THE ESRF BEAMLINE PERSONNEL SAFETY SYSTEM

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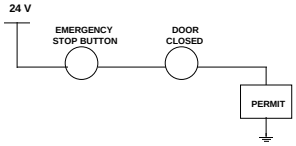
INTRODUCTION

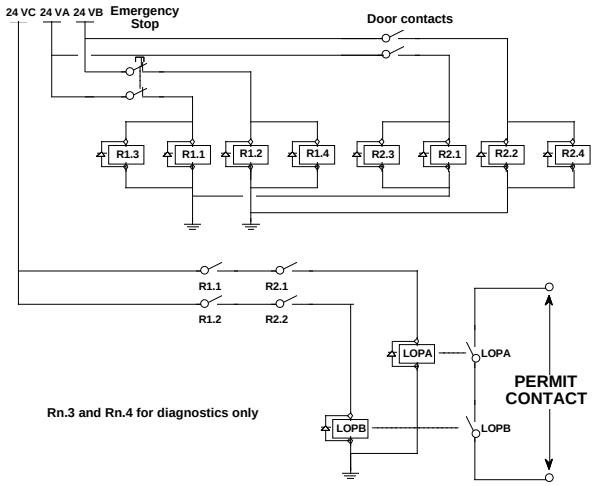
The present paper describes the ESRF Beamline Personnel Safety System. A short description of the basic hardware of the system is given, followed by the description of its functionality. We describe the way the different beamline safety systems are linked to the general accelerator personnel safety system. Since the ESRF has a large number of beamlines (by the end of 1996, 34 beamlines will be installed, with a total of 105 hutches), we have taken great care to design a modular system, which has been optimised to reduce the installation time.

1 THE SAFETY SYSTEM HARDWARE

Since the ESRF accelerator personnel safety system uses a basic hardware developed at Daresbury Laboratory, it was decided to develop the Beamline safety systems using the same hardware. This means that the system is indeed a relay-based, redundant system. With respect to the original Daresbury system however, we are using the third guardline exclusively for monitoring purposes. This does not reduce the redundancy of the system, but rather increases its reliability. The general design principle of the system is shown below, where the circuit for a simple logic diagram is represented.

From this diagram it can be seen that the safety permits are obtained via two identical, independent guardlines.Although there is no automatic consistency check between the two systems, a built-in microprocessor monitoring allows a regular verification to detect possible single faults. It should be noted that the safety function of the system is completely independent of this microprocessor system. Failure of the latter does not compromise the former.



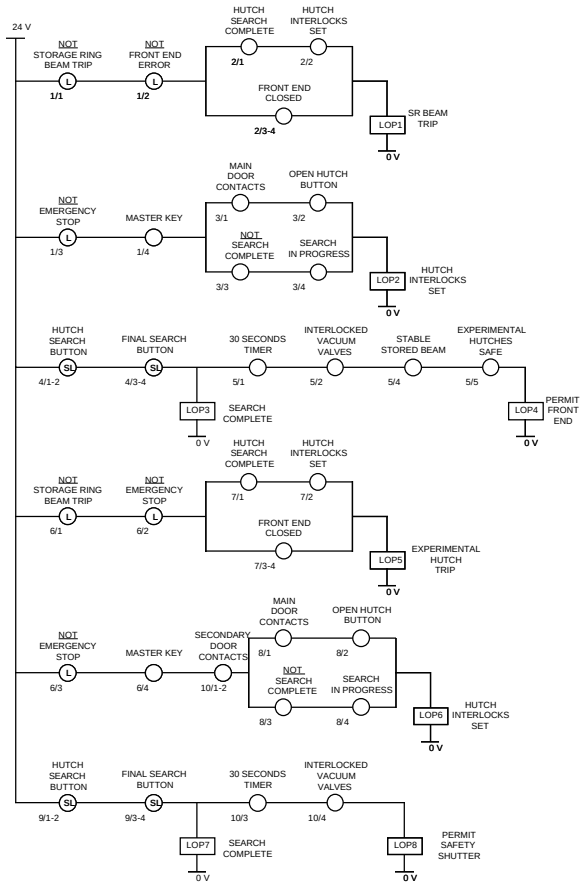


2 THE FUNCTIONALITY OF THE SYSTEM

The role of the beamline personnel safety system is simple, namely the system must a) guarantee that, before radiation can be allowed to enter a hutch, everybody has left the hutch, which is properly closed and b) if for whatever reason a person enters a hutch during operation, the safety system must immediately stop the radiation. In the latter case, in order to maintain the system's general redundancy, the safety system must act on two independent elements which will block the radiation.

