PERSONNEL SECURITY AT THE BROOKHAVEN ALTERNATING GRADIENT SYNCHROTRON*

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Summary. This paper concerns the safety and protection of personnel associated with high energy accelerators with special emphasis on the radiation hazards involved. General philosophies are considered and the personnel security system existing at the 33 BeV Alternating Gradient Synchrotron at Brookhaven National Laboratory is discussed in some detail.

Introduction

General

In analyzing and designing a security system for an accelerator, certain fundamentals must be kept in mind and usually these are difficult to evaluate quantitatively. Briefly stated, these include the following:

a. The extent of the protection system should match the degree of existing hazards.

b. The system should emphasize simplicity, flexibility and minimum cumbersomeness.

c. The system should be compatible and consistent with the talents and expected training program of both the personnel who are to be protected and the personnel who will implement the system.

Although seemingly obvious, these fundamentals quite often lack sufficient emphasis in the maze of detailed design.

Existing Hazards

The hazardous areas at the Brookhaven Alternating Gradient Synchrotron (AGS) to be considered here include all of the main ring, certain small adjacent areas, and the high energy end of the linac injector. There are a total of 11 access ways into these areas (see Fig.1). During full operation of the accelerator, there exists in varying degrees in these areas radiation levels up to many thousands of rads/hour, distributed electrical power systems with up to 5,000 volts and magnetic fields up to 15 kilogauss. These conditions require the complete exclusion of all personnel. When the machine is off, residual radiation levels of several hundred millirads/hour and more exist in many places in these areas.

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Basic Philosophy

The first line of protection at the AGS is based on the following:

a. During full operation, all doors and gates into these areas are to be fully secured and locked and are designed to be quite impassable except by established means.

b. Generally, security system activities and operations will be performed locally at the scene by trained and responsible personnel.

Although important, all other features of the AGS security system are considered as supplementary and as a secondary line to these basics. Since an important link in the chain of protection is the use of personnel, procedures and discipline for these personnel must be carefully detailed and enforced.

Procedures

Initial Clearance

After an extended shutdown of the machine, an inspection tour of the main ring and adjacent areas is made by two teams of two men each. One gate, usually the east gate, is designated as the starting point and a fifth man posted at this gate. The inspection teams walk in opposite directions from this gate, proceed around the main ring, pass each other in the vicinity of the injector and continue around back to the starting point. Thus, these areas are effectively inspected twice. The duties of these teams are as follows:

a. Account for each and every person in these areas, name-by-name, and pass the names (via telephone) to the man stationed at the gate who maintains a detailed check list.

b. Secure and lock all doors and gates.

c. Make a general visual inspection of the machine itself, particularly the main magnets.

The first team to pass each door or gate secures and locks it, insuring by visual and physical observation that the gate is properly locked. In addition, the door switch circuit at each gate must be reset, and this serves to indicate that every door and gate has at least been visited. The locking and resetting function is accomplished by special keys. The second team passing each door and gate inspects and verifies the gate status.

As the various personnel who were in these areas leave through the manned gate, their names are checked off. When all personnel have thus been accounted for, the gate is locked, local circuits reset, and clearance given to main control. Additional circuits must then be reset at the main console. Machine operation, in particular, main magnet pulsing, spiralling beam and accelerated beam, can then proceed.

Brief Shutdown

In the overall operation of the AGS, situations arise quite frequently requiring personnel to enter and be in these areas for periods of an hour more or less. To avoid the moderately lengthy process of complete inspection, a brief shutdown is declared and machine operations are secured. A man is stationed at an appropriate gate and a detailed check list is maintained of all personnel entering and leaving. Once all personnel have left, machine operations are resumed in the same manner as in the initial clearance.

In actual practice, both for the initial clearance and for the brief shutdown, it is frequently required to have more than one gate available for access. Under these conditions, a man is stationed at each of these gates. A final cross check of the lists from each gate is necessary to verify that all personnel are accounted for.

Details and Features

General

The procedures and circuits required to implement the above are moderately straightforward. However, the requirements for special operating combinations and the inclusion of various supplementary features add greatly to the complexity of the analysis of the system and of the system itself. It is at this stage that simplicity and flexibility can most readily be lost; conversely, the fundamentals of security design are most difficult to accommodate. A number of details and features of the AGS system are described not only to indicate particular situations and solutions at the AGS, but also to illustrate the more general consideration of the fundamentals.

