ISBN: 978-3-95450-231-8 ISSN: 2673-5490 doi: 10.18429/JACoW-IPAC2023-THPA049

THE PERSONNEL ACCESS SYSTEM FOR FAIR

D. Gaßmann*, M. Salinas†, C. Betz, GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany
R. Schmidt, Technische Universität Darmstadt, Darmstadt, Germany
A. Antoine, M. Kalinowski, J. Uythoven, European Organization for Nuclear Research, Meyrin, Switzerland

Abstract

Once completed, the Facility for Antiproton and Ion Research in Europe GmbH, FAIR, is to be one of the leading nuclear physics laboratories in Europe and one of the largest and most versatile accelerator complexes worldwide. FAIR can serve a number of experiments simultaneously using fast-cycling synchrotrons. In this context, safety of personnel has the highest priority. The essential function of the Personnel Access System (PAS) is to prevent the presence of personnel in areas with particle beam or its secondary radiation. A particular challenge for FAIR is the large number of areas where personnel can access. For efficiency, it is required that during access to some areas, the beam operation continues in other areas of FAIR. For other hazards (e.g. electrical hazards, RF, laser beams) in certain areas, the PAS ensures that only personnel with adequate authorization can access and provides a safety signal to switch off hazardous equipment. Based on safety PLCs for the control system, the PAS uses some novel technologies such as hand vein scanners and safety radar systems.

PERSONNEL ACCESS SYSTEM

The special design of FAIR allows that a number of experiments can be served simultaneously. In the meantime, it is also required to do maintenance in currently unused beamlines and experimental caves for efficiency reasons. Personnel access and beam operation simultaneously in different parts of the facility is a special challenge from the radiation protection point of view. To handle this kind of operation and to secure areas against beam operation during personnel access, the Personnel Access System (PAS) was defined.

The PAS has to control the access to radiation protection areas for the accelerators and the experiments, so-called NE-Areas, and to check the access permissions of the personnel that wants to enter to prevent unauthorized access.

Further, the PAS is used as a guard for the accelerators and the experiments with respect to prompt dose-rate from beam operation. Therefore, the PAS has to secure NE-Areas against beam operation during personnel access and to stop beam operation in case of an access violation and moreover the loss of the integrity of the NE-Areas.

* d.gassmann@gsi.de
† m.salinas@gsi.de

NE-AREAS

The simplest definition of NE-Areas is that these are the areas enclosed by the PAS. NE-Areas are designed to fence off radiation protection areas, immediately caused by beam operation. This includes prompt and residual dose-rate in the vicinity of the accelerator and the experiments.

Compliant with the German "Strahlenschutzverordnung" (StrlSchV) [1], the controlled and restricted areas are called "Kontroll- und Sperrbereiche" in German. Therefore, the leading parameter defining the boundaries of an NE-Area is the dose rate that defines the area that needs to be controlled compliant with § 52 & § 53 StrlSchV [1].

But, the boundaries of NE-Areas are also set by the structural situation in the buildings and due to the later operational scenarios especially for the purpose of separation of beam operation and personnel access for maintenance.

The PAS differs between three types of NE-Areas.

- A main-area is the main entrance to the accelerators and the experiments and has a so-called Personnel Access Gate (PAG) as an access control for the separation of personnel with respect to their access permissions. Nearby, a material door is necessary to transport larger components into and out of the NE-Areas. A personnel contamination monitoring device is placed near the exit.
- An internal sub-area is a subspace within and only accessible via the dedicated main-area. The sub-area has no PAG but is divided from the main-area by a closable door. This area has a higher prompt and/or residual dose-rate compared to the dedicated main-area. The concept of a sub-area enables a faster access to the main-area, while the sub-area remains restricted. It also reduces the effort for the search procedure and residual radiation measurements in the context of radiation protection procedures.
- An external sub-area is not accessible via the dedicated main-area. However, this area also has no personnel access gate but a closable door to separate it from the remaining building. This area type is in principle only closed during beam operation because it has a slightly higher prompt dose rate compared to the remaining parts of the building, based on weak points in the radiation protection shielding of the main-areas. After shut down of beam operation, it is assumed that they are immediately accessible because no residual dose-rate from activation is expected.

ISBN: 978-3-95450-231-8 ISSN: 2673-5490 doi: 10.18429/JACoW-IPAC2023-THPA049

Presently, FAIR is divided into 19 NE-Areas. This number includes 12 main-areas and 7 corresponding sub-areas.

In the medium term future of FAIR this number raises to 34 NE-Areas because of the expanding experimental set-up of FAIR and the inclusion of further buildings.

The main- and sub-areas of the PAS are built in a modular way consisting of standard components, adequately assigned to the individual modules.

