# Solid Waste Processing and Disposal

# Radioactive Solid Waste Management Practices and Advancements

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Near Surface Disposal Facility in Trombay

ABSTRACT

Radioactive solid wastes, generated from various stages of the closed nuclear fuel cycle of the country, need effective management. Segregation and categorization are important tools for management of these wastes. Low alpha content waste packages after amenable treatment are disposed in the engineered disposal modules of Near Surface Disposal Facility (NSDF). Management of Disused Sealed Radioactive Sources (DSRS) also pose a challenge for safe and secure disposal. Solid waste processing at once must address the challenge to optimize disposal land space of NSDF, while ensuring confinement of activity for prevention of migration to the environment. Technologies, like plasma incineration, spent resin fixation in cement matrix and futuristic disposal modules, like Multitier Reinforced concrete Disposal Modules (MRDM) with robust performance evaluation for meeting the regulatory authorized limits have been deployed.

KEYWORDS: *Radioactive solid wastes, Near surface disposal module, Dis-used sealed radioactive sources, Segregation, Plasma incineration, Resin fixation, Cementation, Multi-tier reinforced concrete disposal module.*

## Introduction

Nuclear and radiological industries, during operation, maintenance and decommissioning, generate solid wastes with radioactive contents[1]. Plant protective gears like, lab coats, hand gloves, shoe covers, skull caps, boiler suits etc., which are organic in nature, contributes nearly 50-60% of the total waste volume generated from various industries and are potentially carry radioactive contamination[2]. The rest of the waste volume is contributed by decommissioned equipment and piping, cemented waste products, used process pots, used spent resins loaded with active isotopes etc. and are having low to high levels of radioactive contaminants. These wastes are mainly low in alpha contaminations and amenable for disposal in various engineered disposal modules of the Near Surface Disposal Facility (NSDF). Typical waste disposal modules are shown in Fig.1. Following the concept of *"Generator as First Waste Manager"*, waste minimization, segregation and R-3 concept (Reduce, Recycle & Reuse) are given utmost emphasis. Though R-3 concept is practiced meticulously, a good amount of potentially contaminated wastes generated needs effective management. Safe management of these wastes has been of priority since the inception of our nuclear energy and fuel cycle programme.

## Waste Segregation and Categorization

Segregation is a very important tool to achieve the highest possible volume reduction and thereby minimize requirement of valuable land space for the disposal modules of NSDF. Solid wastes are segregated based on its physical nature, radioactivity content and applicable processing technologies as on date. Cellulosic waste contributes to about 15-20%, while rubber and plastic wastes contributes to 80-85% of the total treatable Category-I organic wastes[2,3]. Cellulosic wastes, marked as combustible, are packed in cardboard boxes. Rubber and plastic type of wastes, marked as compactable, are packed in 200 L standard Mild Steel drums. Metallic, cemented waste products, residue chemicals, contaminated soils and concrete debris etc. are segregated as non-treatable waste and packed separately in 200 L drums or specially designed packages. Table 1 gives a typical segregation of Category-I wastes based on processing needs.

Solid radioactive wastes are categorized based on beta-gamma activity, dose rate and alpha content. Category-IV wastes need to be stored in the interim storage facility or in retrievable storage in NSDF for its future management. Category-II and III wastes, contributing less than 15% of the total volume but having more than 90% of radioactivity of solid wastes, are disposed in Reinforced Concrete Trenches (RCT) or Tile holes, after applicable conditioning, depending on the contact dose criteria. Category-I waste contributing more than 85% of the waste volume, with less than 10% of contribution in total activity, is processed with applicable technologies for volume reduction and disposed, based on contact dose and potential activity contents, in Stone Lined Trenches (SLTs) or Above Ground RCC Dykes (Dyke) constructed above the closed SLTs[1].

Disused Sealed Radioactive Sources (DSRS) based on the radioactivity content are categorised in five categories. All categories of DSRS from the north, east and western regions

*Table 1: Segregation and packaging of Category-I solid wastes conventional practices.*

| Type of Radioactive Waste | Segregation tag | Packaging |
|---|---|---|
| Cellulosic | Combustibles | Cardboard Boxes |
| Rubber and Plastics | Compactable | 200 L Standard Mild Steel (MS) Drums |
| Others | Non-Treatable | 200 L Standard MS Drums or Specific Containers |

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Above ground dyke (Dyke) Stone Lined Trench (SLT) Reinforced Concrete Trench (RCT)

**Tile hole (TH)** **Multi-Tier RCC Disposal Module (MRDM)**

*Fig.1: Typical Engineered disposal modules of Near Surface Disposal Facility.*

of the country are collected for safe management and disposal at the Trombay site. For southern regions DSRS are collected and managed at BARCF, Kalpakkam[1]. DSRS are transported safely by the generators, after regulatory authorization, till BARC facilities for further management, which are stored as per type of isotopes and category of DSRS.

### Processing Technologies for Category-I Wastes and DSRS

In general, for cellulosic type of wastes, i.e. lab coats, boiler suits, cotton hand gloves, mops are treated by conventional incineration, where volume reduction factor (VRF) of more than 30 is achieved[1,2]. Rubber and plastics type of wastes, i.e. hand gloves, shoe covers, plastic sheets etc, are packed in standard 200 L barrel drums and compacted using high pressure hydraulic compactor achieving VRF of 3-5[1,2]. Non treatable wastes like metal scrapes, decommissioned equipment, cemented waste products, solid residues etc. are conditioned or packed in secondary containers and disposed in SLT or Dyke.

