HEALTH PHYSICS AND OPERATIONAL EXPERIENCES IN A TREATMENT AND PACKAGING FACILITY FOR SOLID AND SEMI-SOLID WASTES AT E.I.R.

J.Schwammberger, H.Brunner

Health Physics Division
E I R, Eidg. Institut für Reaktorforschung
CH-5303 Würenlingen, Switzerland

1. Summary and conclusions

Solid or semi-solid wastes have either to be stored for long periods or to be disposed by dumping into the ocean or enclosure into suitable geological formations. Each case requires an appropriate treatment and packaging of the wastes. Despite the relatively low specific activities there exist considerable radiation hazards for the operating personnel due to incorporation risks. At EIR Würenlingen a waste treatment facility was built that reduces such hazards to acceptable levels. The main installation is a large combination of steel boxes, well ventilated and held at reduced pressure. Operations that can be carried out include sorting of wastes, compression of loose wastes or drums, dismantling or reduction to small pieces, solidification of sludges with cement, casting of concrete mantles and covers etc. All direct contacts between personnel and radioactive material are avoided. Either the men work from outside the box with gloves or remotely operated hydraulic tools or machines, or they work inside the box with respiratory protection or in ventilated plastic suits. An incinerator plant under construction will bring further volume reduction of burnable waste, even for α-activities. Our experiences are reported and show that radioactive wastes of low or medium specific activity can be treated and packed according to any requirements without hazards for the operating personnel, the surrounding population or the environments of the treatment facility or the storage sites.

2. Purposes of the laboratory and choice of the concept

Most wastes are produced and collected in forms that do not allow storage for more than a few years. For storage over extended periods of years or final disposal a treatment of the wastes is indispensable. Years of improvised waste handling experience and an extensive literature search resulted in specifications and an operations plan for each treatment method considered, from which the necessary working conditions and installations could be derived. Thus we developed a concept for an installation that should best suit our needs. The laboratory came into operation in 1970 and can be used for the following methods :

- sorting of mixed wastes, mainly into four groups: combustible, non-combustible, compressible, non-compressible;
- baling of wastes by pressing for volume reduction;
- solidification of liquid or semi-liquid wastes (sludges) with cement;
- dismantling and cutting of large waste items (filters, components, plastic sheets) into small pieces that fit into 100 or 200 liter drums;
- enclosure of wastes in cement or concrete.

The wastes must be packaged into steel drums or prefabricated concrete containers according to international transport regulations and requirements for final disposal such as dumping into the deep ocean. Most of the wastes were low- and medium-level wastes from EIR operations (average input 100 m^3/yr), but also wastes from other sources (some 40 m^3/yr) such as industry, research institutes, hospitals and in smaller amounts from nuclear power stations were treated. About 10 percent were medium-level wastes. The laboratory is only in operation during the regular working hours. The crew consists of a supervisor, a health physics technician and four to five operators. In 1971/72 wastes were treated during an effective average of 30 weeks per year, the rest of the time was used for revisions, decontaminations, vacations etc. With an average yearly production of 650 drums (200 liter) of conditioned low-level waste and 80 concrete containers of medium-level wastes the capacity of the laboratory is not fully utilized. By increasing the number of operators and working during two shifts a day an input of 400 - 500 m^3/yr of unconditioned wastes could be handled.

3. Description of the laboratory

The laboratory was installed in an already existing massive one-story reinforced concrete building, 22 x 17 x 4.5 meters. An annex contains the installations for cement mixing and the feed pump. The building (plan, Fig.1) is divided into a large storage, loading and operating hall, entrance and exit lock areas, active and inactive change rooms and office, and a personnel access and control lock. The ventilation system is housed in two rooms on top of the change rooms, together with the breathing air supply and the continuous exit air monitor.