Access Classifications

It was found advantageous to define three conditions of access for the security status in these areas, namely:

a. Free access - no restrictions on entering or leaving.

b. Restricted access - existing where there are no overall machine operation hazards, but where residual radiation exist at significant levels so that it is prudent to restrict entry only to certain personnel.

c. Controlled access - existing whenever the machine is in full operation, or full operation is imminent. In this case, all interlocks are active.

Having thus defined these conditions, the type of access is directly related to the degree of danger allowing maximum flexibility of activities without imposing severe limitations. These definitions directly associate themselves with the status of the machine and have proven to be of considerable value in the overall picture of machine activities. Further, appropriate procedures can be clearly delineated according to the class of access in effect.

In practice, areas are subdivided to permit matching the condition of access with the hazard in that subdivision. The security status in adjacent areas can be used to automatically set the cross interlocking. The condition of access is set by a key switch at the corresponding control area. This and other applications of access classifications to circuit functions are discussed in the following paragraphs.

Gate Operation

Generally, the locking arrangement at the gate consists of a double solenoid operated bolt, one solenoid for locking, and one for releasing. This allows considerable flexibility in circuit design and compliance with various requirements of the security system in a rather straightforward manner. For purposes of emergency exit or entry, even during power failure, the lock assembly includes mechanically coupled emergency release arrangements: a slide bar on the inside, and a break glass/turn knob on the outside. Even though the legitimate need for this feature would be infrequent, such need justifies the additional complexity and the small loss in security. After an emergency operation, a mechanical reset within the lock assembly is required before the gate circuits can be again reset, thus drawing attention to the emergency release. In addition, the pilot lights on the main console which normally show a steady light are arranged to flash in this event.

During restricted access, the circuits are arranged such that the release solenoids can be energized by certain key operated switches located adjacent to the gates. Keys for these switches are issued only to personnel who require access to these areas and who are aware of the radiation restrictions in these areas. Panel lights on the main console indicate when the gates are unlocked.

Having changed the security status to controlled access, these key switches will no longer operate the bolt solenoids and a second key operated switch at each gate becomes activated.

This second key switch will operate the release circuits, but only with the simultaneous operation of a corresponding push button on the main console, thereby enabling the machine operators to verify that machine operations are properly secured. Further, procedures require a health physicist to be the first to enter the area and, using a portable instrument, verify that the beam is indeed off.

This second key switch is also used for operating the locking solenoid and for resetting the door switch circuits. For reasons of flexibility, such switches are located on both sides of a gate. To eliminate the possibility of locking one's self in, resetting the circuits and thus permitting machine operation, only two keys are allowed in circulation for these controlled access functions. Circuits are arranged so that machine operation can proceed only when both keys are in a captive-ON position in key switches located external to the hazardous areas. Having only two keys in circulation enhances the accountability of the keys themselves and clearly delegates the authority and responsibility of the security gates to the personnel assigned to these tasks.

As a function of the area classifications, all reset circuits are dropped when the security status is changed to restricted access. Consequently, all door switch circuits automatically require reset each time controlled access is set up and the initial clearance is made.

Under conditions of restricted access, a certain few gates are best left unlocked for various reasons. Upon going to restricted access, circuits are arranged to automatically operate the release solenoids on these gates.

Linac Injector Operation

Quite frequently, the linac injector is operated with full beam for its own purposes while the remainder of the AGS machine is not operating. Because of equipment arrangement, this combination results in the 50 MeV linac beam entering a small portion of the main ring, and gates exist in the main ring at A16 and L5 (see Fig. 1) to enclose this area. This latter area is then under controlled access, while the rest of the main ring can be under restricted access. The details of circuit interlocking between these areas are arranged to change as a function of security status in each area.

Magnet Pulsing Interlocking

Normally, the door switch circuits interlock the pulsing of the main ring magnets. However, during a brief shutdown, it is often desirable to maintain magnet pulsing. Therefore, bypass circuits initiated by the machine operators allow this pulsing to continue while the gates are open. Following the shutdown, the circuits are arranged to automatically remove this bypass as an auxiliary function of the final reset operation of the door switch circuits. To insure this automatic removal, a time delay circuit initiated by the bypassing operation will itself cancel the bypass if at least one gate is not opened within the timing period.

