PLC controlled search & secure safety interlock system for accelerator

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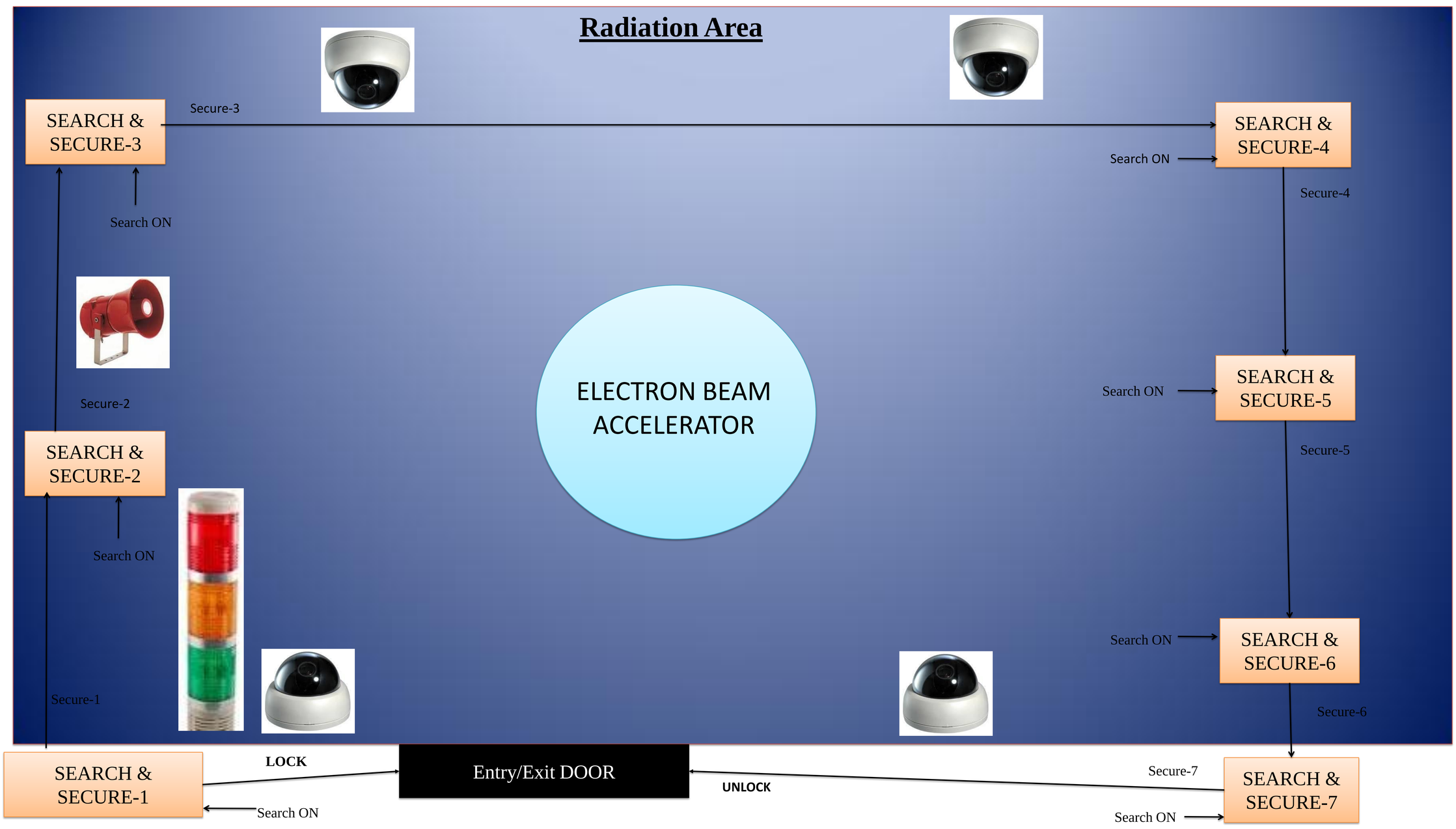
Introduction: The electron beam accelerator is used to generate high amount of X ray dose. This X ray dose is used in various applications for irradiating different products. The X dose at the same time is very harmful for the human beings since it damages the tissues of the human body and may cause cancer. In order to ensure the safety of the accelerator operator it is required that no one should be present in the radiation region when the accelerator is ON. A safety arrangement has been made in order to meet the human safety requirements.

In safety systems the system with hardwire interlocks are preferred because of their inbuilt safety feature. But it is often difficult to design such systems if sequence and timings are needed. The present system is a PLC supported safety system. Here different search-secure units are mounted at various critical location in the accelerator area. All these units are powered one by one using the output generated from the PLC in order to obtain sequential operation. When the field located search and secure unit is cleared by the operator during search operation, an output from each unit is generated. Output from these unit is duplicated using relays. One output is fed to the PLC and the other one is connected in series to generate a hard wire interlock output. The interlock output is fed to the HVDC trip of the accelerator. Is any of the emergency button on the search and secure unit is pressed the accelerator switches off immediately and the radiation switches off.