About half of the operating hall serves as a temporary storage and transfer area for incoming wastes. The other half is the main working area with a large (8 x 6 x 3.3 meters) combination of massive airtight steel boxes, consisting of a transfer box for loading wastes either into the sorting or the operations box, a sealed operations box, a sorting box, a baling press box and a cement box with an exit lock. The boxes are connected by hydraulic sash doors with electrical interlocks between the inner and outer doors in order to avoid operating errors and spreading of contaminations. The sorting box (Fig.2) contains a foot-pedal-controlled conveyor belt with three external working places and sealed connections for drums that can be removed into the operations box. The conveyor discharges into the press box. The sorting box is protected by two independent fire extinguishing systems with CO_2 and water. The baling press box (Fig. 3) accommodates a 100 ton press where loose waste or filled 100 liter drums can be compressed to 1/5 or less of the original volumes. A lucite hood is lowered on top of the baling container during pressing and the air expelled from the compressed waste is directly drawn into the exit air system. In a feed loop prefabricated cement is circulated by a pump between the cement preparation annex and the cement box where it can be filled by simple and safe means into the steel drums containing the conditioned waste and compacted by a vibrator. Sorting, press and cement box operations are done from outside from the operating hall by means of glove openings or hydraulic controls (Fig.2). All other operations such as dismantling, cutting, filling of compressed drums into larger drums are carried out in the operations box (Fig. 3). Access for working inside the sealed operations box is only possible through the personnel access lock (Fig.4) and the operators are dressed in proper protective clothing. The breathing air equipment can supply up to five operators in fully ventilated suits. In case of a power failure two reserve tanks with compressed air allow an evacuation of all five workers without any hurry or hazard by the usual procedures through the access lock. The latter serves as the control room for the supervision of operations inside the operations box with all the necessary equipment for voice-controlled intercommunication with and between individual or all operators. The intercom cables are located in the air hoses of the ventilated suits. Special quick-connect contamination-proof couplings and parallel air and intercom connections in the control lock and the box permit individual adjustment of intercom and air supplies before the operators enter the box.

All parts of the building are also connected by a loudspeaker intercom system.
The whole laboratory is very well ventilated with about 20 air changes/hr. Filtrated and if needed warm air is fed into all rooms and is then sucked through three sets of absolute filters into the operations box and from there into the other boxes. The exit air ventilators draw the air from the sorting, press and cement boxes through two filter stages with glass fiber absolute filters,of which one filter unit is located directly after each box while the second stage unit is in the exit air duct before the ventilators. Ventilation control keeps the boxes at reduced pressures of 10 - 30 mm water gauge pressure difference.

4. Equipment for radiation protection

Incoming "hot" waste drums and components can be temporarily stored in the operating hall behind a 60 cm thick concrete wall.Shielded transport containers are available for transfers of medium-level wastes. The boxes are made of 5 mm thick steel sheets without additional shielding, but for the treatment of medium-level waste mobile lead shields of 5 cm thickness can be installed at the respective working places. The baling press is connected to the cement box by a rail track with a hydraulically operated trolley (Fig.3) carrying a container with a cylindrical 6 cm thick lead shield which takes up the drums for pressing, concreting and unloading through the exit lock of the box.

At the three most exposed locations outside the boxes GM counter γ-dose rate monitors are mounted. In the storage/loading area and the exit area of the operating hall and in the control lock sets of portable instruments for β/γ dose rate and β/γ and α surface contamination monitoring are available together with shielded detectors for wipe tests and air samples. Exit contamination control of the personnel is done by background-compensated β/γ hand/foot monitors in the active change room and the operating hall, a scintillator α hand monitor in the active change room and by very sensitive β/γ and α hand/foot monitors at the exit of the inactive change room. The air in the operating hall is continuously sampled and the filters are periodically checked for α and β/γ. The exit air activity from the boxes is continuously monitored and registered for α and β/γ activities. The exit of the operations box and the active change room are equipped with showers. A complete and sufficient stock of radiation protection materials is maintained.

5. Operational and health physics techniques

The wastes are delivered into the operating hall in closed steel drums, in some special cases in sealed plastic bags. All treatment operations are executed inside the boxes. The interlocked sash doors permit safe transfers without leakage of activities. If the large door of the operations box has to be used, a plastic tent is connected as a temporary lock for the transfer of large equipment or waste items.All rooms are regularly controlled by wipe tests. Special care is given to the transfer of filled containers from the box to the exit lock area.Drums are washed with water in the box and transferred wet. When leaving the exit lock of the cement box they are immediately checked for contamination at the entire surface.This is done in the operating hall where final decontamination can be done if necessary, before a crane transports the containers to the exit lock area.