Beam Stops

In keeping with the philosophy of simplicity and straightforwardness, the basic method used to stop and prevent beam radiation is beam stoppers. Interlocking various equipments associated with the beam steering devices or acceleration process is used only as backup. Beam stops exist at two locations; at the low energy end of the linac injector to control radiation in the linac area, and in the beam transport to the main ring to control radiation in the main ring area. In each case, two vacuum valves, positioned in series for redundancy purposes, are used for beam stops. Circuits set to sense the failure of either valve to close upon demand will automatically operate on other components to stop the beam.

Information

A number of supplementary features, devices and procedures have been incorporated in the AGS security system. Each time the machine status or operating conditions change, announcements are made on the public address system by the machine operators for information purposes, and as a warning of an impending additional hazardous situation. At each gate and in various other areas, appropriately labelled lamps and lighted signs indicate the general status of the machine. Red warning lights with suitable signs exist in certain areas and generally at all gates. As an additional warning, circuits are arranged to turn off the main lighting system in each area when all gates to that area are locked and reset leaving only minimal emergency lighting necessary to see and locate a crash button or telephone in the area.

Local Protection Means

Crash buttons exist at frequent intervals throughout all these areas and are arranged to actuate the beam stoppers, to turn off certain high voltage systems and to turn on the area lighting system. Annunciators, one for each crash button, are located in the main control room to facilitate the proper and full evaluation of each emergency operation. Telephones in these areas are connected in a party-line arrangement to amplifiers with loudspeakers in the appropriate control rooms. These telephones permit rapid and unimpeded communications to the machine operators in the event of a hazardous situation.

Keys

Since special keys serve as an important link in the security system, the market was surveyed in some detail and a unit selected in which unauthorized duplication would be quite difficult. The key blank itself is unusal in that it has a curved shape instead of the more conventional flat shape. Even if key blanks were available, it is impossible to make duplicate keys with conventional key cutting machines. In fact, finished keys are available only from the manufacturer.

Self-Protection

As a means of individual protection, various arrangements of keys, tokens, etc. to be carried by each person, and arranged to prevent machine operations in this event, were considered at some length. However, certain problems inherent with the basic scheme exist which are difficult to accommodate. Implementation of these arrangements were considered as adding significantly to an already complex system and it was, therefore, decided to defer such an arrangement, at least for the present.

Typical Gate

Fig. 2 shows a typical gate installation complete with status indicating lamps, gate warning light and sign, telephone and solenoid lock. A desk arrangement is included to facilitate the process of maintaining detailed check lists. The turnstile seen here was installed to permit its evaluation as a means of counting people. In fact, it has proven to be quite useful in the physical control of personnel to permit the proper maintenance of check lists.

Conclusions

In the year and a half that the system has existed more or less in its present form, only three incidents have occurred in which there was a breach of the security system. Two of these cases, directly related to personnel failure, resulted from shortcomings in established procedures and failure to follow existing procedures. In the third case, a hazardous situation arose because of a combination of an improperly locked door and the lack of a special door switch to indicate this situation.

In general, the security system at the AGS has proven quite successful. Experience has indicated that the complexity of the system, particularly from the point of view of personnel and procedures, is in reasonable balance with respect to the hazards existing and the flexibility required.