The DSRS are safely decasked, separated from inactive instruments and cemented in cement matrix. Cemented waste packages are managed based on solid waste categories and disposed to the applicable disposal modules of NSDF. Till date tens of thousands of DSRS of µCi to kCi range have been successfully and safely managed.

### New Approaches in Processing Technologies and Advance Disposal Module

Conventional incineration of rubber and plastic wastes was hitherto limited by the low temperature (~1000K), as toxic gas formation including dioxins and furans at these temperatures was a significant concern. The availability of plasma incinerator (temperature > 1500K) now allows more rapid processing of all types of incinerable wastes.

Plasma pyrolysis and incineration system at WMD, Trombay (Fig.2)[3,4] has allowed processing of Category-I combustible wastes, including rubber and plastics, at a rate of 25 kg/hr. This setup has been retrofitted in the existing diesel fired incinerator system. Through the process more than 2500 kg of wastes (cellulosic, rubber and plastics) have been processed successfully achieving a VRF of more than 30 for each type of wastes[3]. Discharges from the system are measured using iso-kinetic sampling system and analyzed by in-house developed methodology. The values observed were well within the limits specified by the regulatory authority, i.e. dioxin and furans observed to be less than 0.1ng TEQ/$m^3$.

Spent resins from spent fuel storage bay were planned to be polymerized before disposal. Considering associated fire hazards, a novel cement (Mixed Slag + OPC) matrix has been investigated and in-drum cementation of loaded resins has been successfully demonstrated by retrofitting the modified cementation system in the polymerization system (Fig.3)[4]. The system has successfully demonstrated more than 10 cementation campaigns including nine actual spent resin

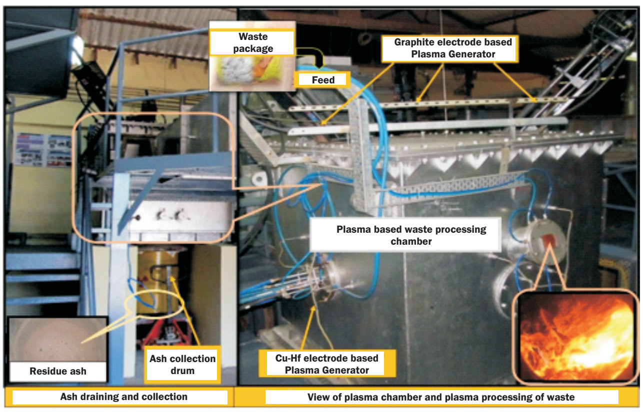


*Fig.2: Plasma based incineration system and plasma processing of mixed wastes.*

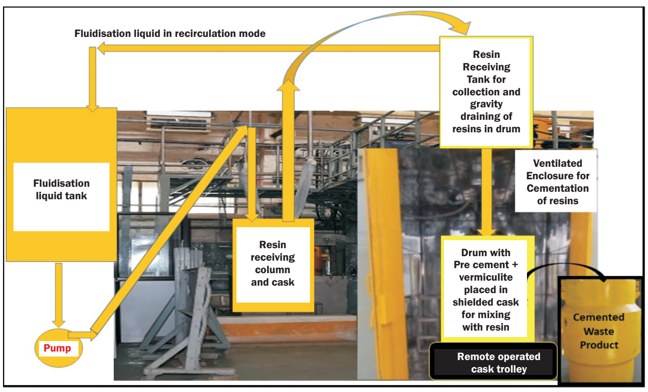


*Fig.3: Facility for resin fluidization and fixation in cement matrix.*

hopers from Dhruva, each was having about 50 Ci activity. Product quality has been confirmed where leaching rate less than $10^{-4}$ g/cm$^2$/day and compressive strength more than 50 kg/cm$^2$ could be achieved.

DSRS also have potential use after integrity check in other applications based on total left-over activity. Considering the same, before deciding for final disposal, recycle and reuse concept is introduced to minimize number of DSRS disposal frequency. Dismantling and disposal costs are also inducted. Repatriation of the sources to the country of origin is encouraged as far as possible. Safety and security of the general public has been accorded the highest priority during deciding the management of DSRS.

Towards requirement of optimum land space utilization and improvised disposal of radioactive solid waste, after amenable processing techniques, an advance disposal module, namely Multi-tier RCC Disposal Module (MRDM) has been designed and constructed (Fig.1). The module, 60 % below ground and 40% above ground, is expected to replace, Dyke, SLT and RCT in future with enhanced safety in waste disposal with optimum land space utilization factor[4].

## Conclusions

Management of radioactive solid waste in India has progressed maturely and safely for all categories of wastes generated from entire nuclear fuel cycle including decommissioning activities as well as disused radioactive sources from applications like medicine, industry and research. Demonstration of plasma based processing using indigenously developed technologies has open up new field for effective volume reduction for all combustible waste forms. Based on the feedback of plasma incineration demonstration system, higher capacity plants are planned at Tarapur for radioactive as well as for municipal solid waste management. Immobilization in improvised cement composition has shown effective and safe management option for spent radioactive resins. Multitier disposal module has shown advantages for simplifying disposal for all categories of wastes in same disposal modules having improved engineering safety and optimal land space utilization factor. Department has also implemented a well-planned strategy and procedures for safe management of DSRS. Continuous efforts towards research and development to impart innovative and advance technologies have resulted in efficient and effective management of radioactive solid wastes in line with international practices.

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