NUCLEAR WASTE HANDLING TECHNOLOGY

FOR UNDERGROUND STORAGE AT WIPP

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ABSTRACT

The Waste Isolation Pilot Plant, WIPP, is being built near Carlsbad, New Mexico to demonstrate that nuclear waste can be stored safely in underground geological formations. The ability to retrieve the waste within a limited time period must also be demonstrated. Remote handled, RH, and contact handled, CH, waste will be handled at WIPP. The facility will consist of the waste building, three shafts, approximately 140 acres of excavated storage rooms and drifts underground, and administrative and support buildings. All nuclear waste will be transferred to the underground through the waste building and the waste shaft. Two shafts have been sunk, and drifts are being excavated 690 meters (2250 feet) below the surface. Waste handling downstream of the waste shaft station is discussed in another paper.

BACKGROUND AND OVERVIEW

The WIPP facility is being designed by Bechtel under contract with the U.S. Department of Energy, DOE, to store nuclear waste. Currently, only Department of Defense waste is slated for storage at WIPP. Exploratory and vent shafts have been sunk, and drifts are being excavated for the experimental storage areas. The WIPP facility is scheduled to begin receiving nuclear waste in 1989 and continue for 25 years. Waste will be shipped to WIPP by road and by rail; about 75 percent will arrive by rail. When it becomes fully operational, the facility will be capable of handling 57 cubic meters (2000 cubic feet) of CH waste and two RH canisters a day.

The nuclear waste handling techniques that will be employed at WIPP pose a number of challenging problems not encountered in existing nuclear facilities. For example, the facility must provide for the transfer of CH and RH waste down the same shaft and through the same drifts underground. Furthermore, the handling system must be capable of demonstrating that the stored waste can be retrieved within a specified time period.

Design Requirements

The basic requirement of the WIPP facility is to demonstrate that RH and CH waste can be received and stored in underground salt formations. This entails the following unique design requirements:

- A wide variety of CH and RH waste containers must be handled at WIPP; e.g., the size of CH containers varies from a 208-liter (55-gallon) drum to a maximum envelope of 2.44 x 3.05 x 3.66 meters (8 ft x 9 ft x 12 ft).
- RH waste and CH waste must be transferred down the same shaft and underground drifts; hence the RH waste will need to be shielded in a facility cask.
- RH TRU canisters will be stored horizontally in the walls of the storage rooms.
- Only uncontaminated waste containers will be stored. Contaminated containers must be overpacked.
- All waste stored at WIPP must be capable of retrieval for a specified period of time; the target period is 5 to 10 years.
- Due to the shielding requirements, very heavy payloads must be transferred down the waste shaft and through the underground drifts.

Waste Handled at WIPP

A broad range of waste forms must be handled at WIPP.

CH waste, which by definition has a radioactivity level of less than 200 mRem/hr on the surface of the waste container. CH waste will be received in the following waste containers:

- Six-packs (six 208-liter DOT 17C/17H drums strapped together); 80% of all CH waste will be received in this form.
- Modular steel boxes 1.37 x 1.37 x 2.29 meters (4-1/2 ft x 4-1/2 ft x 7-1/2 ft).
- Small quantities of other containers such as individual 208-liter (55-gallon) drums and M3 steel bins.

Damaged CH waste containers will be overpacked in the overpack and repair room of the Waste building; e.g., 208-liter (55-gallon) drums will be overpacked in 314-liter (83-gallon) drums. The overpacked containers will then be handled by the same equipment and in the same manner as the other CH containers.

RH waste will be received in the following canisters.

- RH TRU canisters 660 mm (26 in.) in diameter by 3.2 meters (10 ft 6 in.) long with a surface dose rate of 200 mR/hr to 1000 R/hr.
- DHLW canisters, 609 mm (24 in.) in diameter by 3.05 meters (10 ft long) with a surface dose rate of 7000 Rem/hr maximum.

Damaged RH canisters will be overpacked in the hot cell into slightly larger overpack canisters, which will then be handled in the same manner as unoverpacked canisters. It is expected that less than 2 percent of the canisters will require overpacking.

