AN IMPROVED SAFETY SYSTEM OF A RADIATION FACILITY FOR INDUSTRIAL STERILIZATION

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Abstract - Modernization of the original safety system of the radiation facility for industrial sterilisation at the "Vinča" Institute of nuclear science is described. In order to improve radiation safety of the facility, the latest recommendations and requirements of IAEA have been implemented. The concept and design of the modernised system are presented. The new elements of the safety system are described and the improvements achieved by means of this modernisation are pointed out.
Key words: safety system, radiation facility, ^{60}Co.

1. INTRODUCTION

The gamma irradiator of the Institute of nuclear sciences "Vinča" performs the industrial process of sterilization of single use medical appliances, food, pharmaceutical, cosmetic or other products or raw materials. The sterilization is carried out by ionizing radiation from a ^{60}Co source. Currently a $9.25 \cdot 10^{15}$Bq (250,000 Ci) source is being used. The facility has been designed to accommodate safely the source of maximum activity of $3.7 \cdot 10^{16}$Bq (1,000,000 Ci). When the facility is not operating, the source is submerged into a water storage pool 6.5 m deep. The design of the facility and the principle of laying down the source classify it as the IV group of facilities for industrial sterilization [1].

In order to ensure a high level of radiation safety the facility is equipped with an autonomous safety system. In accidental situations, or in cases of failures of some of its elements, this system discontinues the irradiation process and returns the source to fully shielded position.

The original safety system has been ensuring a safe operation of the facility both for the personnel and for the environment since 1978. Having in mind this long period of intensive use of the facility, with the aim of increasing the radiation safety, and to upgrade the properties of the safety system to meet the latest requirements and recommendations of the IAEA [1,2], a modernization of the original safety system has been undertaken.

The accidental conditions causing the trip of the safety system could be due to either radiation or radiation-free events. The original safety system is activated by a power failure as a radiation-free event or by a fall out of the ^{60}Co source from its container or by inadvertent entry of a person through the product entry or exit ports as radiation events. The reaction of the safety system to any system malfunction or to a detection of accidental conditions is returning the source to the fully shielded position.

2. THE MODERNIZATION OF THE SAFETY SYSTEM

The original safety system consisted of: two ionization chamber measuring channels for the measurements of radiations in the irradiation chamber and in the maze, pressure mats at each product entry or exit ports of the maze, one emergency cable and emergency stop buttons located in the irradiation chamber, a safety delay timer allowing the irradiation chamber inspection in the course of preparations for start-up, and an electromagnetic lock on the door of the chamber.

The ionization chamber situated in the irradiation chamber serves to detect the position of the source. While the source is in the exposed position no person can have access to the irradiation chamber. The other ionization chamber situated in the maze serves to detect accidental carrying the source out of the irradiation chamber. A failure of either of the two channels will cause a safety system trip and return of the source to the fully shielded position.

Through the product entry and exit ports the products are transported to and out of the irradiation chamber by the product conveyor placed in aluminium containers called tote boxes. At both entry and exit ports pressure mats have been installed in order to register any inadvertent entry of personnel. Any excitation of these pressure mats will discontinue the irradiation process and the source will be returned to the fully shielded position.

In the course of preparations for the start-up the operator inspects the irradiation chamber during the time allowed by the safety delay timer and locks the door of this chamber by the key A. Once the safety system has been activated, this key is used to initiate the irradiation procedure. In case that during preparations someone was left behind in the irradiation chamber or in the maze, an emergency stop cable located around the walls of the irradiation chamber and of the maze and emergency stop buttons are available for stopping the process and returning the source to the fully shielded position. The key X is in possession of the manager of the facility and it is used for disabling parts of the safety system in the process of reconfiguration or replacement of the source. These processes are carried out following the written administrative procedure.

For the purpose of routine controls of radiation levels on the premises a portable radiation monitor is available to the personnel. Despite the written procedures and requirements set for the use of this monitor, in the accidents that have occurred in similar installations throughout the world the portable monitor was out of order or had not been used at all [3].

The basic requirements set to the modernization of the safety system were related to the extension of the detection capabilities of both radiation and non-radiation causes of accidental states retaining, at the same time, the concept, operating modes, and all elements of the original safety system. In addition, a better presentation was required of the state of the system, of the causes of its operation, and the possibility of connecting this system to a cental computer was required.

The modernized system was extended to include detection of fire in any part of the installation and detection of earthquakes. The extension also covered the detection of a rupture of the encapsulation of the source ^{60}Co and the addition of a photoelectric system for controlling the product entry and exit ports. These extensions have been materialized by introducing into the safety system the following elements [4]:

- the electronic control system of the product entry and exit ports,
- detector of contamination of the storage pool water,
- detector of fire,
- seismic detector,
- the portable radiation monitor indirectly incorporated into the safety system,
- the central unit for displaying status and signalization.

All elements, original and new, of the safety system have been connected to a central unit for the purpose of presentation of the state of the system and for the corresponding signalization. This unit, as listed above, is another new element introduced into the structure of the safety system. Block diagram of the modernized safety system of the gamma irradiator is shown in Fig.1.