Entries and exits of NE-Areas are possible through six standard door types equipped with safety switches, which will stop beam operation immediately in case of an access violation, when a person enters the area without permission. The way the PAS stops beam operation is shown in chapter Beam-Off-Groups.

Presently the number of doors controlled by the PAS and equipped with safety switches is 86 doors. In the medium-term future of FAIR there will be roughly around 111 doors controlled by the PAS. The door types are described in the following.

1. The Personnel Access Gate (PAG) is used for the biometrical identification and separation of personnel with respect to their access permissions.
2. The Material Door (MAD) near the PAG allows the transport of larger equipment into and out of the NE-Area.
3. Area-to-Area Doors (AADs) are escape route doors for emergency reasons between two NE-Areas to enable an escape route through the borders of the areas.
4. Escape Doors (ECDs) are also for emergency reasons and enable escape routes out of NE-Areas into the remaining building or to the outside.
5. Sub-Area Doors (SADs) enable or disable the access to the sub-areas.
6. The Radiation Shielding Doors are used to reduce the dose rate for the remaining parts of the building.

All the information on the PAS, the NE-Areas and the dedicated equipment of the single areas mentioned above, as well as a lot of more information are collected in a central database to manage the connections of all parts of the system. The radiation protection department of GSI administers and operates this database.

ACCESS MODES

In principle, access to the NE-Areas can be classified in three different access modes called General Access, Controlled Access and Closed Access.

- In General Access the PAG is disabled and the nearby MAD enables access to the NE-Area for all persons with access permission to the corresponding building in which the PAG and MAD are located.
- In Controlled Access, only personnel with specified access permissions can enter the NE-Area through the PAG compliant with § 55 & § 63 StrlSchV [1].
- In Closed Access, no personnel access is allowed. This mode is active especially during beam operation and while cool down afterwards.

For closed access in preparation of beam operation, it is necessary that there are no persons left in the NE-Area. This will be achieved by alarming the area and through a Search-procedure executed by the radiation protection department. The Search is necessary to finally check whether all persons have left the NE-Area and to create a defined state for the PAS to switch in an access mode with higher restrictions. An acknowledgment via a key switch will confirm the start and success of the procedure.

For safety reasons and to avoid the Search before switching from Controlled Access to Closed Access, Controlled Access is also available with a Personnel-Key-System (PKS), which allows the PAS to count the persons inside the NE-Area in a safe way. Therefore, each person who enters the area needs to take a PKS-Key when entering the area through the PAG. When the person leaves the area through the PAG again the person gives the key back. So the number of missing keys equals the number of persons inside the corresponding NE-Area. While one or more PKS-Key is missing, beam operation is disabled.

BEAM-OFF-GROUPS

The guard function of the PAS uses links to various locations along the beamline to stop or prevent beam operation. By shutting down these locations, beam operation is no longer sustainable inside a dedicated NE-Area but other NE-Areas might have beam operation proceeding.

From all components necessary to sustain beam operation along the beamline only a few components are capable to prevent beam operation in a specified NE-Area quickly and purposeful without preventing beam operation in the whole facility. These few components are important for the safety of a NE-Area from the PAS point of view and therefore called Important Safety Elements (ISE).

ISE have two states, safe and unsafe. In safe state, these components prevent beam operation in the dedicated NE-Area. In unsafe state, the components are ready for beam operation at least from PAS point of view.

A Group of ISE preventing beam operation in a dedicated NE-Area, is called Beam Off Group (BOG) of that NE-Area. A BOG consists of two or more ISE, for example two Dipole-magnets. The BOG disables the deflection of the beam into a dedicated NE-Area and therefore prevents beam operation in that area.

With switching the BOG to SAFE, the ISE are forced to switch into the SAFE state to stop beam operation. While switching to the SAFE state the BOG sends a leading interlock signal to the Machine Protection System to provoke an imminent beam abort.

A BOG is safe while personnel access, in case of an access violation and in other cases leading to the loss of integrity of the NE-Area. Each NE-Area is assigned to one BOG per incoming beamline to ensure personnel access safety. Presently the number of BOGs is 9. In the medium term future of FAIR there will be roughly around 21 BOGs controlled by the PAS.

In principle, a BOG enables safe access to a NE-Area but only with respect to prompt dose-rate. Nevertheless, the PAS can support the risk mitigation strategies of Third

ISBN: 978-3-95450-231-8 ISSN: 2673-5490 doi: 10.18429/JACoW-IPAC2023-THPA049

Party Systems (TPS), which are components beyond the scope of the PAS, by offering safety signals of the BOGs and by offering the access control for the check of special access permissions to the NE-Areas. Therefore, the PAS will provide a pair of potential free safe contacts, which fulfill the requirements for a Performance Level (e) (PLe) safety function. These contacts can be used, multiplied and further processed by the responsible person for the hazardous third party equipment. The PAS will also read a potential free feedback signal that is required in order to detect the success of the switching command for diagnostics.