Approximately 1000 RH TRU canisters, total, will be received at WIPP. It is expected that a maximum of 40 DHLW canisters will be handled by the facility. The pintle will have the same configuration on all canisters that will be processed at WIPP.

HANDLING FACILITIES

Yard Receiving

During the early stage of WIPP facility operation, all shipments of waste will be made by truck. At some future date, facilities will be provided for receiving rail shipments.

All CH waste will be shipped in TRUPACT containers, which will be offloaded from the transporter in the yard by a straddle carrier and placed on an air pallet immediately adjacent to an airlock.

The RH waste will arrive in shipping casks. The most likely cask for shipping RH waste is the DHLW cask which is being designed by General Atomic. However, WIPP facility design provides for interfacing with existing irradiated fuel shipping casks. The casks will be moved into the RH area of the waste building for offloading.

The yard receiving area will provide space for the storage of TRUPACTS and casks and their transporters.

CH Waste Handling Facilities

The waste handling building consists essentially of three areas, the CH area, the RH area, and the hoist tower, as shown in Figs. 1 and 2. The CH area consists of:

- Three airlocks. The TRUPACTS are brought into the waste building through the airlock on an air pallet. The building side door of the airlock is designed to also serve as a tornado door.

- CH handling area, where the waste is unloaded and palletized. During unloading and palletizing, the CH waste containers are checked for surface contamination using portable monitors and swipe tests. Space is also provided in this area for surge storage of palletized waste and empty pallets.

- CH airlock between the CH area and the waste shaft. Pallets are placed on the conveyance loading car in this airlock while the conveyance is traveling down to the storage area.

- Overpack and repair room. TRUPACTS with waste containers that are damaged or contaminated are transferred to this room, where the waste containers will be overpacked or wiped clean, as required. Minor repairs of CH waste containers and TRUPACTS will also be performed in this room.

RH Waste Handling Facilities

The RH area consists of the following:

- Cask unloading area with a 125-tonne crane and cask preparation area. The shipping cask is taken off the transporter and placed on the air pallet in this area. The shipping cask preparation station is also located in this area.

- Cask unloading room. Dry cask unloading is performed with the shipping cask "mated" to the hot cell transfer port in the ceiling of the cask unloading room.

- Hot cell with space for four work stations: the weld station, the inspection station, and two future stations.

  Also, the storage capacity for empty overpack canisters is provided in the hot cell. Other major equipment in the cell includes the 14-tonne bridge crane, the bridge-mounted electromechanical manipulators, and master-slave manipulators at the operating work stations. Operations in the hot cell can be observed through six shielded windows and with the aid of remote TV cameras.

- Canister shuttle car cell, which houses the canister shuttle car. The shuttle car, which transfers canisters to the cask loading port, also serves as a canister surge storage rack. Seven canisters can be stored in the shuttle car.

- Facility cask loading room, which also serves as the airlock for the waste shaft. The room houses the facility cask rotating fixture for rotating and restraining the cask during loading. The canister transfer port telescoping shield and shield valve are located in the floor of this room. The hoist with grapple and shield bell are suspended from the ceiling of the cask loading room.

Waste Hoist

The waste hoist transfers both the CH and the RH waste in the hoist conveyance down to the storage level. This is a friction hoist with six hoisting ropes and three tail ropes. The hoist conveyance is designed to carry two loaded waste pallets resting on ledges located in the side walls of the conveyance; or the conveyance can carry one facility cask resting in the facility cask car. The hoist is driven by a 700-hp motor located in the hoist tower inside the waste building. The hoist has a 41-tonne payload capacity.

Underground Storage

Underground storage facility includes:

- Waste shaft loading area, at the foot of the waste hoist, provided with sufficient space and head room to allow transfer of CH waste and RH canisters onto the underground transporters. An airlock is located next to the shaft in this area.

- Underground drifts.

- Storage rooms.

