Volume Reduction of Solid Radioactive Waste From Research Reactor and Nuclear Laboratories – Industrial Experience

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ABSTRACT

Various research reactors and nuclear laboratories at Bhabha Atomic Research Centre, Mumbai, India generate approximately 600 m^3 of radioactive solid waste annually. These wastes are categorized and segregated based on their radiation field, physical nature and radionuclides present. The low level waste is further segregated based on compactability criteria. The compactable wastes are packed in 200 litres carbon steel drums and pelletised to get a volume reduction factor of about five. The compaction system designed for Cat-I (Table-1) radioactive waste is having 200 Tons capacity hydraulic press, housed in a well-ventilated enclosure. Before pelletisation, the drum is assayed to estimate β,γ activity. Further, the imaging of waste drum is also done so as to avoid any possibility of noncompactable material being taken for pelletisation.

The pelletisation system comprises of conveying, pushing, indexing and compacting. All operations are controlled by programmable logic control (PLC) based control system. Apart from the drum palletisation, the system is also equipped to compact the used Pre and HEPA filters, being generated from exhaust and supply air system of clean room, nuclear laboratories, research reactors, fuel reprocessing plants, high level waste management facility etc. The system is designed to handle about 5 drums or filters per hour. So far about 3000 number of each, HEPA filters and waste drums have been safely compacted and disposed.

INTRODUCTION

Radioactive solid waste generated in the nuclear installation is of varied nature. They can be broadly classified as combustible/non-combustible, compactable/non-compactable. The combustible waste mainly consists of cellulosic materials, like cotton wears, papers, mops etc. Due to process constraint and presence of certain radionuclides, all such combustible solid waste is not amenable for incineration. Hence, wastes are segregated based on compactable and non-compactable nature. Compactable waste forms around 55% of total waste received including about 10-12% of filters. The materials, which can be compacted are polythene/PVC container, rubber gloves, mops, packing materials, empty tins etc. In India, compactable waste is baled in drum at some sites. The baling system, due to spring back, gives lower volume reduction factor and causes extra pressure on the lid of the drum. To minimise radiation exposure as well as to overcome the problem due to spring back action, fully automatic system is developed to pelletise waste and to get a volume reduction factor of five. This results in saving of valuable engineered storage space and land.

During preliminary investigation, a hydraulic compactor of 200-tons capacity was found to be the most suitable for this type of waste. The volume reduction factor of 5 could be achieved with this capacity of compactor. The solid waste and air filters are received from waste generators in 200-litre capacity carbon steel standard drums and in polythene bags respectively. After assaying and imaging, the drums and filters are taken for compaction. Most of the compactable wastes are having radiation field less than 0.5-mGy/hr with few packages of higher radiation field up to 2-mGy/hr. During compaction, air released from the package is suitably treated. To keep the system under negative pressure, the compaction chamber and gravity roller complete with pit are enclosed and are connected to exhaust system through Pre and HEPA filter banks. Arrangement is made to collect and pump out the liquid, if any oozed out from waste during compaction. To reduce the exposure to the operating staff, most of the process steps are made fully automatic with safety interlocks. Only loading of the drums and filters for compaction is carried out manually. All the system components are designed for easy accessibility, decontamination and maintainability.

SYSTEM DESCRIPTION

The system has been designed to receive the drum/filter, convey it to the press, compact the same to $1/5^{th}$ of its original height and discharge it to a container for disposal. The side view of the compaction system is shown in Fig-1. A loading belt conveyor with capacity to hold 5 drums/filters receives it by a crane. Actuator operated flap gates are provided on loading belt conveyor to hold each drum in a separate compartment for feeding one at a time. The feed belt conveyor takes one drum at a time and brings it up to the compaction table of the hydraulic press. A double action hydraulic actuator pushes the drum to the centre of the table. After closing of entry and exit doors, ventilation damper opens to connect the enclosure of the hydraulic press with dedicated ventilation system. Ensuring that both entry and exit doors are closed and ventilation damper open; drum-indexing dies (from either side) bring the drum/filter to the centre of the table, making it ready for compaction. After indexing and piercing the index die retracts back and pelletisation operation starts.
The hydraulic ram compresses the drum/filter in 3 stages to get the required volume reduction (Fig-2). Once the compression cycle is completed, the entry and exit doors open and the actuator pushes the pellet out of the enclosure onto the gravity roller conveyor. The pellet then falls on top of the slide gates and is collected in a reusable bin having bottom opening for disposal of the pellets. Simultaneously, the actuator retracts and the hydraulic jack goes down to its original position below the belt conveyor, then the second cycle starts.

The pelletisation system consists mainly of the following sub-systems.

Conveying System

Cotton braided, negligible friction endless belt with linear speed of 5 m/min. is provided to transport the drum/filter. The belt is supported on carbon steel roller and driven a geared motor.

