Radiation Processing Technology for Healthcare Sector in India

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Abstract

The setting up of the ISOMED facility in the year 1974 by Department of Atomic Energy, Government of India had been the harbinger of the technology of gamma radiation sterilization for healthcare products in India. The indefatigable efforts of the department for over four decades have convincingly demonstrated the techno-commercial viability of this technology for the health sector in the country. A brief account of the decade-wise growth of this technology in India from Technology Life Cycle perspective has been presented unveiling impact of this technology on societal front together with recent paradigm changes initiated to foster the global competitiveness of radiation sterilized products in India. The operational experiences cherished hitherto have been briefly summarized while throwing the light on the anticipatory challenges.

Keywords: *Terminal sterilization, Disposable medical devices, Gamma irradiators, ISOMED*

1. Introduction

The cornerstone for demonstration of techno-economic viability of the technology of Radiation Processing of Healthcare Products (isotopic radiation based) in India was laid on January 1,1974 by commissioning of the ISOMED (**I**rradiation **S**terilization of **Med**ical **P**roducts) facility by the Department of Atomic Energy, Government of India (Figure1). ISOMED facility is a Land Based Stationary Gamma Irradiator that provides a panoramic radiation exposure to the continuously moving product boxes (filled with healthcare products) and are loaded on to overhanging product carriers driven by overhanging monorail

Figure 1: ISOMED facility - BRIT/DAE

chain conveyor**.** The ISOMED facility in operation and its Isometric view have been depicted in Figure 2 and Figure 3, respectively. The facility with indomitable perseverance and immaculate quality culture has processed over 0.32 million cubic meters of health care products hitherto and established a niche for itself in this technology domain in the Asia-Pacific region [1]. The products with a profound societal impact entail Intra Uterus Devices (IUDs) for the terminal sterilisation using ionising radiation to meet population activity related objectives under societal mission of the Government of India and United Nations. Oral Polio Vaccine Droppers have been terminally sterilised for the ambitious Pulse Polio Mission of the Government of India. Similarly, Orthopaedic implants for the crucial implant surgical procedures have been processed to render much improved post-surgery quality of life for the patients. Cellulosic surgical dressing materials have been terminally sterilised for the use by the Central Sterile Services departments of the hospital establishments to alleviate risks due to hospital acquired infections thus reducing morbidity and mortality rates.

The facility has obtained all the relevant cGMP (current Good Manufacturing Practices) and quality management system related certifications as pertaining to the process of terminal sterilisation using ionising radiation, thus playing a decisive role in the well-regulated and stringent current Good Manufacturing Practices controlled sector of the healthcare industry, at the domestic and international front. These certifications along with the impeccable quality operations at the facility, have helped the stakeholders of the facility to accelerate their export quantum.

The colossal reservoir of technical expertise cherished by the facility that precipitated by the exemplary legacy of customer-oriented quality centric services has propelled myriad entrepreneurs from the private sector to embark upon contract radiation sterilization services sector with the technical knowhow from the department of atomic energy. The trust and confidence gained by the technology of radiation sterilization amongst the health care industry over the years, justifies without an iota of doubt, the mission behind setting up of the ISOMED facility.

Since the inception of the technology of Radiation Sterilization for healthcare products in India in the year 1974 till the year 2005, along with ISOMED there was only one private sector facility in the northern part of India which had been serving the healthcare industry for their large-scale terminal sterilization needs on contract basis. Both these facilities deployed isotopic radiation (Cobalt-60) hence the technology of e beam or x Ray radiation sterilization remained a distant reality in the domestic sector until recently.

In the following sections, an attempt would be made to provide a holistic insight into the decade wise growth of the technology of gamma radiation processing of healthcare products in India from Technology Life Cycle (TLC perspective) [2]. The product range, limitations and future prospects of the technology would also be dealt with.