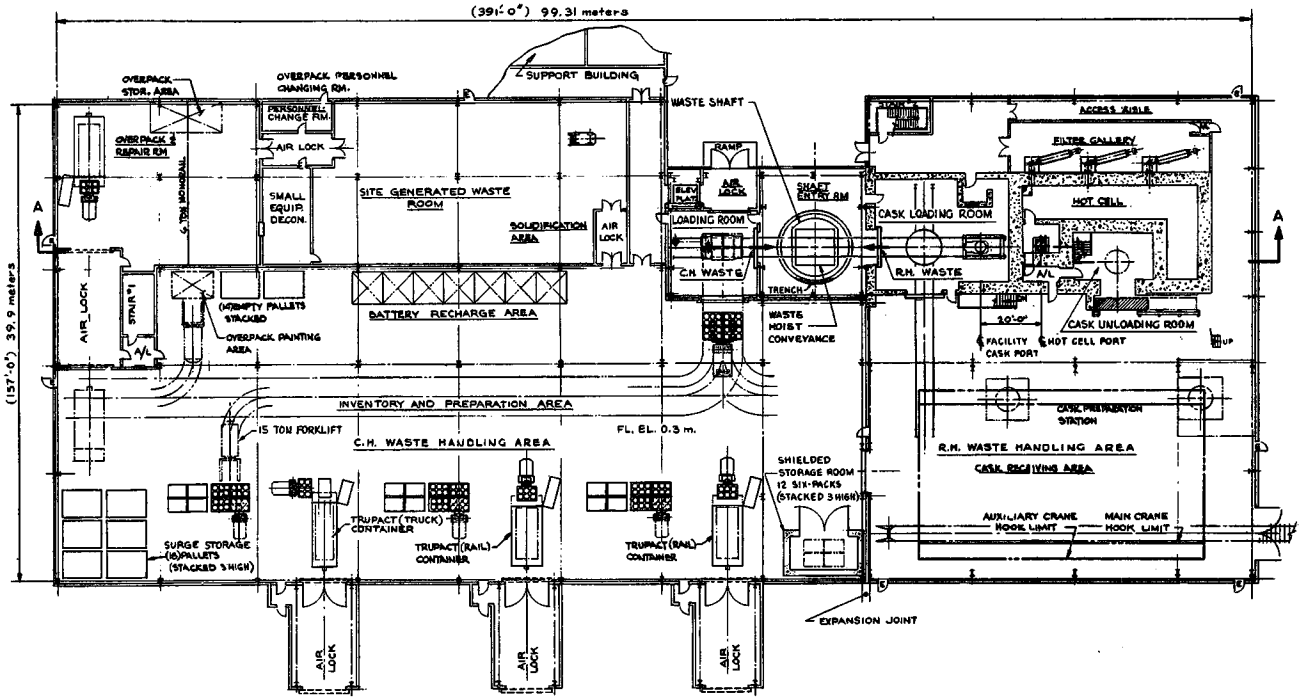

Fig 1. Waste Building Plan.

