DEVELOPMENT STATUS OF PERSONNEL PROTECTION SYSTEM FOR THE IFMIF/EVEDA ACCELERATOR

T. Kojima*, T. Narita, K. Tsutsumi, K. Nishiyama, H. Takahashi, H. Sakaki
Japan Atomic Energy Agency, IFMIF Accelerator Development Group,
2-166 Obuchi, Omotedate, Rokkasho-mura, Kamikita-gun, Aomori 039-3212, Japan

Abstract

In the IFMIF/EVEDA Project, the prototype accelerator experiments to produce a deuteron (D^+) beam with the beam current of 125mA accelerated up to 9MeV at the CW mode are planned. The Personnel Protection System (PPS), which has two functions of radiation safety management and accelerator operation management, has to protect the personnel against unnecessary exposure, electrical shock hazard and the other dangerous phenomena. Since the radiation safety management during and after beam operation is a critical issue for the IFMIF/EVEDA accelerator, PPS with high reliability is indispensable. To realize the high reliability, for PPS design policy, we decided to use and customize proven systems and hardware, and applying dual PLC system [1]. This article presents the PPS design for the radiation safety management.

INTRODUCTION

The International Fusion Materials Irradiation Facility / Engineering Validation and Engineering Design Activities (IFMIF/EVEDA) Project is carried out at the BA site in Rokkasho, Aomori, Japan. The prototype accelerator consists of Injector extracting D^+ beam energy of 100keV, a 175MHz RFQ (4-vane type; output beam energy up to 5MeV), the first section of superconductive linac (SRF Linac; output beam energy up to 9MeV), beam dump, and the other accelerator subsystems [2].

Personnel Protection System (PPS) is a part of the control system for the IFMIF/EVEDA prototype accelerator. The PPS has two functions, which are radiation safety management and accelerator operation management in order to protect the personnel against unnecessary exposure, electrical shock hazard and the other dangerous phenomena.

Because the D^+ beam of 125mA/9MeV at the CW mode operation will be produced for the engineering validation, the radiation safety management is very important since the high radiation environment in the accelerator vault is assumed during and after beam operation. Therefore, the development of PPS with high reliability is indispensable for the radiation safety management for the personnel entering/leaving of radiation controlled area. In order to obtain the high reliability, we decided to use and customize the proven system and hardware to eliminate risks by initial failure, and apply dual PLC system to prevent malfunction.

*kojima.toshiyuki@jaea.go.jp

CONFIGURATION OF PPS

Fig. 1 shows a general configuration of the PPS. The PPS consists of a couple of PLCs, the PPS console, personal key boxes, door control boxes, emergency stop buttons, cameras for monitoring etc. In order to centralize status of the PPS equipments, all signal paths are hardwired from equipments to the PLCs.

One PLC system consists of one set of PLC and signal path which is composed to cables, limit switches and so on (for example, PLC-A and signal path for PLC-A in Fig. 1). The PPS consists of PLC-A system and PLC-B system and each system is configured separately and works independently.

The dual PLC system is adopted for higher reliability because the PPS only permit some actions when both PLC systems make same judgement. For example, workers can only operate the accelerator subsystems when both PLC-A and PLC-B system permit the operation.

The PPS console is used for monitoring and operating at the control room. The personnel entering/leaving of the radiation controlled area is managed by taking/returning personal keys. Access doors on the controlled area can be opened by the personal keys.

In the accelerator vault etc., some emergency stop buttons are installed. The beam operation is stopped by pushing the button.