Acknowledgements

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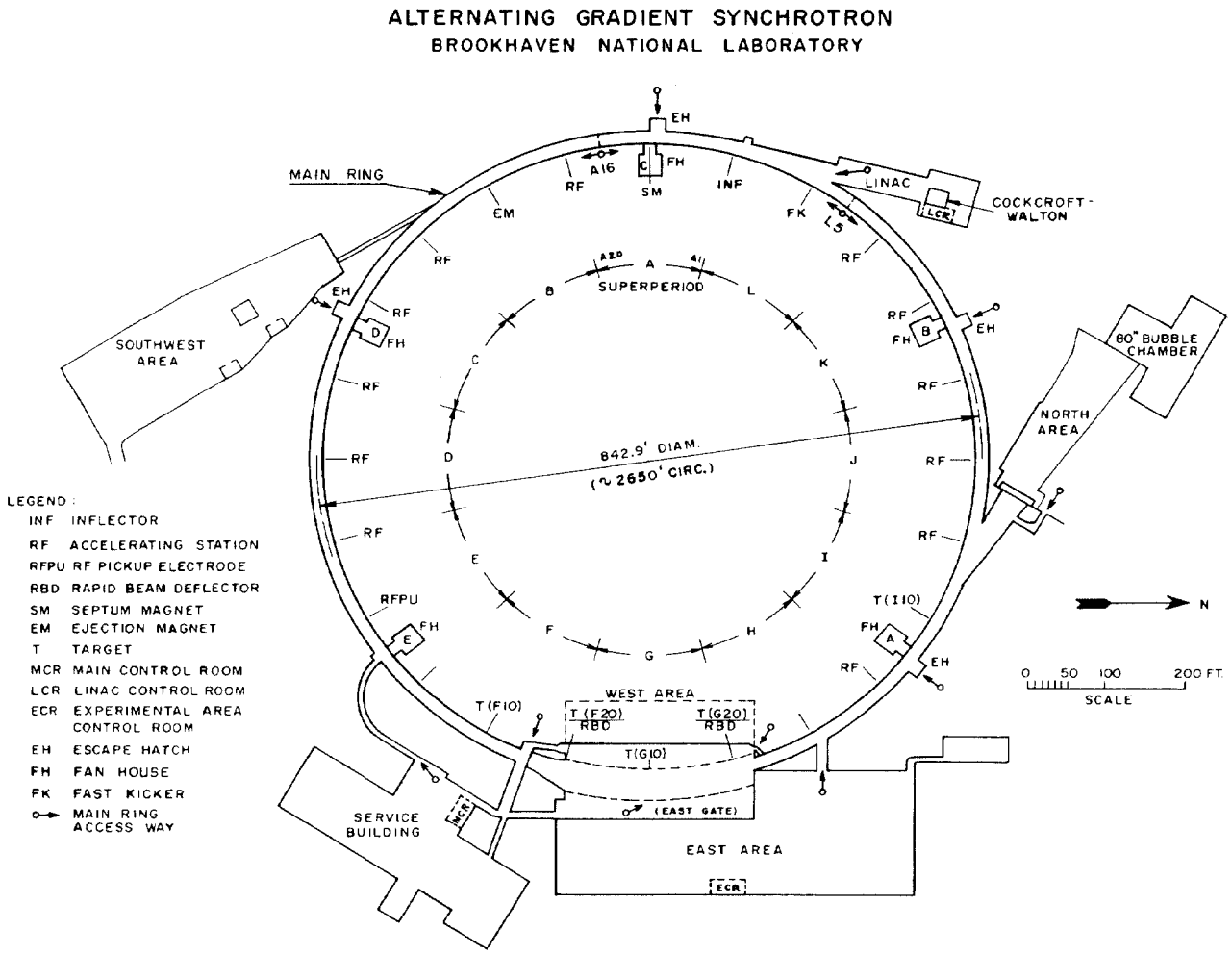

Fig. 1. AGS Complex.

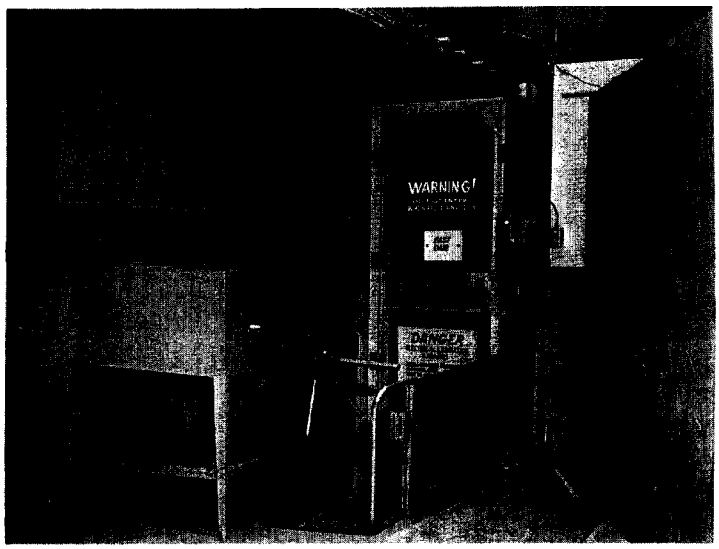

Fig. 2. Typical Gate.