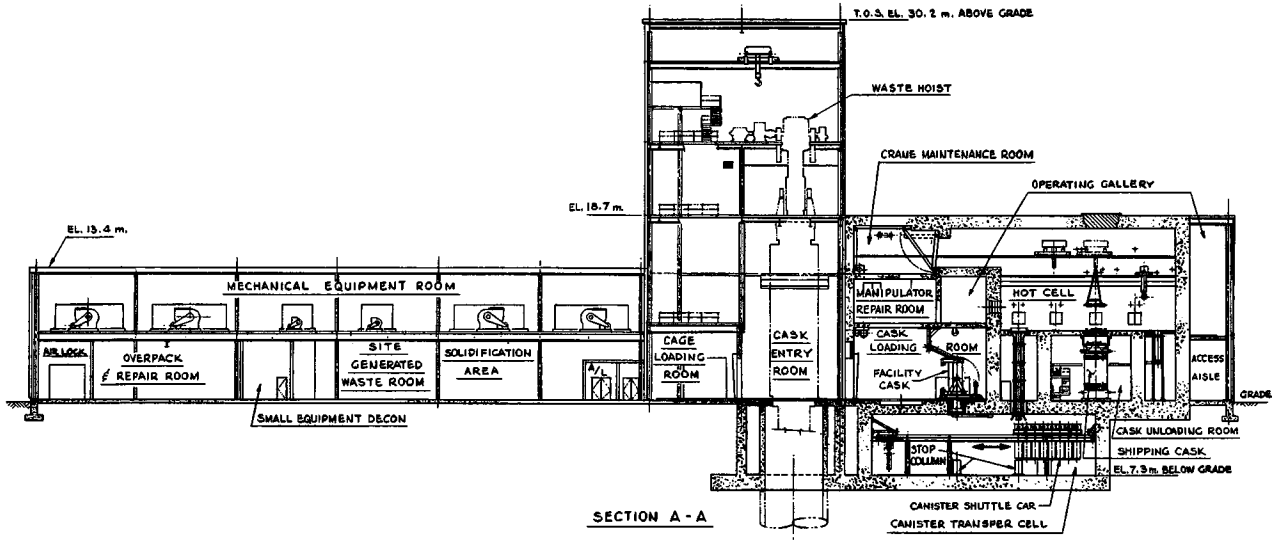

Fig 2. Waste Building Elevation.

HANDLING EQUIPMENT

The facility cask (Fig. 3) will permit all waste to be contact handled downsteam of the waste building. Cask shielding design permits a maximum dose rate of 200 mRem/hr on the cask surface, when carrying a 7,000-Rem/hr canister. The cask has two shield valves, which enable the cask to be loaded and unloaded with external grapples. The cask design interfaces with the horizontal emplacing fixture which will push the canister out of the cask into the storage tube in the wall of the storage room. The cask weight of about 32 tonnes established the 41-tonne (45-ton) payload of the waste hoist. The 41-tonne payload, in turn, was a factor in establishing the requirement for a friction-type hoist in the waste shaft. The cask will be loaded in vertical position in the cask loading room.

The cask will rest horizontally on the facility cask car during transfer in the waste hoist conveyance. The cask will be carried in the underground drifts by a transporter capable of transferring the cask onto itself. The use of a self-sufficient transporter avoids the need for a hoisting system underground which in turn minimizes room ceiling heights.

A single grapple design will be employed for the grapples in the hot cell, the cask loading room, and the emplacer. The grapple mechanisms will be actuated electrically. Grapple features include the ability to push canisters when operating horizontally and a safety design feature by which the grapple pawls are held in the load-carrying position by the payload itself. The grapple is about 380 mm (15 in.) in diameter which ensures that the grapple can enter all cavities that can hold the 609 mm (24-in.) diameter canister. The grapple has a manual overide provision which permits the release of payload in case of grapple malfunction. However, the canister must be set down and the load taken off the grapple before the grapple can be opened.

The 14-tonne (15-ton) hot cell crane will be a standard remote cell crane with the special feature of manual overides. Operators stationed outside the hot cell will be able to transfer the crane manually to the crane maintenance area.

The overpack welder consists of a stationary TIG weldhead and a canister holder which rotates the canister overpack being welded. The welder is automatic and will be remotely controlled from the operating gallery.

The hot cell equipment includes the following additional major items:

(1) A bridge-mounted electromechanical manipulator for transferring overpacks and general remote handling operation assistance.

(2) An overpack storage rack which accommodates enough overpacks to overpack the maximum number of canisters that can arrive in one shipping cask, minus one. One overpack is placed in the weld station.

(3) Master-slave manipulators at the overpack station and the inspection station.

(4) Pass-through drawer at the inspection station.

The canister shuttle car has redundant drive mechanisms inside the shuttle car cell. The drive motor is located outside the cell for easy access. Inserts will be installed in the shuttle car tubes when the smaller DHLW canisters are being handled.

The facility cask loading system permits dry loading of the facility cask with personnel present in the facility cask loading room. The system is centered around the cask rotating fixture, which integrates the design of the facility cask and car with the telescoping port shield and shield valve and the cask loading grapple with the grapple shielding bell. A unique feature of the system is the grapple shielding bell which rests on the grapple. When the grapple hoist lowers the grapple onto the facility cask, the bell will come to rest on the top of the cask. Thus, when the cask upper shield valve is opened, shielding is provided for operating personnel in the vicinity of the cask. Similarly, the telescoping port shield, which mates with the bottom of the casks, provides shielding during the cask loading operation. The cask rotating fixture rotates the cask to the vertical position by utilizing cask car driving power. The bottom trunnions of the cask and a major portion of the cask weight are always supported by the facility cask car, thus minimizing the possibility of the cask being dropped accidentally. The fixtures indexes the cask over the telescoping shield port and restrains the cask during loading. A series of interlocks will prevent accidental out-of-sequence operations that could result in radiation exposure to personnel.