Working in the operating hall and at the sorting, press and cement boxes is done in ordinary coveralls without additional protective garments. For work inside the operations box the operators change completely into special underwear, coveralls, rubber boots, hoods and gloves, for wet work also disposable plastic suits. The normal respiratory protection is the army gas mask, fully ventilated protective suits of EIR designs are only worn for Tritium, Carbon-14 or Radium wastes. All protective clothes offer relatively comfortable working conditions for periods of 2 1/2 to 3 hours between half-hour or longer breaks. When leaving the operations box the operators take off clothes and respiratory protection in the access lock and undergo there a coarse contamination control. After a shower in the active change room they check again for contamination and leave for the inactive change room where they put on their own underwear and ordinary working or street clothes. A final contamination check follows at the exit of the inactive change room. When using ventilated suits the men take a shower with the suits on at the exit of the operations box (Fig.4) before entering the access lock. There the suit is taken off with the help of another man wearing mask, hood and gloves, who makes the first contamination check. All complicated or hazardous operations are supervised and monitored by the crew's health physics technician. But each crew member completed a 4 weeks' radiation protection course at EIR and has to take care of his own radiation protection and monitoring. The supervisor of the laboratory is also a fully trained health physics technician. Independent controls of working environment and methods are performed by the working place survey group of the Health Physics Division.

For personnel monitoring direct reading pocket chambers (200 mR) and film badges with quarterly evaluation are used, supplemented by TLD chips in finger-rings which we designed to stand heavy mechanical work without damage to chips or gloves. Incorporation monitoring is done by periodical urine analyses, after risky operations or incidents by special investigations and whole body counting.

6. Operational experiences

Radionuclide composition, physical and chemical forms of the wastes vary a great deal and require very different treatment and packaging methods which, except the pressing, must be manually executed. A rationalized conditioning by special remotely or automatically operated equipment is out of reach for an installation of this size for space and cost reasons. In 1971 and 72 wastes with the following main activities were treated :

α-emitters (mostly Pu)	ca. 10 Ci	Tritium	ca. 260 Ci
Radium	ca. 1 Ci	Carbon-14	ca. 3 Ci
mixed fission products + ^{60}Co	ca.660 Ci		

The average whole body doses of the personnel due to external exposure were about 1.5 rem/yr and were similar for the entire crew. The incorporation monitoring showed no values above the investigation levels, most of them could be interpreted as representing less than 1 percent of the MPBBs. These minor incorporations resulted from Iodine-131 or Tritium work in the operations box.

No air contaminations outside the boxes in the operating hall have been found, and surface contaminations outside the boxes are extremely rare events at harmless levels less than five times the operational guides for uncontrolled zones. This proves that practically no contaminations are spread from the interior of the boxes to the outside. The reasons for this are: an excellent ventilation and relatively large negative pressure differences in the airtight boxes, rigorous and disciplined controls of personnel and material at the exits of the boxes, and frequent coarse decontamination of the boxes before the contamination levels become too high. A certain hazard exists for the hands of the operators due to relatively frequent damaging of gloves. If no wounds are inflicted, washing is in most cases sufficient for decontamination. Only in three cases the hands had to be decontaminated by a specialist from our first aid and personnel decontamination team. One operator received a cut into the hand from an Iodine-131 contaminated item. The wound was washed with saline solution and surgically cleaned by a physician. This was the only, minor incident and had no lasting consequences.

Our experiences have been excellent, the concept chosen is well suited to our needs. Summing up : good protection of the personnel depends on a reasonable combination of installations that are appropriate to the tasks and a good and disciplined working technique with reliable radiation protection and monitoring.

