Laboratory Research Irradiators with Enhanced Security Features

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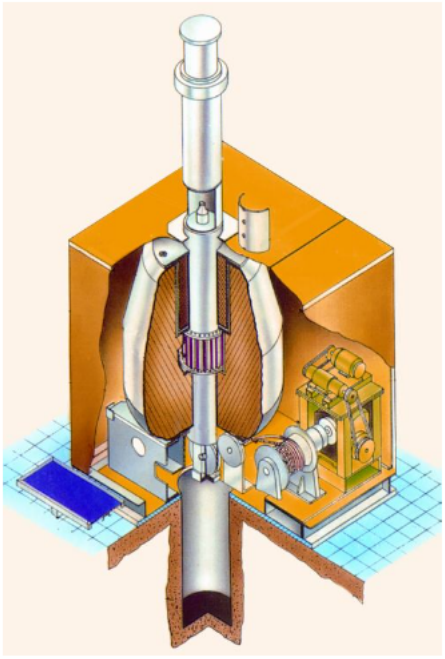
ABSTRACT
Over the years BRIT has developed state of art technology for laboratory research irradiators which are suited most for carrying out research and development works in the fields of radiation processing. These equipment which house radioactive sources up to 14 kCi are having a number of features to meet users requirements. They are manufactured as per the national and International standards of safety codes. The paper deals with design, development and application aspects of laboratory research irradiator called Gamma Chamber and also the new security features planned for incorporation in the equipment. Equipment are being regularly manufactured, supplied and installed by BRIT in India & Abroad. There is a number of such equipment in use at different institutions and are found to be very useful.

I INTRODUCTION

Applications of radioisotopes & radiation are finding increasing applications in many areas of Medicine, Industry, Agriculture and Research. To facilitate various types of studies and experimentation and to exploit their application commercially, it is necessary to have different types of radiation equipment which are meeting the user's requirements and are versatile, compact and safe to use. Board of Radiation & Isotope Technology (BRIT) is pursuing a vigorous programme of design, development and production of different types of radiation technology equipment for their use in various fields which are conforming to national and international standards and can be installed, operate and maintained in any institution. In order to study effect of radiation on material and to further ensure it commercial viability a Laboratory scale research irradiator called Gamma Chamber has been designed by BRIT which is manufactured supplied regularly. First Gamma chamber was developed in late sixties and since then many models have been designed with incorporation of new features. BRIT has supplied 185 units of different models including 31 which are supplied and installed abroad.

Gamma Chamber is self shielded research irradiator having radiation source Co-60 and sample chamber for controlled irradiation. It is self contained dry source storage category I type irradiator. Material for irradiation is to be placed in sample chamber located in central drawer of the unit. Equipment is provided with option to operate in auto or manual mode. Adequate shielding of lead and steel around the radiation source limits the radiation field on external surface well within the permissible limit. Good dose uniformity is attained by stationary source cage provided in equipment, in addition a mechanism for rotation and stirring is also provided which help enhancing dose uniformity.

A well planned quality control and assurance programme is adopted during all stages of design, manufacturing, testing and commissioning of these equipment to assure a supply of high quality product at competitive prices.



Gamma Chamber

Control panel

II DEVELOPMENT OF LABORATORY RESEARCH IRRADIATOR: GAMMA CHAMBER

It is a versatile equipment for research studied in many fields such as Radiation effect on material, Mutation breeding , Food preservation , Radiation chemistry, Radiation Sterilization, Sterile male insect technique etc.

Gamma Chamber is a small irradiator for irradiation of products under controlled conditions. It's development calls to meet a number of necessary parameters but with conflicting requirements not only from functional and manufacturing points of view but also from regulatory points of view so that the price of the unit remains economical, competitive and affordable for its sustained usefulness.

The following aspects, therefore, have been considered during design and development and subsequently manufacturing of these type of units.

(a) Design considerations: During the design, the following aspects are considered

(i) Functional
(ii) Regulatory and Safety
(iii) Manufacturing
(iv) Quality assurance and Control
(v) Transportation in public domain
(vi) Installation & handling

Design of Gamma Chamber usually starts with a given set of parameters having to do with the optimum amount of product volume to be treated and the dose desired. From these, the amount of source activity required to effect the treatment is determined and then a geometric configuration between the source and the product is decided to satisfy functional requirements. Considering all these factors. BRIT has designed and regularly manufacturing two models of this equipment Gamma chamber, 5000 & 1200 (GC 5000, GC 1200) which vary in irradiation chamber /sample chamber size and capacity of housing radioactive source. It is an equipment which can be installed in a room of size approx 4mX4m X4m (ht) and has capacity to irradiate sample size which can be accommodated in 5000 or 1200 cc chamber depending on model being used. It houses radioactive source Co- 60 in doubly encapsulated stainless steel pencils in a stationary cylindrical cage which emits radiation to the sample chamber in which object for irradiation is placed.