Figure 2: ISOMED facility in operation

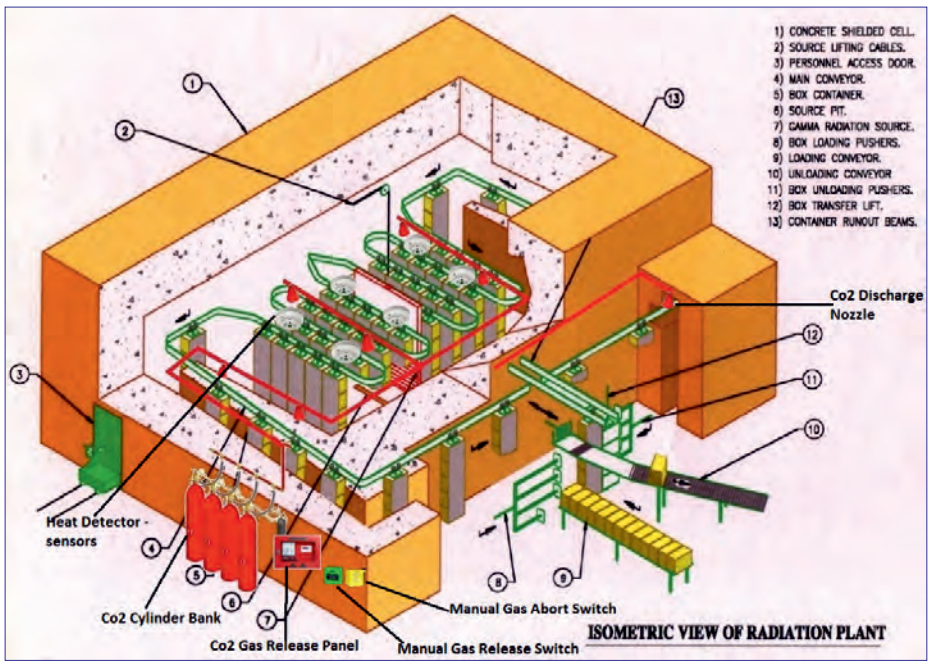

Figure 3: Isometric view of ISOMED

2. Growth of gamma radiation processing technology (TLC perspective)

Decade I (1974-1984): Technology introduction phase

The challenges during the technology introduction phase surfaced in form of sensitizing the healthcare industry about Installation, Operational and Performance Qualification aspects, material compatibility issues, process reliability, regulatory compliance, sustainability and techno commercial viability for the healthcare industry in India. Taking cognizance of the challenges, the technology was introduced by the department in form of UNDP assistance, IAEA technical cooperation, that supplemented by the sanguine support and coordination from the healthcare industry and the regulator. Several technical symposium / workshops were arranged with proactive involvement of the stakeholders from the healthcare industry in India. To impart a credible assurance to the healthcare industry about sustainability of the technology,Government of India also embarked upon an integrated plan to produce indigenously, the industrial Cobalt-60 irradiator sources that are inevitable for a radiation processing facility deployed for radiation processing on industrial scale. During this phase, Installation, Operation and Performance protocols of the radiation sterilization process were standardized and put to routine practice. The quality control for the radiation sterilization process was based on Perspex dosimeters - spectrophotometric readout along with biological indicators viz. ATCC-14884. The statutory licenses in the capacity of the primary as well as the contract manufacturer were also obtained for the radiation sterilization of the products from the Maharashtra State Drug Control Department as described in the Drug and Cosmetics Act 1940 [3] and rules there under. In the end of this technology introduction phase, the healthcare industry had been facilitated with enough technical knowhow, together with the assurance of availability of a techno commercially viable process for terminal sterilization of their products on long term basis.

