

PLC CONTROLLED SEARCH & SECURE SAFETY INTERLOCK SYSTEM FOR ACCELERATOR

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Abstract

A PCVM type 3MeV DC Electron beam accelerator has been developed at Electron Beam Centre, BARC, Mumbai, India. A PLC assisted search and secure system has been designed, developed and installed as the human safety system for radiation protection in the accelerator area.

INTRODUCTION

The electron beam accelerator has various subsystems. All the subsystems have to work together in a pre-defined sequence to generate the desired accelerated electron beam from the accelerator. All the subsystem such as vacuum system, sweep scan magnet unit, high voltage unit, chiller water unit, air circulation unit, search-secure, safety interlock unit, steering/focussing magnet unit has to be controlled. Each group of similar units has been provided with a PLC controller in order to perform the fully automatic operation of that subsystem. Finally all the PLCs are connected together on Modbus TCP-IP network to achieve a single point control of the accelerator. A touch screen panel has been provided at the control panel as an institutive user interface.

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.

The cell area has one shutter and one entry/exit door. Before starting the search operation the shutter is closed and its status is monitored using a limit switch. The Entry/exit door has been provided with a mechanically close but electrically locks type of door lock. The door lock also provides the door open/close feedback signal for interlock purpose. The door lock operates automatically and controls the entry of any new visitor before the search operation starts. In order to locate any visitor or operator inside the cell search operation is performed. Seven no of search and secure units have been installed at carefully selected locations inside/outside the cell area. Each of this unit consists of two button and two indicators. Green Button as 'secure' (it is to be pressed during search operation), Red button as 'Emergency OFF' (It is to be pressed by the person trapped inside the cell to switch off the accelerator), 'Search ON' indicator indicates that the unit is active and 'secure' button can be pressed. If the secure button is pressed, the second indicator indicating 'Secure' will turn on indicating the unit is secured. Performing the 'secure' operation on these field units ensures the operator who is performing the search and secure operation physically goes to the location where the unit is located and ensures that he has personally ensured that nobody is present in that region.

All the seven Search & Secure field units are connected to 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 operation 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

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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.

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 offers timing and sequence flexibility but retains the safety merit of hard wired circuit.

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