Indexing System

Hydraulic driven system is provided to bring the drum/filter in centre of the table. The die has three sets of rupturing pins for piercing holes into drum. Piercing is done to allow escape of air and liquid, if any, during the compression.

Hydraulic Press

Hydraulic operated press pelletise the drum/filter in three stages. The ram speed is 0.25 m/min.

Control Panel

The system is controlled by PLC based control panel with man machine interface (MMI).

Ventilation System

To keep the enclosure of the compaction system under negative pressure and avoid air activity release in working area; 16 nos. of air changes are provided through suitable ventilation system.

DESIGN BASIS

As the drum contains assorted waste, it was not possible to arrive at a theoretical basis for calculation of force required for compaction. Therefore, the force was determined by actually simulating waste conditions and the requirements. Actual tests were conducted independently on drums filled with simulated waste materials, using a hydraulic press of 300 tons capacity. Based on the trials, it was observed that a load of 125 Tons would provide a volume reduction of five. Similar trials were conducted for compaction of used HEPA filters (size 610X610X305mm) and a force of 40 Tons was observed to be sufficient. Considering the factor of safety as 1.5 and need for a single unit; a force of 200 Tons was optimized for compaction of drum/filter.

SAFETY FEATURES

The following safety measures have been adopted for the safety of the operators and machine Interlocking has been provided in such a way that the compression will start only after closing of the front and the back doors.

The exhaust ventilation with HEPA filter is provided to take away the contaminated air released during the compression of the drum/filter. Inter locking is provided in such a way that the compression will start only after opening the damper of the exhaust system.
Provision has been provided for taking air samples at the outlet of the exhaust system.

The system provides the following inter locking to avoid accident and consequent machine damages.

- The ram will come down only after both the indexing dies reach in the home position
- The pusher will actuate only after opening the door.
- The feed conveyor will start only after ensuring the jack position at home and the door in open position.

- The next compaction cycle will start only after ensuring that the previous compaction cycle has been completed.
- A sump complete with pump and high/low level control is provided to handle the liquid.
- The MIMIC has been provided on the control panel to know the status of sequential operations.
- Adequate arrangement has been made for decontamination of the complete system.

OPERATING EXPERIENCE

The system (Fig-3) has been commissioned in August, 2002. Since then, it has been providing uninterrupted service of volume reduction. The facility is operated in a single shift of 8 hrs. Normally about 30 nos of filters/drum are pelletised in one shift. As indicated earlier, 3000 nos of used filters and 3000 nos of waste drums have been compacted without any major maintenance. Radiation exposure to the working personnel is found to be within permissible limits. Air activity in the operating area has been measured on regular basis and the values are much below one DAC level. This is mainly because of proper ventilation provided to the compaction chamber having a HEPA filter and a dedicated blower. Activity released through the stack is below detection limit for alpha as well as beta, gamma radionuclides. Decontamination of the system is required to be done once in a fortnight to avoid any spread of loose contaminant.

CONCLUSION

The system is found to be cost effective and useful. It has saved the useful disposal space. Based on the experience gained; similar system is being installed at other waste management facilities.

Table I. Categorization of Radioactive Solid Waste

Sr. No.	**Category**	**Radiation field on the surface of waste package**
1	I	Up to 2mGy/hr.
2	II	>2mGy/hr. up to 20mGy/hr.
3	III	>20mGy/hr.
4	IV	Waste bearing Alpha activity (>4000 Bq/gm)

