTURE

The key feature of any safety system is its simplicity and reliability. Therefore we have used simple relay logic and hard-wired system for the Protection system, which is the heart of our RSS. This has kept the cost low and maintenance easy. Radiation detection and measurement is also done totally with analogue systems. The digital part is used only for display and annunciation. However, we now plan to replace the Protection system with PLC based system and use standard modules to build the system. Some development work for better estimation of radiation levels will also be taken up.

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