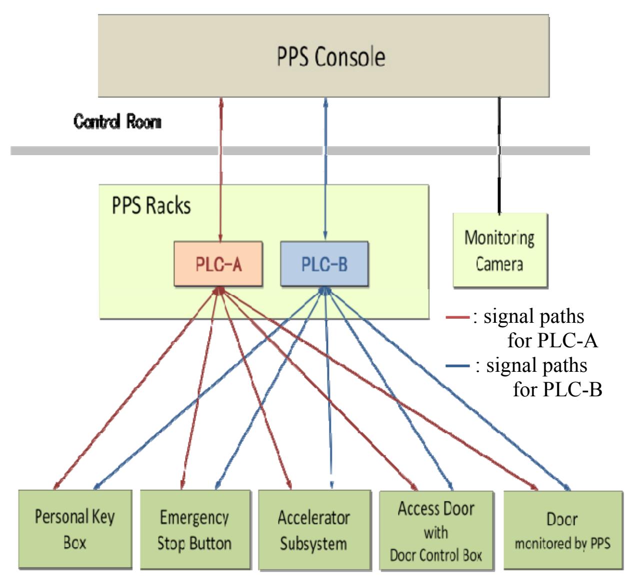

Figure 1: General configuration of PPS for the IFMIF/EVEDA prototype accelerator.

RADIATION CONTROLLED AREA

Fig. 2 shows the radiation controlled area of the PPS and the layout of main equipment for the PPS. The controlled area consists of the accelerator vault (yellow part in Fig. 2), radiation hot area (blue part in Fig. 2) where nuclear HVAC system and heat exchangers for cooling water etc. are installed. The PPS manages the entering/leaving of the radiation controlled area according to the classification of the access mode described in Tab. 1.

Table 1: Access Mode of PPS

Access Mode	Status
No Access	"No Access" means a prohibition against all access to the accelerator vault. * On beam operation * While radiation dose is too high to enter the radiation area after beam operation.
Controlled Access	"Controlled Access" means accessible to the accelerator vault and radiation hot area, when the supervisor gives permission. * During preparation for beam operation. * Interval of beam operation. * Maintenance at the radiation hot area
Authorized Access	"Authorized Access" means possible to access to the accelerator vault and radiation hot area, without permission. * Under suspension of accelerator subsystems * During maintenance works

During beam operation, "No Access" mode means prohibition against all access to the accelerator vault. Only when no person in the accelerator vault is confirmed and "No Access" mode is selected, the beam operation is permitted by the PPS. When the access door is opened or the lock is released, the permission for beam operation is immediately cancelled by the PPS.

In the "Controlled Access" mode, the access to radiation hot area for maintenance etc. is possible on beam operation when the permission is given by supervisor, but the access to accelerator vault is prohibited. During preparation for beam operation, access to both areas is possible when the permission is given by supervisor.

To let two status modes of "No Access" and "Controlled Access" on beam operation distinguish surely, two personal key boxes are prepared. One is used for entering to the accelerator vault, and the other is used for entering to radiation hot area, so that it is possible to enter to hot radiation area during beam operation under the management of PPS. The key for the accelerator vault is impossible to pull out during beam operation by the PPS.

For "Authorized Access" mode, the access to both controlled area for maintenance etc. is possible. In this mode, two kind of personal keys are also needed to access the both area, because the access mode of PPS is never changed to "Controlled Access" or "No Access" before all personal keys are returned to key boxes.

EQUIPMENTS LAYOUT

PPS Racks

The PPS consists of four racks; Uninterruptible Power Supply (UPS) rack, PPS control rack (PLC-A), Cable connection rack, and PPS control rack (PLC-B), arranged from left to right in Fig. 2 (1). These racks are installed in RF & Power Supply Area.

PLCs are installed in the PPS control racks (A and B) with same composition, and the PPS is full duplication including signal paths. The UPS has capacity of 5kVA and ability to supply the PPS equipments without electric power interruption during 10 minutes until startup by a backup generator.

PPS Console

The PPS console is used for monitoring and operating against personnel entering/leaving for controlled area from the control room. The PPS console consists of PPS control panel, an intercom, LCD monitors etc., as shown in Fig. 2 (2). In the PPS console, it is possible to survey the situation in the accelerator vault and shipping bay area by monitoring cameras and intercoms. In addition, the console is also used for monitoring the important points for radiation boundary, for example "Door monitored by PPS" in Fig. 2.