SYSTEM OPERATION : The 3 MeV electron beam accelerator is an industrial accelerator developed for the various industrial electron beam processing applications. The accelerator generates high dose X-ray radiation as by product when operational. The Accelerator is placed inside a hall made of thick concrete walls. The accelerator hall is called as the cell area. All the power supplies and other support systems are placed outside the cell area. Cables and electrical connections from the accelerator to the power supplies are made through S bands holes created in the walls of the cell. Since the accelerator generates large amount of radiation, which is actually a required feature for the irradiation but at the same time all the human being working in that region has to be protected against the radiation. The cell area needs to be fully evacuated for any human presence before starting the accelerator. A PLC based search and secure system has been installed to ensure all the regions of the cell area has been thoroughly checked for human occupancy and there is no human present before we can start the accelerator. The whole search and secure operations is carefully designed to check each and every corner of the cell area. Besides this the system provides an option of emergency shutdown of the accelerator. The emergency switch off button has been provided at various locations in the cell area. If a person is trapped then he can press the emergency button and the high voltage in the accelerator will switch off immediately and source of radiation will cease off.

All the PLC controller unit for control and monitoring. The limit switch to sense the shutter close and electrically lockable lock and a hooter is also connected to the controller unit. Before the search operation starts, the shutter is closed in order to stop any new visitor entry. The Search & secure (S&S1) unit get power automatically when the shutter closer switch turns ON. The operator will secure the unit S&S1. This operations also starts a hooter for 20seconds inside the cell to indicate the search operation has started so that if anybody present in the cell can move out. Securing the S&S1 will unlock the door for 10 seconds so that the operator can go inside the door and close the door. The door gets automatically locked after 10seconds. This closure disables any new entry. After the door is closed S&S2 unit gets the power from the PLC. The operator secures the unit S&S2, unit S&S3 gets the power from PLC and so on. After all the six S&S units have been secured the door gets unlocked for 20 seconds so that the person performing the search operation can come out of the cell area. The operator clears the S&S7 in order to finish the search operation. The timing between each of the S&S operation has been set by PLC such that the total operation has to be performed within in a fix time of 180seconds. This time duration has been a comfortable period to perform the operation. If the operator spends more time then he adds the vulnerability of a visitor located inside the cell to move into other secured areas. If the operator fails to finish the operation and come out of the cell within 180seconds, the PLC will reset all the S&S units and the whole operation has to be done again. Output from all the S&S units and door interlocks are connected in series to generate a hardwired interlock signal. This signal is connected in series to the high voltage of the accelerator. If any of the series connected interlock fails the HVDC will switch off and make the accelerator off. The sequence of search operation can also be seen on the HMI panel. Other safety interlocks such as radiation meter, Ozone monitor are also connected to this safety system. The accelerator control system has been designed using industrial PLC in such a way that an operator with short duration training can operate the accelerator. The control system has been equipped with the self diagnostic features for quick finding of faults in the failed subsystem. This feature reduces the down time of the accelerator by giving type and location of fault hence helps in quick recovery of the accelerator.



Salient Features:

1) The search operation has to be performed in a fixed sequence only.
2) The SCRAM units are powered in a sequence using the PLC.
3) Pressing Emergency OFF at any SCRAM unit will stop the accelerator and the total search operation has to done again.
4) If the operator spends more time in clearing all the SCRAM units. The whole operation will reset and it will be require it to be done again. The total search time provided is 180 seconds.
5) Output from all the SCRAM units are hardwired and connected to accelerator trip. All these outputs are also parallely monitored on the control panel.
6) This scheme gives the sequencing flexibility and the advantages of hardwired interlock.
7) The safety state of the cell area is also indicated using a tricolor tower lamp. Red as Radiation ON, Yellow as search ON, Green as accelerator off and no radiation.
8) All the doors are also hardwired interlocked to the main interlock . If any body forcibly opens the door the accelerator will switch off automatically.
9) CCTV cameras has been provided in different areas of the cell. These cameras give a view of the cell area on a LCD TV for operator to cross verify the presence of a visitor in the cell region.
10) The hooter generates a loud sound for 20seconds immediately after the search operation is started in order to alert the people inside the cell area to move out of the cell.
11) Announcement is also done on the PA system to move the people out of the cell area before the search operation is started.

CONCLUSION

The safety control system has been commissioned and it is working satisfactorily. Operation of the accelerator has been done on trial basis. Different mock trials have done to check the effectiveness of the safety system. The system has been cleared for operation by local safety committee as well DSRC (design safety review committee). This system has the merit that it is offers timing and sequence flexibility but retains the safety merit of hard wired circuit.