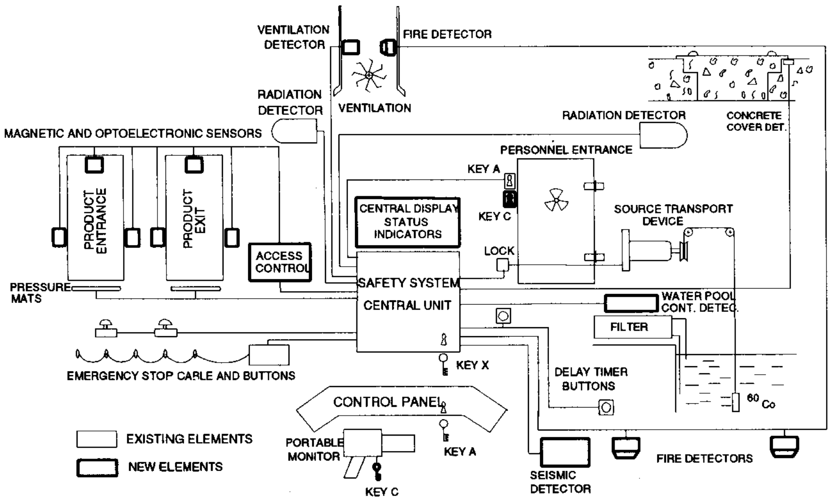

Fig. 1 Modernized safety system of the facility for industrial sterilization in the Institute "Vinca"

3. NEW ELEMENTS OF THE SAFETY SYSTEM

Some of the more interesting new elements of the safety system will be described in more detail. First of all is the central unit for the presentation of the state of the system and signalization. This unit provides the operator with a complete information of the state of the installation and clearly indicates the cause of any trip of the safety system. All data are presented on an LCD alphanumeric display containing 2x20 characters. The messages shown on this display are of the type:

NO ENTRY	AUTHORIZED PERSONS ONLY	SAFETY SYSTEM TRIP
IRRADIATION IN PROGRESS	SPECIAL REQUIREMENTS	MEASURING CHANNEL FAILURE

All possible states of the system have been included in the corresponding set of messages. Each change of the display is accompanied by a short sound signal in order to draw operator's attention that a change has occurred.

The central unit is provided by an RS-232 interface thus it can be connected to a PC. Fig.2 shows the block diagram (a) and a simplified flow chart (b) of the central unit.

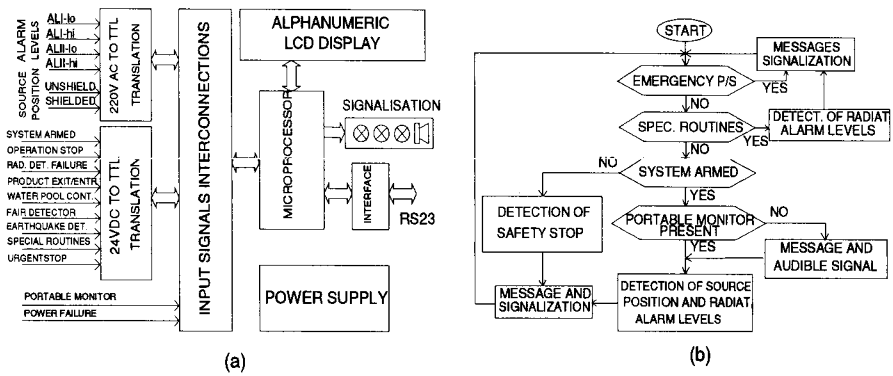

Fig. 2 shows the block diagram (a) and a simplified flow chart (b) of the central unit

The portable radiation monitor, has also been incorporated into the safety system. This has been done indirectly, i.e. the key of the electronic lock C is fixed to the monitor there fore the operator has to carry the monitor when entering or leaving the radiation chamber, thus has to meet the requirement that the chamber should not be entered without this monitor.

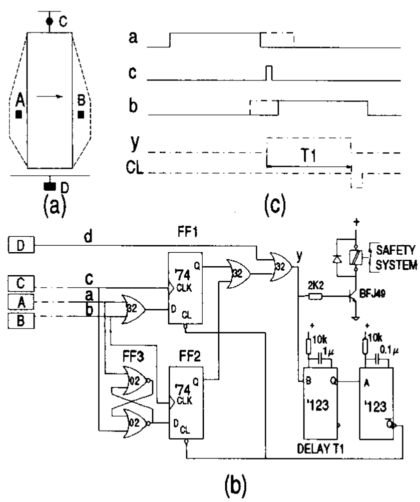

Fig. 3 Detectors position (a), block diagram (b) and signal timing (c) of the electronic control system at the product entry and exit ports

With the original safety system it was possible to enter deliberately the irradiation chamber by stepping over the pressure mats at the product entry and exit ports or by hanging on the conveyor belt. In order to prevent this type of entry into the high radiation area a new, additional, electronic control system has been designed, Fig.3.

The additional electronic protection system "recognizes" the tote boxes and permits only their entry to the maze. This system detects both direct entry or an entry of a person hung on the conveyor belt. The detection is performed by two pairs of photoelectric sensors (A and B) and by one inductive proximity switch (C), shown in Fig. 3. Micro switch D, shown in Fig.3a, registers any activation of the original pressure mat. The electric circuit controlling the product entry and exit ports in shown in Fig. 3b. The timing diagram of the corresponding signals is shown in Fig. 3c.

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