Decade II (1984-1994): Technology ascent phase

The decade witnessed spiral growth in the number of healthcare establishments availing themselves of the technology of radiation processing for terminal sterilization of their healthcare products. The state-of-the art laboratory in BARC played a major role in developing protocols for radiation stable polymeric configurations under regulatory approval and commercial deployment in domestic as well as global market. The large-scale radiation sterilization of single use disposable medical devices was taken up with improved product competitiveness. The nation acquired optimum competence in commercial production of Cerric - Cerrus dosimeters which are extensively used for routine radiation dosimetry at par with the global standards. During the decade, a paradigm shift occurred in form of private sector establishment entering into offering contract radiation services for sterilization of the healthcare products.

Decade III (1994-2004): Technology ascent phase (continued)

Without an iota of doubt, the steadfast efforts of the department of atomic energy during the technology ascent (decade II – 1984-1994) had provided the fillip to the acceptance and popularity of the technology in the healthcare industry in India. The decade III (1994-2004) even further accelerated the technology growth curve. The domestic healthcare industry could conform to the stringent quality qualification parameters in terms of terminal sterilization with an immaculate quality framework facilitated by the radiation processing industry in the country. The radiation processing industry thus complemented the primary manufacturers of the healthcare products in meeting their vision from global business perspective.

Decade IV (2004-2014): Technology maturity (early phase)

The era began with a sudden spurt in number of radiation processing facilities in the private

sector thus widening the market share of this technology for the healthcare sector. The core focus during the decade was on the c GMP (Current Good Manufacturing Practices) from the national / international regulators. The PDCA (Plan, Do, Check, Act) approach intrinsic to Quality Management System Standards, was bolstered by more stringent c GMP based quality framework akin to pharmaceutical industry. The quality terms such as Change Control, Deviation, Out-of-Specification, Training need identification, Self-inspection were now being practiced ubiquitously by the major radiation services providers in India.

Decade V (2014-2024) : **Technology Maturity (mid phase)**

It was during this decade, to enhance global competitiveness of the Indian radiation processing industry, several paradigm changes were brought in core functional areas of the technology.

A novel animated training simulator viz. ISOTRAIN (Irradiator Simulator for Operational Training in Animated Environment) for the Land Based Stationary Gamma Radiation Processing Facilities has been developed. The paradigm changes have been brought in the Cerric Cerrus Potentiometric Dose Measurement System in form of an application interface viz. ISOCAD (Integrated System of Computer Aided Dosimetry) that averts the risk of errors due to manual transcription of quality critical radiation dose data to the healthcare products.

A professional training module on ISO 11137 [4] for the radiation processing industry has also been developed and being offered to the radiation industry professionals.

An encouraging development in form of the Centre State collaborative work towards setting up Integrated Medical Device Manufacturing Parks has redefined new realms for the technology of radiation sterilisation. It is a remarkable accolade for the technology that these parks have preferred gamma radiation sterilisation facility as one of their service providing nodes in their eco system. This gesture has further bolstered the confidence of the healthcare industry in the technology of gamma radiation sterilisation.

During this phase, railroaded efforts from the department have paved the way for the introduction of the technology of electron bean sterilisation for the terminal sterilisation of the health care products.

3. Healthcare Products commonly processed by radiation.

Some of the medical products which are routinely sterilized using gamma radiation are listed as follows:

- Single Use Disposable Medical Devices (medical grade plastics based)
- Hospital Supplies (radiation sterilization has proved to be effective in alleviating risk of morbidity and mortality due to nosocomial infections)
- Intra Uterus Devices
- Medicated/Non-Medicated, absorbent/nonabsorbent gauge dressings
- Medicated ointments
- Burn dressings
- Absorbent/ Nonabsorbent sutures
- Petri dishes for clean room validation in pharmaceutical industry
- Containers and closures
- Orthopedic implants

- Drugs and chemicals
- Cosmetics
- Ayurvedic raw materials
- Silver Agitated Antimicrobial Dressings
- 70% v/v Iso Propyl Alcohol Pre-Pads
- X Rays protection gloves