SAFETY ASPECTS

Following the scope defined for the PAS, the project is being designed in accordance with the Machine Directive [2]. This ensures that machinery is safe for use and that personnel is free of risks while meeting all relevant safety standards. As a result of the risk analysis, several Safety Instrumented Functions (SIFs), instruments to detect hazardous conditions and take appropriate actions to reduce risks, have been identified. These are being implemented into the safety control system in order to minimize the risk of injury to personnel and potentially to accelerator components. Therefore, the PAS is fully controlled by SIMATIC 1500 Safety PLCs from Siemens.

In order to ensure that the SIFs are correctly implemented, verification and validation of the safety software is essential. This is to ensure that the SIFs are properly integrated into the PAS control system and that they are functioning as intended. To assist with this, a tool developed by CERN, called PLCverif, is being used. PLCverif is a verification and validation tool which is specifically designed for safety software. It uses a combination of static and dynamic analysis techniques in which the safety PLC code is parsed into simpler language in order to contrast it with verification cases [3]. This process is a repetitive one, meaning that the integration of one or more elements into the safety system requires a re-evaluation of the SIFs, according to the V model, a methodology that describes the software development process throughout the whole lifecycle of a project [4].

ACCESS & MATERIAL TRANSPORT

Special access zones are provided for the access to the NE-Areas including the PAG, which is used to identify and separate the personnel with respect to their access permissions within the access mode Controlled Access. The PAS has to verify that only trained and authorized personnel can enter the areas and thereby only single access is allowed to be sure that these requirements are fulfilled.

For the first authorization factor a QR-code scan from the official dosimeter according to § 66 StrlSchV [1] is necessary to open the outer door of the PAG. Inside the PAG there is a monitor that displays all the information necessary for the entrance procedure. By stepping on a two zoned contact mat and by an ultrasonic anti-piggybacking-device the PAG ensures that only a single person had entered.

For the second authorization factor a biometrical one is used to verify that the shown QR-code matches with the person inside the PAG. For this purpose, a hand-vein scan technology proves the identity of the person inside the PAG.

Furthermore, the PAG includes the PKS station for safely counted access and a dosimeter station for issuing an electronic dosimeter for access to controlled areas.

With this, all special access permissions are checked and if the check is passed, the access to the inside of the NE-Area is granted by opening the inner door, otherwise, the outer door opens again. For leaving the NE-Area the procedure will be vice versa.

If the NE-Area is in controlled access mode, a material transport procedure is necessary to maintain the defined state of the area, while material transport of larger components into or out of the area. This is done by switching the controlled enclosure of the NE-Area slightly inwards to the next door or narrow passage for the time the material transport is executed through the nearby MAD.

The person executing a material transport requests the transport via a nearby phone to the radiation protection department to release a so-called Material Transport Key (MTK) to unlock the MAD. With the MTK released, the procedure starts and the muted light curtain at the alternative enclosure position is activated. This creates a new small zone between the light curtain and the MAD of about 10-20 m². At the same time, the PAG will be disabled for entrance and exit procedures for the remaining transport process.

To verify that no person is left inside the transport zone, the zone between the MAD and the light curtain will be searched by radar before the MAD unlocks. If the scan is successful, the MAD can be opened and the material can be placed inside the transport zone without losing the integrity of the NE-Area and without an alarm. After finishing the physical transport, the MAD will be closed again. By turning the MTK back in position the zone between the light curtain and the MAD will be searched again by radar whether there are persons left in the transport zone. If the area is clear, the procedure will be finished, the light curtain is disabled and the PAG will be enabled for entrance and exit procedures again for regular operation.

REFERENCES

[1] StrlSchV, https://www.gesetze-im-internet.de/strlschv_2018/

[2] Leitfaden Machine Directive, https://www.dguv.de/medien/dguv-test-medien/_pdf_zip_doc_ppt/leitfaden_maschinenrichtlinie_2.pdf

[3] B. Fernández, E. Blanco, and A. Merezhin, "Testing & verification of PLC code for process control," in *Proc. of the 14th ICALEPCS'13*, San Francisco, CA, USA, Oct. 2013, paper THPPC080, pp. 1258–1261.

[4] Kevin Forsberg and Harold Mooz, "The Relationship of System Engineering to the Project Cycle", in *Proc. of the First Annual Symposium of National Council on System Engineering*, Oct. 1991, pp. 57–65. doi:10.1002/j.2334-5837.1991.tb01484.x