The CH waste loading car is an electrically operated rail vehicle with a platform capable of powered up and down movement of about 150 mm. When loading the hoist conveyance, the pallets are placed on the car platform with the platform in the up position. The car is transferred to the hoist conveyance where the platform is lowered. As the platform is lowered, the pallet which overhangs the sides of the platform will come to rest on support stands or ledges that are integral to the conveyance, thus transferring the pallets from the car to the conveyance. The car, with its platform down, is then withdrawn back to the CH airlock. Another car identical to the CH waste loading car will be located in the waste shaft loading area underground. The second car unloads the conveyance in a reverse sequence to the one just described. The two cars, one on the surface and one underground, will permit maximum utilization of the hoist with minimum rest periods for loading and unloading.

FACILITY MAINTENANCE

Contact maintenance is planned for all facility equipment, including hot cell equipment. Hot cell crane overrides will permit the crane to be withdrawn to the crane maintenance area where hands-on repairs will be performed on the crane. A shield door is provided between the maintenance area and the hot cell. Thus, the crane can be used at all times to remove radioactive canisters from the hot cell, or from the canister shuttle car, to allow contact maintenance of all equipment.

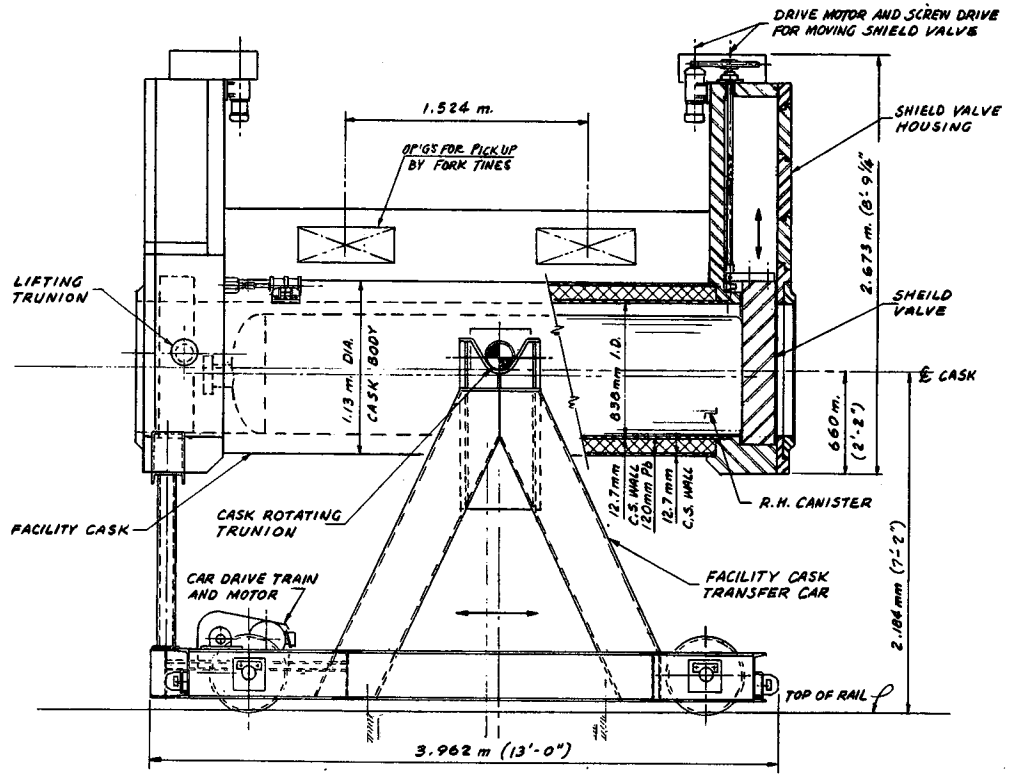

Fig 3. Facility Cask on Transfer Car.

