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THE PORTUGUESE GAMMA IRRADIATION FACILITY

C.M. Mendes, J.C. Almeida, M.L. Botelho, M.C. Cavaco,
E. Almeida-Vara, M.E. Andrade

Physics Department, ICEN / LNETI, E.N. 10,
2686 SACAVEM Codex Portugal

ABSTRACT

A Gamma Radiation Facility was built up in the National Laboratory of Industrial Technology and Engineering (LNETI) , Lisbon, Portugal.
This plant (UTR GAMA-Pi) is a Cobalt-60 dry storage continuous facility with a nominal capacity of 1.5×10^{16} Bq. The initial activity is 1.1×10^{16} Bq and the troughput capacity 10^3 ton/year for product with a bulk density of 0.2 g/cm^3 treated with a minimum absorbed dose of 25 kGy. Complementary control devices were installed: ventilation system, closed water refrigeration circuit, internal TV system, detection and extinction fire system and emergency power group.
It must be emphasized that the best attention was given to the conception and efficiency of the interlock safety systems.
This facility will be utilized mainly for radiosterilization of medical articles and decontamination of wine cork stoppers.

KEYWORDS

Irradiation facility; Cobalt-60; dry storage; irradiator; safety systems; irradiation process; medical devices; cork stoppers.

INTRODUCTION

The National Laboratory of Industrial Technology and Engineering (LNETI) responding to numerous demands from the industry for irradiation services has decided to build a Cobalt-60 Gamma Irradiation Facility. None of the potential users fulfilled the requirements necessary to justify the construction of their own facilities, in particular, a large enough production volume. LNETI has developed a considerable effort in recent years, in order to demonstrate and introduce in the country economically relevant applications in the field of Radiation Technology, namely the radiosterilization of medical devices. Although the production of disposable devices is low in volume and diversity the availability of an irradiation facility associated with a well-developed mould industry will be determinant in the near future.

This plant (UTR GAMA-Pi) was developed with the support of IAEA under the programme of Cooperation and Technical Assistance for the period 1983 - 1988 (POR/8/002). The irradiation facility was supplied by Techsnabexport, Moscow, URSS. LNETI had the responsability for the building, design and assembly of all supporting infrastructures. The plant is an overlapping source facility with a planar dry storage irradiator , working mode continous. It has an initial activity of 1.1×10^{16} Bq while the mean capacity is 125 kg/h for 0.2 g/cm^3 product density treated with 25 kGy. According to the manufacturer its nominal activity is 1.5×10^{16} Bq.

UTR GAMA-Pi is designed for the sterilization of medical devices. However it can also be used for the irradiation of other products such as cork stoppers (Botelho et al., 1988), plastics and a limited number of food and feed. It should be underlined that gamma radiation treatment of cork stoppers, improving their quality and increasing the manufacturers economic benefits, will bring great advantages for the portuguese cork industry, one of the most important in this country.

Description of the irradiation facility

The irradiation facility consists of five principal areas:

- the irradiation cell;
- the labyrinth and transport conveyor system;
- control room;
- reception storage area for non-sterile products;
- storage area for sterile products.

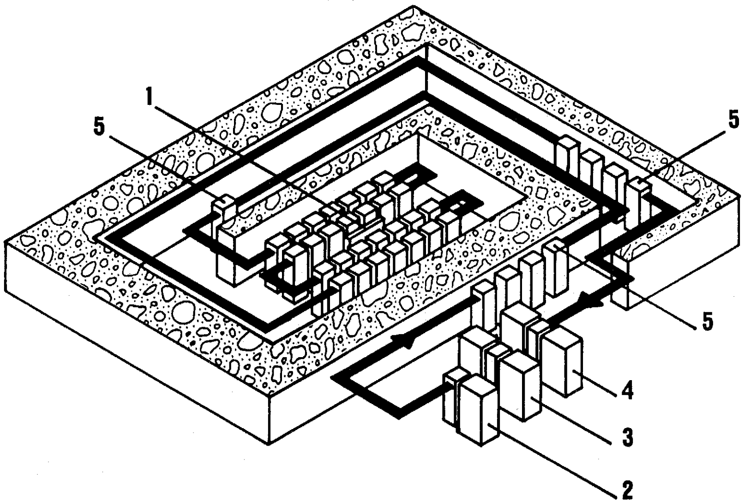

Fig. 1. Schematic diagram of the irradiation cell, labyrinth and conveyor system: 1 - irradiator; 2 - charge mechanism; 3 - rearranjement mechanism; 4 - discharge mechanism; 5 - waiting position.

The irradiation cell, which is of high-density concrete has walls 1.8 to 2 m thick, with an area of 30.75 m^2. The labyrinth surrounding the irradiation cell is 23.3 m long.

The irradiator with an over-all area of 0.864 m^2, consists of 30 stainless-steel tubes (inner diameter 16 mm). The Cobalt-60 sources, stainless-steel double encapsulated (81 mm long x 11 mm diameter), are enclosed into those tubes. In the storage position the irradiator is into a concrete pit, shielded with iron steel blocks. An electromechanical system raises the sources to the working position.

The product is carried by 40 carriers suspended from an overhead monorail conveyor (speed 6.7 m/min). There are two rows of 7 carriers each side of the source, each one can be loaded with 4 product boxes (0.4x0.4x0.4 m^3).