This redundancy means that, if a problem occurs on an Experimental Hutch, the PSS will not only prompt the closing of the corresponding shutter, but will also immediately close the front-end. If however a problem occurs on an Optics Hutch, the PSS will immediately close the front-end, but will also immediately dump the electron beam in the Storage Ring.

The general logic diagram of a (2-hutch) beamline is shown in the logic diagram.



The upper part corresponds to the Optics Hutch, the lower part to an Experimental Hutch. As explained above, every safety system has a link to the accelerator PSS to trip the beam in case of a problem on the Optics Hutch. As can be seen from the logic diagram, this occurs if the front-end is opened without the hutch being searched (i.e. if somebody forces a door, or enters using an emergency door release button). Outside every Optics Hutch, a SR Beam Trip emergency button is installed, which, when activated, trips the storage ring. The closing of the front-end takes roughly 4 to 5 seconds. Six seconds after the front-end permit has been tripped, the PSS verifies that the front-end is indeed closed. Otherwise, it considers that the front-end is no longer operational, and again the Storage Ring beam will be dumped.

Before the front-end (or shutter in case of an Experimental Hutch) can be opened, a search has to be carried out. The search is initiated by a button on the PSS panel, which is installed next to the main hutch door. The search is carried out by a single person, who has to press one or more search buttons inside the hutch. At the end of the search, the hutch door is electrically locked by the PSS (in case of more than one door, all so-called secondary doors are locked when initiating the search). Before a hutch can be searched, the so-called "Hutch Interlocks Set" must be raised. As can be seen on the diagram, this requires that all emergency buttons inside the hutch are safe, as well as the presence of the so-called master key. This master key is operated within a key system used for interlocked local shielding, and also provides a hardwired means to block a beamline for safety reasons (e.g. during a work permit issued for a beamline). Note that the emergency stop buttons have a dual role, since they also switch off all the electric power inside the hutch, apart from the lighting.

When the search is finished, a 30-second warning period is triggered, during which danger bleepers and beacons inside the hutch are switched on, to warn anyone who has accidentally stayed inside the hutch after the search, that he must immediately press an emergency stop to trip the search, and thereby prevent the opening of the front-end / shutter.

In order to obtain the permit to open the front-end, three more interlocks must be set. All vacuum valves which are inside the white beam path must be opened. During refills of the storage ring, all front-ends must be closed. This is taken care of by the so-called "Stable Stored Beam" interlock, which comes from a key on the general accelerator PSS. Either this key is in the Stable Stored Beam position, allowing the operation of the beamlines, but blocking the Storage Ring injection, or it is in the Injection position, blocking the beamlines, while allowing injection into the Storage Ring. This implies more connections between each beamline PSS and the accelerator PSS, namely the Stable Stored Beam information to the beamline PSS, and the front-end status (open/closed) from the beamline PSS.

Finally all the Experimental Hutches must be safe to allow the opening of the front-end. This is the redundant action of the PSS in case of a problem on an Experimental Hutch, as discussed above.

3 GENERAL LAYOUT OF THE BEAMLINE PSS

The central part of the PSS is the logic centre. The logic centre includes the logic crate, with the interlock modules, the relay and terminal interface boards, and the 24-Volt power supplies. Every hutch has a Hutch Interface Panel, which contains the user interface of the system, i.e. the different buttons to start and finalise a search, and to enter inside the hutch, the emergency door release button, as well as a number of illuminated panels (Hutch Searched, Front-end / Shutter Open, Stable Stored Beam). Finally inside the hutch the emergency buttons, the search buttons, and the different bleepers and beacons are installed.

The logic centre is designed such that the basic systems correspond to a 2-hutch beamline. Additional hutches can be added, up to four per logic centre. For

beamlines with more than four hutches, extra logic centres are necessary. The extension of an existing beamline PSS by adding extra hutches is straightforward, using plug-in extension units, requiring no rewiring inside the logic centre.