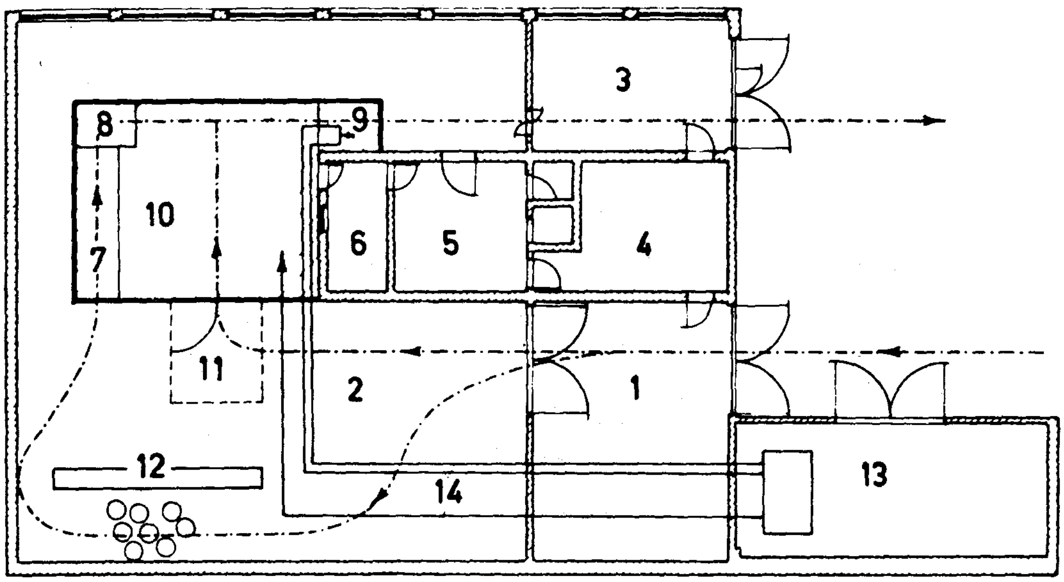

Fig. 1 : EIR waste treatment laboratory, floor plan

1 vehicle + waste entrance lock area
2 storage, loading + operating hall
3 waste exit lock area
4 inactive change room
5 active change room, shower
6 personnel access + control lock
7 **sorting box**
8 baling press box
9 cement box
10 sealed operations box
11 protective tent at large box door
12 shielding of incoming waste store
13 cement preparation annex
14 **cement feeding tubes**

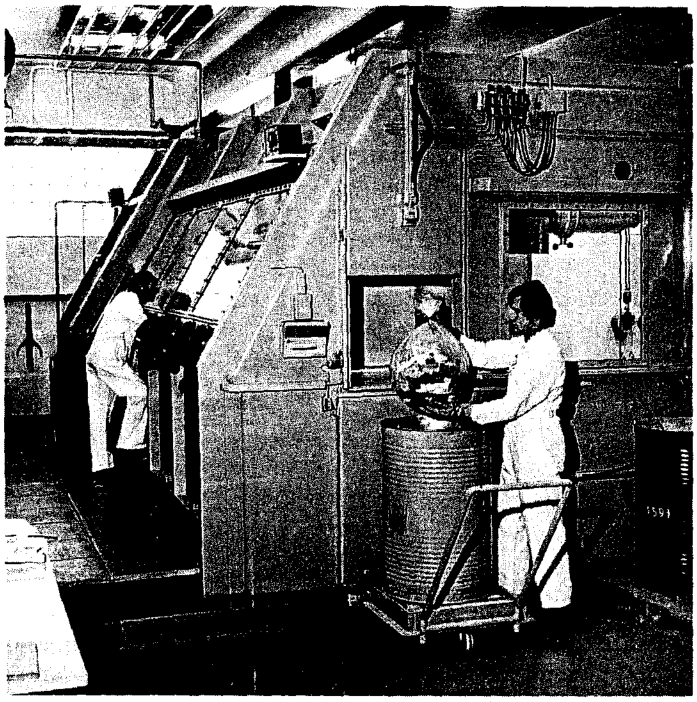

Fig. 2 : **Exterior of the sorting box and the transfer box.** An operator is loading a plastic bag into the sorting box, where another operator is sorting the waste from the conveyor belt into several drums or the press box (left background). The lower, closed sash door is used for the transfer of drums into the operations box, visible through the window at the right. γ-dose rate monitors are mounted at the working face of the boxes.