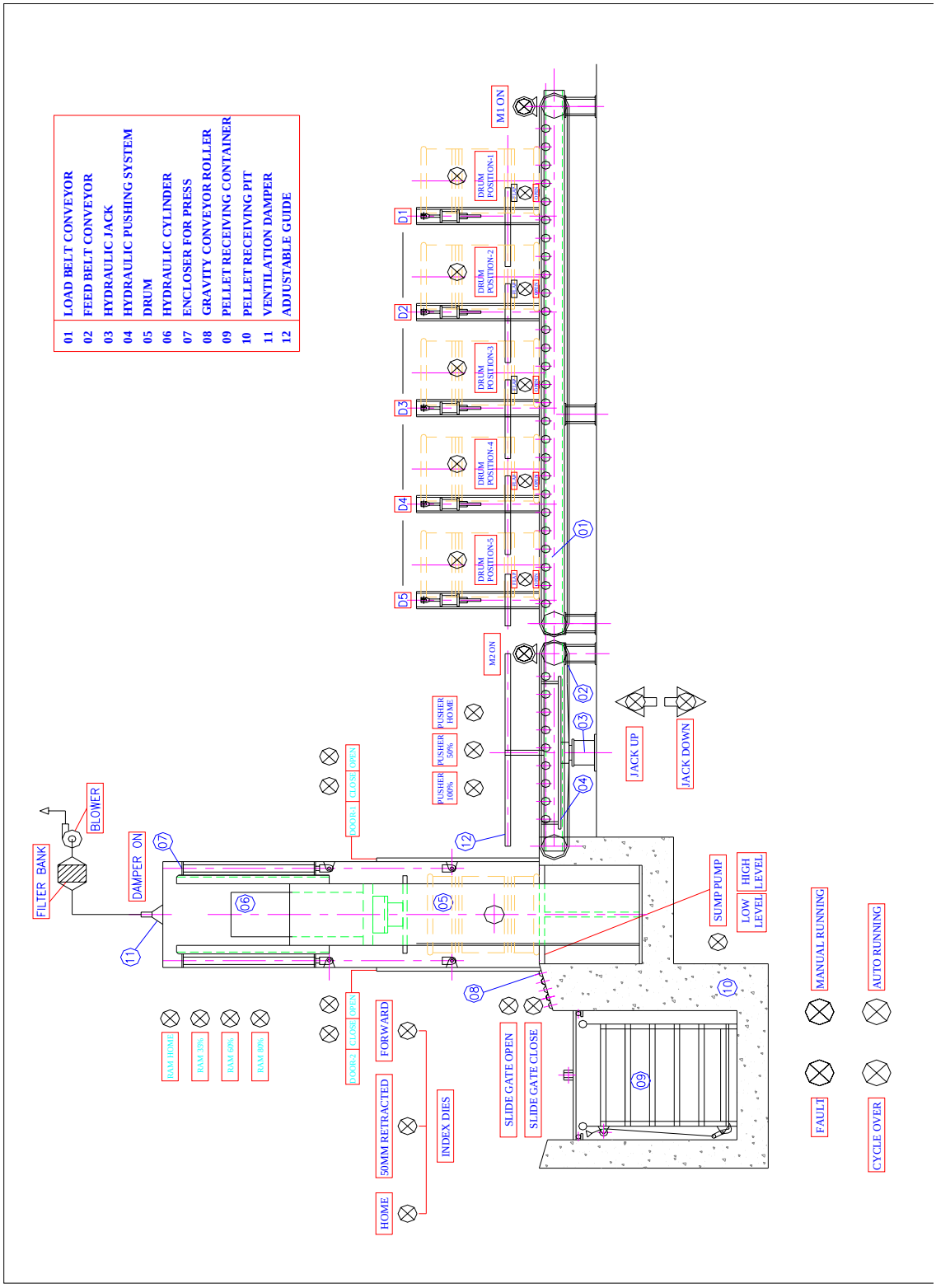

Fig. 1. Side View of drum/filter pelletisation system

Fig 2a. Compacted Drum Fig. 2b. Drum before compaction

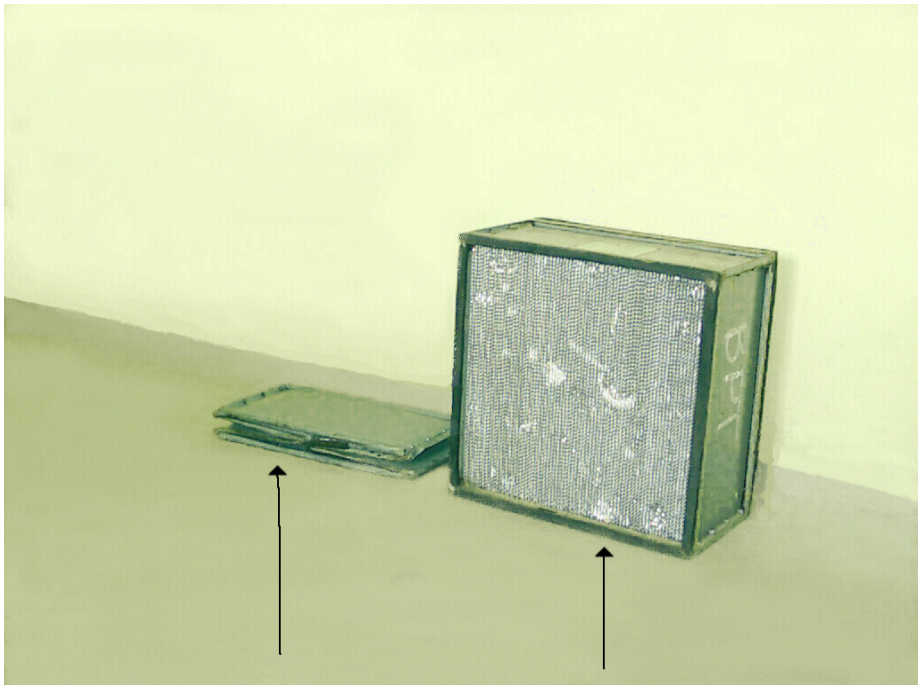

Fig. 2c. Compacted Filter Fig 2d. HEPA filter before compaction

Fig. 2a-2d. Photographs showing waste drum and used HEPA filter before and after compaction

Fig. 3. Drum/filter pelletisation system