The PPS control panel provides the follow switches; Access Mode switches, permission switches for personal key boxes and door control boxes, an emergency stop switch, etc. By using these switches, the supervisor can manage the access doors for personnel entering/leaving for controlled area.

Personal Key Boxes

Personal keys are used for unlocking access door in the controlled area. When workers enter into the controlled areas, each worker has to take a personal key. Unless all keys are returned to the key box, the beam operation is not permitted.

Two personal key boxes are installed in the access room for entering the accelerator vault (yellow key panel) and for entering the radiation hot area (blue key panel) as shown in Fig. 2 (3).

The workers cannot take the keys on the yellow key panel during the beam operation, while they can take them on the blue key panel, when the supervisor gives permission by the PPS to enter to the radiation hot area.

Door Control Boxes

For the access doors (indicated red circles in Fig. 2) to enter the controlled areas, access door control boxes are installed near the door. When permission to release the access door lock is given by the PPS console, the door lock is released and the access to controlled area is possible.

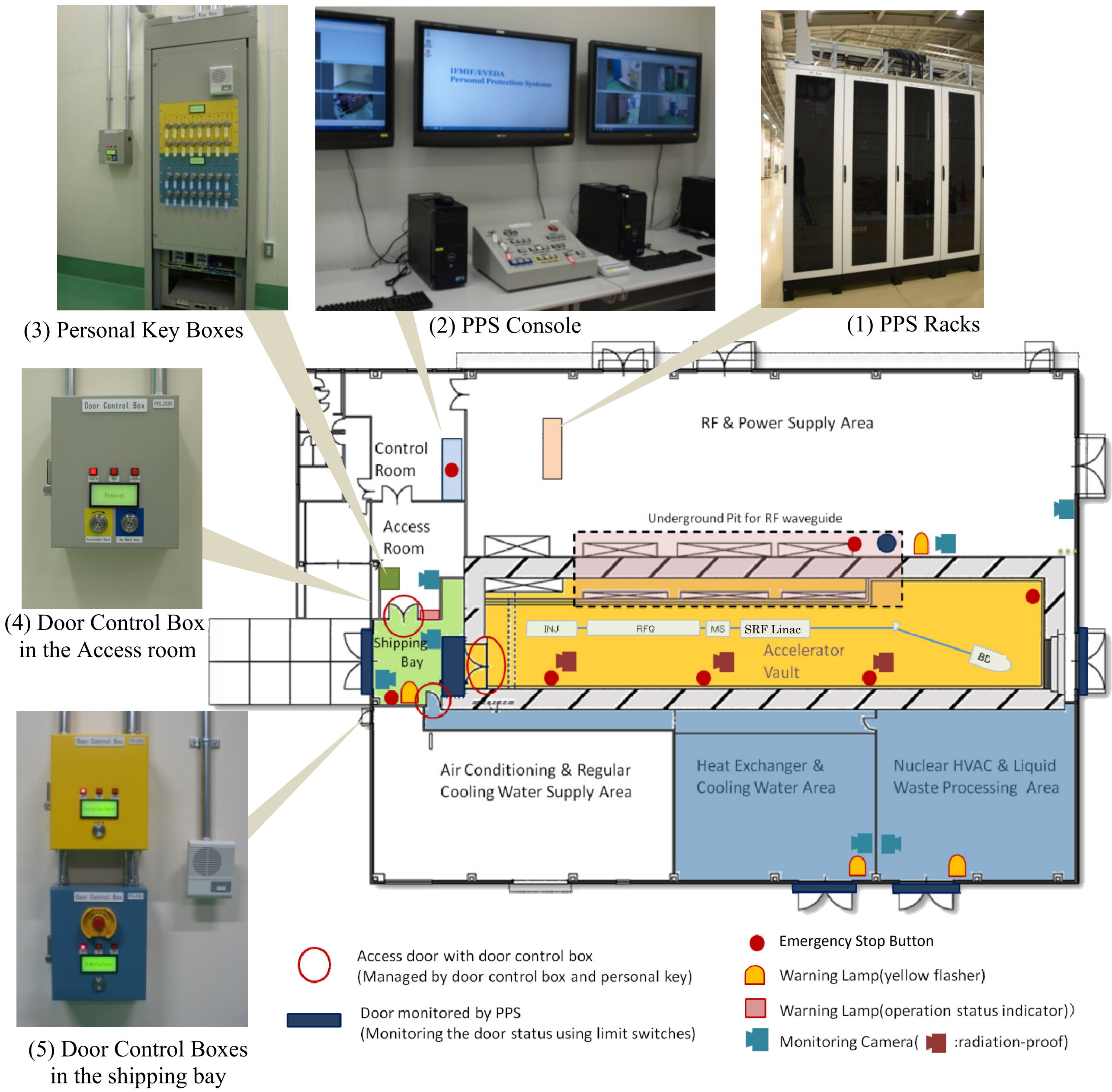

Figure 2: Radiation controlled area and Layout of main equipment for the PPS.

As indicated in Fig. 2, the workers have to access to the accelerator vault or the radiation hot areas from access room through the shipping bay. In the access room, the door control box is set, and the door lock can be released by yellow or blue keyhole as indicated in Fig. 2 (4). In the shipping bay, two access door control boxes are set for each access door (Fig. 2 (5)). After the supervisor can confirm the number of workers in the shipping bay by the monitoring cameras, a permission signal to the PPS is given by the supervisor, each door lock can be released by each personal key and person can enter to each areas.

(1) Emergency Stop Button (2) Monitoring Camera in the radiation proof box

Figure 3: Emergency stop button & Monitoring camera.

Emergency Stop Buttons & Monitoring Cameras

Four emergency stop buttons (Fig. 3 (1)) are installed in the accelerator vault in front of the accelerator subsystems; Injector, RFQ, SRF Linac, and Beam Dump.