An irradiation cycle has 56 different irradiation positions. Between the 14^{th} and the 15^{th} position the carriers rotate 180° and present the opposite face of the box to the source. After the 28^{th} position each carrier returns to the loading/unloading station (Fig. 2). The two boxes of the upper level take place on the lower level, which is empty as the other two boxes were unloaded. A new pair of boxes are loaded on the upper level and the carrier goes back to the irradiation cell. In each half cycle the two boxes of the lower level receive the dose fixed and the two boxes on the upper level receive the first half of this dose. The dwell-time is set according the product density and required dose.

The facility is operated and controlled from the control desk inside the control room. A visual survey of the loading/unloading area can be made from the control room.
The loading/unloading station consists of charge, rearranje and discharge mechanisms, associated with a rolling carpet at the inlet and outlet of products.

The facility is fully automatic and works on continous mode. The plant design gives good dose uniformity the efficiency is about 19 % for 0.2 g/cm^3 density and 25 kGy.

A preventive maintenance plan has been set up for all several types of electrical and mechanical systems of the facility.

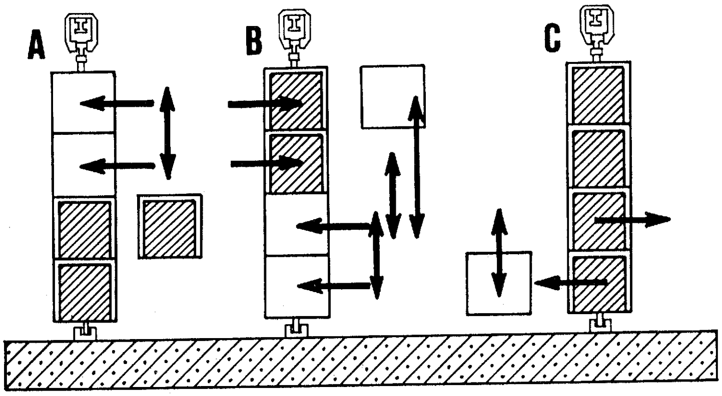

Fig. 2. Schematic diagram of loading/unloading station. A - Charge mechanism. B - Rearrangement mechanism. C - Discharge mechanism. ⟶ - Box movement. ↕ - Elevator movement.

Interlock Safety Systems

The labyrinth entrance has no physical barrier, therefore to garantee the necessary radiological protection and furthermore to ensure a correct sequence of operations several kinds of interlocks systems were installed in the irradiation facility.

The operator must perform several tasks before the sources leave the safety pit and take the irradiation position. Taking a monitor with him the operator must make a tour of inspection of the irradiation cell to assure that it is unoccupied. Following this first step the operator has to actuate an electric switching key inside the irradiation chamber initiating a one minute period during which the operator comes back through the labyrinth and starts the irradiation process introducing the same key on a second electrical switching in the command board. During this time period a klaxon warns the irradiation process is about to start. If these two steps are not performed during the one minute period the sources can not be raised.

When the irradiation process has been started several radiological safety systems are activated which origine the source emergency dropping if actuated:

- a contact platform located at the entrance of the labyrinth;
- a photo-electric group, after the contact platform in the first labyrinth corridor;

  both systems, contact platform and photo-electric group, turn on flashing lights and a klaxon when activated;

- two electrical switches depressed by hand are situated in different positions of the labyrinth and a third one in the irradiation cell;
- eight radiation detectors are positioned on three critical areas, namely the irradiation cell, labyrinth and the operator room.

In order to assure the correct operation and the plant safety the following systems are installed:

- a ventilation system exausts air from the irradiation chamber allowing a maximum 20 % air flow reduction;
- a fire detection and extinguishing system (HALON 1301) - the later normally works on manual mode;

  both systems may origin the emergency dropping of the source;

- a regular fire extinction system (CO_2 and water) in accordance with the national building codes is available;
- a refrigeration system inside the storage pit provides the source cooling.

It should be emphasized that most of the above referred systems are redundant to avoid unnecessary halt of the irradiation process.

Process Control

During the comissioning the main parameters of the irradiation facility were determined.

To stablish the dwell-times and ensure the aplication of the dose required, according the product density, an electronic cycle timer was installed. This cycle timer allows to resume the process at the same point where it stopped wherever any accident or system failure occurs. It is adjusted only to compensate the radioisotope decay.

During the irradiation of products routine dosimeters (red perspex and/or ethanol--monochlorobenzene type) are placed inside a number of selected boxes in the zones of minimum and maximum doses. The dosimeters are removed, read and the results recorded.

Colour-changed indicators to distinguish irradiated from non-irradiated products are used.

Responsabilities and Organization

As a basic principle the irradiator operator has the responsability for delivering the absorbed dose specified by the primary manufacturer.

Provisions are being made to train the convenient and qualified plant staff capable to acomplish the safe operation of the plant and a correct irradiation process.

When operating, the product unit dimension and density should be verified upon reception. After this control each product unit will receive an identifying label with the following data :

- name and adress of the irradiation facility;
- minimum absorbed dose [kGy];
- date and reference number;
- colour change indicator.

Irradiation Certificates complying with international recommended Good Radiation Practice will be issued.

Short Term Improvements

In the near future the storage area should be implemented in size and automated to a higher standard level.

The loading/unloading station together with the conveyor speed should be improved in order to increase the throughput capacity and a more versatile irradiation process.

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