The connections between the logic centre and the Hutch Interface Panels are done via connectors on both ends. This allows the installation time to be minimised and significant pre-testing of the systems to be carried out.

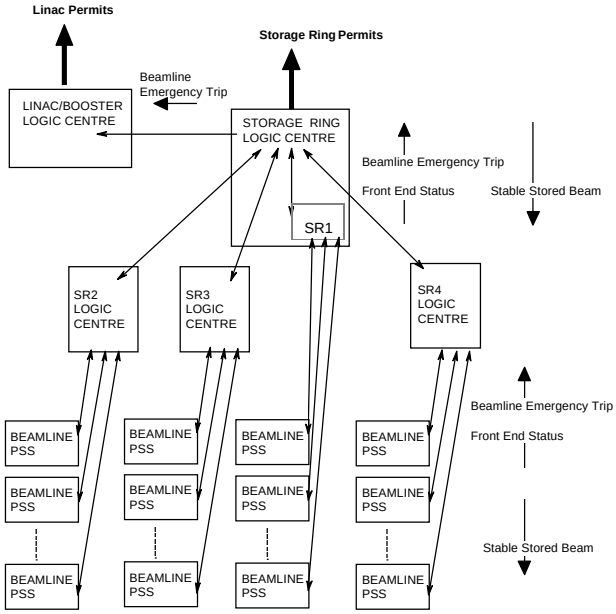
Although in principle all the beamline safety systems are identical, the system is sufficiently modular and flexible to allow small modifications of non-standard beamlines. The PSS is also used to incorporate the necessary laser safety for those beamlines where high-power (class IV) lasers are in use.

4 CONNECTION OF THE BEAMLINE PSS TO THE ACCELERATOR PSS

As explained above, every individual Beamline PSS has to be connected back to the main accelerator PSS, to provide the Storage Ring emergency trip, indicate the front-end status, and receive the Stable Stored Beam mode. Within the Accelerator Safety system, this information is centralised in the main logic centre, situated near the injection zone. This logic centre provides all the permits for the Storage Ring, and also includes the area interlocks for SR1, a quarter of the Storage Ring tunnel, which includes the injection area. The individual beamline safety systems are all connected to the corresponding Storage Ring sub-area logic centre, from where the global information goes to the central Storage Ring logic centre. The diagram below shows the general architecture.

Note that the tripping of the Storage Ring beam by the accelerator PSS is triple-redundant: the fast action is normally achieved by tripping the Radio-Frequency. As a redundant back-up, a copper block is inserted inside the beam (reaction time < 1 second). If after 1 second the beam killer is not inserted (checked via position switches) the Storage Ring dipole magnets are switched off.

The connection of the Beamline Safety Systems to the Accelerator PSS is made via junction boxes, located inside the Storage Ring Tunnel, near the corresponding Port Ends, using connectors. All these junction boxes were installed and connected to the accelerator PSS, before the installation of the first beamline. As long as the beamlines are not installed, the connectors are temporarily terminated with shorts. This allows us to limit the interruption of the machine in order to connect a new beamline PSS to a very short time, typically a few hours, which is the time needed to do the necessary testing. This is very important since only a few shutdowns per year are available for installation work, which obliges us to connect new beamlines during operation runs.



5 PROBLEMS ENCOUNTERED

The first systems were installed in 1993, and at present we have equipped 28 beamlines, which corresponds to more than 80 hutches. Up to now not a single fault has occurred, in the sense that no dangerous situation has been created due to a PSS failure.

We have had a limited number of relay failures, where relays have failed to close. Since we have an active safety system, this did not create a safety problem, it only meant that for example a hutch could not be searched, or a permit raised.

The main problem we have comes from the fact that we have electric locks on the hutch doors (deadbolts). From time to time, these deadbolts do indeed fail, although the door contacts indicate the closed position of the door. A person who does not pay attention could therefore open the door, with the front-end open, thereby tripping the Storage Ring. Although this is not a safety problem, it is of course extremely inconvenient because it obviously stops all the beamlines. The addition of extra warning lamps on all hutch doors, indicating that the hutch is interlocked, as well as a concerted effort on the training of people working on the beamlines, has allowed us to drastically reduce the number of trips. To date in 1996, i.e. after roughly 100 days of beamline operation, not a single beam trip due to a PSS failure has occurred.