When an abnormal or an emergency phenomenon happens, it is possible to stop or cancel for the beam operation by pushing the nearest button. The emergency stop button has a built-in alarm. The alarm rumbles loudly during the emergency stop button is pushed and also does during 5 minutes before starting beam operation to alert.

To monitor the important area for radiation safety at the control room, the monitoring cameras are installed in of the accelerator building. In the accelerator vault, 3 cameras are installed in the radiation proof box with lead shielding (Fig. 3 (2)). The 3 web cameras installed in the shipping bay and the access room make it possible to monitor views of the personnel entering/leaving for the controlled area. Some web cameras to monitor the radiation boundary are also installed in the RF & Power Supply Area and the hot radiation area.

SUMMARY

The PPS for the IFMIF/EVEDA prototype accelerator has been designed. In order to manage workers for maintenance, three status modes of "No access", "Controlled access" and "Authorized access" are applied for the accelerator vault area and the radiation hot area. For each status modes, management of workers for the entering/leaving is carried out by the personal keys, the monitoring system.

In the present status, sequence logics and programmed ladder on PLCs are applied, and the PPS has already performed the equivalent radiation safety management.

According to the interface signals between PPS and the accelerator subsystems, the responsible officers both JAEA and European Institutes are discussing details. Each interface signal will be performed at the linkage test with the accelerator subsystems in Europe, before they will be delivered to Rokkasho site [3].

REFERENCES

[1] T. Kojima et al., "Design policy of the Personnel Protection System for the IFMIF/EVEDA Accelerator", Proceedings of the 6th Annual Meeting of Particle Accelerator Society of Japan, Tokai, Japan, August 2009.

[2] H. Takahashi et al., "Overview of the Control System for the IFMIF/EVEDA Accelerator", Proceedings of the 6th Annual Meeting of Particle Accelerator Society of Japan, Tokai, Japan, August 2009.

[3] T. Kojima et al., "Linkage test of Control system and Injector for IFMIF/EVEDA Accelerator", Proceedings of the 7th Annual Meeting of Particle Accelerator Society of Japan, Himeji, Japan, August 2010.