(b) Control System - A PLC based control system facilitates exposure of radiation on to products / samples for certain preset time for creating desired changes in the products. It mainly consists of following systems :

(i) A radioactive source, Co-60
(ii) Biological shielding
(iii) Mechanism of movement of Sample chamber into an out of irradiation field
(iv) The Irradiation/Sample chamber
(v) Control and safety devices

(c) Functional Requirements: Generally the following functional requirements are considered for the design of Gamma chambers.

(i) Size of irradiation volume – diameter & height.
(ii) Dose rate – Activity.
(iii) Dose uniformity – source configuration.
(iv) Shielding.
(v) Handling & installation.
(vi) Servicing & maintenance.

Since the equipment is used for sample irradiation for mainly research purpose optimum size of the chamber has been designed to ensure good dose uniformity.

III SAFETY ASPECTS

(a) Regulatory & Safety: Stringent requirements of safe transportation of radioactive materials as stipulated in the various national and international safety standards are to be met in the design of the components as well as in the systems of the irradiator apart from meeting the functional requirements. The design must meet Type B (U) requirements for safe transportation of equipment containing radioactive materials. Equipment has to meet tests of accidental conditions of the transport to get Type B (U) approval from regulatory body. Major tests of accidental conditions are indicated below.

(i) **Mechanical (Drop) Tests :** The equipment/package need to be dropped onto a hard unyielding target (atleast 10 times heavier than the product) through a height of 9m followed by a second drop through a height of 1 meter on a steel punch of 15 cm diameter rigidly mounted on the unyielding target.

(ii) **Thermal Test:** Following the above drops the same package is than required to be exposed to a thermal environment of 800 degree centigrade for 30 minutes, to assess the overall structural integrity of the package.

(iii) **Water Immersion Test:** In this test, the package is a water head of at least 15 meter for about 8 hours and the structural integrity of the specimen are further examined.

Transport of Gamma Chamber

Test Facility at ARAI, Pune

(b) Aacceptance Criteria: After going through the above tests the acceptance criteria in the shielding loss due to the cumulative effect of mechanical and thermal tests should not cause radiation level to increase beyond a permissible level as stipulated in the safety code. The Gamma Chamber meets all the performance criteria for qualifying as Type B (U) package.

(c) Manufacturing: Manufacturing of equipment is carried out by adopting various standard manufacturing codes. Materials of construction and manufacturing processes are carefully selected so that the products are not only fabricated of a very high standard but also are economically fabricated so that overall cost of the equipment is comparable to similar type of irradiators in international market.

(d) Quality Assurance & Control: A very stringent quality control and assurance programme is adopted during design, manufacturing and commissioning of these equipment to assure a consistent quality product supply. During the process, of development, the design is evaluated and validated by testing models and prototypes. During manufacturing a strict quality control programme is adopted to ensure use of right raw materials, processes, and other related tests. A complete documentation on design, manufacturing and their tests is generated for each type of equipment for traceability of any information at a later date.

IV ENHANCEMENT OF SECURITY FEATURES OF GAMMA CHAMBER

Gamma Chambers are being incorporated with enhanced security features necessary to ensure that radiation source used in the equipment are security protected during their use. Following modifications have been made in the equipment to deter, detect and delay the unauthorized access or theft or removal of radioactive material during all stages of its management.

(a) A limit switch will be mounted on one of the lugs of main unit. Any attempt to remove top cover of the cabinet will be sensed and a buzzer will give alarm.

(b) Additional 12 nos. of M 8 Countersunk Hexagonal headed screw in addition to the 12 no of M 20 hexagonal bolts will be fixed in the top plug of the main body of the cask to make top plug removal difficult.

(c) The M 8 screw heads will be covered/filled by magnet operated buttons. This will delay the process of opening of bolts.

(d) The cage plug will be covered by a top cover to conceal the hexagonal bolts and the socket head of countersunk screw to prevent direct access to bolts.

(e) An electrical plunger at the bottom of the cask will be attached and during the default position the plunger will stop the drawer to come down.

(f) A stopper plate will be attached to the bottom drawer to prevent it from lifting from the top.

(g) A stainless steel covers of 1.6 mm thick will be provided in the inner periphery of the source cage so that it will be difficult to attach the hook to the cage.

V CONCLUSION

With the vast experience in the design, manufacturing, installation and commissioning of the Laboratory research irradiator such as Gamma chamber over a period of time, it is possible for BRIT to design, develop and produce more safe, compact, user friendly laboratory research irradiator with the high density material for research applications which require irradiation of materials with ionising radiations of varying dose. Incorporation of additional security features will give confidence to the user as well as regulatory body for safety and security during all stages of its management.