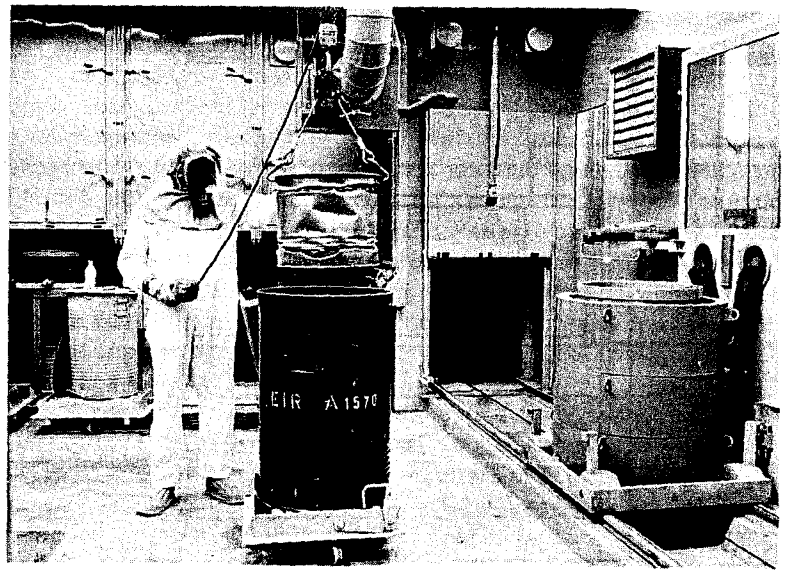

Fig. 3 : Interior of the operations box. A 100 liter drum (only partially compressed for the sake of clarity) has been removed from the baling and transfer trolley with its shielded container (at the right on the track). The sash door of the baling press box is kept open, normally it would be closed during that phase (right background). The right hand wall has a series of windows and glove ports for the external operator of the press and the transfer trolley. An entrance air filter is also visible. In the background at left the wall of the sorting box is seen with an exit air duct and the attachments and trolleys for the sorting drums below. The operator wears the usual dress for work inside the box.

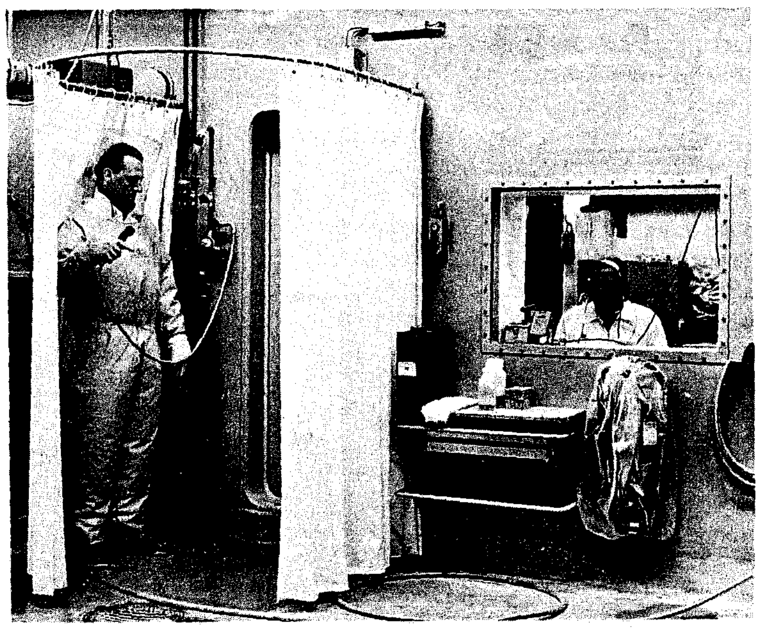

Fig. 4 : Exit of the operations box to the personnel access and control lock. An operator in a fully ventilated PVC-suit with clear hood and intercom takes a shower before leaving the operations box through the door into the access lock. Behind the window the operator in the control lock has intercom contact with the operators in the box and regulates the air supplies. Five air and intercom hoses are connected at the right of the window. The hoses are disconnected from the suits before leaving the box. Decontaminating material and a contamination-protected fire extinguisher are below the window.