Figure 4: Images for healthcare products sterilized using Gamma Radiation (Courtesy ISOMED Customers)

- Mannitol, Lactose, PEG 6000 for process line sterilization validation in pharmaceutical industry
- Di kits for rural health applications, drapes, catheters, surgical blades

4. Merits of the Radiations Sterilization Technology

- The process has high reliability and precision in terminally sterilizing the product
- The Sterilization Assurance Level (SAL) of 10^{-6} can be conveniently met with the product manufactured under GMP by controlling a single parameter i.e. time of exposure
- The process renders inherent flexibility from the product shape standpoint
- Heat labile plastic medical devices and pharmaceutical products can be safely sterilized as the process is cold in nature
- Flexibility in packaging as the products can be packed individually in sealed bags and sterilized in the fully packaged form.
- Terminal Sterilization mode ensures that the product sterility is retained indefinitely until packaging integrity is at risk.
- Unlike steam and EtO (Ethylene Oxide) mode of sterilization, radiation sterilization is ubiquitously practiced in continuous mode of operation with no residual toxicity / process driven quarantine issues.
- Radiation sterilization enlarges the market for ready to use pre-packaged products.
- Radiation sterilization does not make the products radioactive; the processed products are completely safe to handle

5. Limitations of Radiation Sterilization Technology

- Change control in form of augmentation of the source strength (additional Cobalt-60 loading to respond to increased throughput requirement) is time-intensive
- Radiation sensitivity of polymeric compositions at times is an issue
- Aqueous pharmaceutical preparations have been reported to have poor radiation compatibility
- Single use disposable syringes have compatibility issues with radiation sterilization
- The perpetual decay of the Cobalt 60 radioactive source puts a continuous product load demand at the contract radiation service provider's end
- Global regulatory concerns with its repercussions in terms of cost towards physical protection system for Cobalt-60 based radiation processing facility
- For a Coablt-60 based irradiator in continuous mode of operation, part process load is economically not viable.

6. Current Challenges and Future Prospects

The current challenges with respect to the technology of gamma radiation sterilization relate to increasing global awareness towards security aspects of high intensity gamma irradiators. Similarly, year-round availability of the healthcare products for the radiation service providing establishment becomes a challenging task as the technology of isotopic radiation has an intrinsic committed cost factor in terms of perpetually decaying radioactivity of the Cobalt-60 radio

nucleoid. The introduction of Medical Devices Rules 2017 by the Government of India [5] has also posed challenging c GMP (current Good Manufacturing Practices) structured regulatory environment for the radiation sterilization service providers. Nevertheless, this challenge needs to be viewed as an opportunity from the global competitiveness standpoint.

The global market for the single use disposable medical devices has been growing spirally over the years. The alarming concerns relating to residual toxicity issues intrinsic to EtO (Ethylene Oxide) sterilization practices world over have been a prime factor for the healthcare industry to look forward to the technology of radiation processing ambitiously. Inter-alia, at the domestic front, the full reliance attained by the department of atomic energy in the entire life cycle of the industrial grade Coablt-60 sources (a key component of the Gamma Irradiators) has lured the private sector to invest significantly in the radiation processing facilities across the nation. It is strongly believed that with such added capacities assimilated, the nation is poised to acquire an iconic status in the global radiation sterilization sector in the near future.

Incidentally the department has provided a fillip to its committed efforts for introducing the technology of electron beam radiation sterilization in the country which has been discussed in a dedicated chapter on EB irradiation. The Installation/Operational and Qualification aspects of the technology would need synergistic efforts in tandem with the primary manufacturers of the healthcare products and key stakeholders in highly regulated medical devices market at domestic as well as global front.

It is believed that the next decade would witness laudable accolades with colorful feathers in the cap of the radiation processing industry in India where the country would be showcasing its complete MAKE IN INDIA technological capability towards commercial utilization of Technology of Electron Beam Sterilization for the healthcare products.

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