OPERATIONAL DESCRIPTION

CH Waste Handling

CH waste will be transferred from the TRUPACTS onto steel pallets by means of forklifts. Four six-packs or modular steel boxes can be placed on a pallet. The pallet is then moved by a 14-tonne (15-ton) forklift to the CH airlock where it is placed on the CH loading car. Two pallets, one on top of the other, will be placed on the car and moved into the waste hoist conveyance. The car will be withdrawn from the conveyance and the palletized waste will be lowered to the storage horizon 690 meters below the surface. A car identical to the one in the waste building will remove the palletized waste from the conveyance which will then return to the surface. A forklift will transfer the waste from the car onto the underground transporter which is a lowboy-type vehicle. The vehicle will move the pallets to the storage rooms where forklifts will unload the waste containers and stack them three high. The empty pallets will be returned to the waste building for reloading. The full production rate will be 14 pallets per 8-hour shift, which will require seven hoist trips.

The TRUPACT interiors and their contents will be checked for radioactive contamination and damage prior to and during unloading. If the TRUPACT interior is contaminated, it will be moved by air pallet to the overpack and repair room, where the TRUPACT will be unloaded and the waste containers will be wiped clean or overpacked. After processing, the clean or overpacked waste containers will be transferred back to the CH handling area for standard handling. Decontamination and minor repairs will also be performed on the TRUPACT before it is returned from the overpack and repair room. Individual waste containers will also be checked for contamination during transfer from the TRUPACT onto the pallets. Contaminated or damaged waste containers will be transferred to the overpack and repair room for the processing described above.

RH Waste Handling

The shipping cask will be removed from the transporter by the 125-tonne bridge crane located in the RH handling area of the waste building. The crane will rotate the cask to vertical and place it on an air pallet. The cask will remain on the air pallet throughout the cask-unloading operations. The air pallet will move the cask to the cask preparation area where the following hands-on operations shall be performed.

(1) The outer cask lid will be removed.

(2) The bolts of the inner lid will be removed.

(3) A fixture, or a bridle, will be attached to the inner lid. This fixture will incorporate a pintle of the same configuration as the canister pintle.

(4) An adapter with an inflatable seal collar will be installed on the cask. The adapter with the seal collar deflated will clear the sealing of the cask unloading room.

The pallet will transfer the cask to the cask unloading room and place it under the hot cell transfer port. When the adapter seal collar is inflated, it will contact the ceiling around the transfer port. However, an airtight seal is not required since the hot cell is at a negative pressure to the cask unloading room. The shield door of the cask unloading room will be closed, and all personnel will evacuate the cask unloading room. The adapter does not provide shielding from canisters being transferred into the hot cell, and the cask unloading room ceiling is not thick enough to protect personnel during canister handling in the hot cell.

The hot cell crane will be used to lift the shipping cask inner lid into the hot cell and to remove the waste canisters from the shipping cask. Normally, the canister will be transferred from the shipping cask to the inspection station where it will be inspected visually and swiped to ensure that it is free of contamination. The crane is provided with a rotating block to facilitate canister inspection. The canister neck can be inspected by setting the canister down in the inspection station and releasing the grapple. It is expected that less than 2 percent of the canisters will require overpacking. These canisters will be transferred to the overpack welder and inserted into the overpack. The overpack lid, with the pintle, will then be placed on the overpack and welded to the overpack. The overpacked canister will be transferred to the inspection station. After inspection the canister will be transferred by the crane to the canister shuttle car which also serves as a surge storage rack. The canister shuttle car will move and index the canister below the telescoping port shield and shield valve.

The empty facility cask will be rolled into the facility cask loading room on the facility cask car. The cask will be resting on the car horizontally. The cask's upper (forward) trunnions will be inserted into the cask rotating fixture. Then, as the cask car continues to be driven forward, the rotating fixture will be rotated which will cause the cask to be rotated up. The car will continue to move forward until the cask is rotated to vertical position directly above the telescoping port shield.

The grapple with the shielding bell resting on it will be lowered onto the top of the cask. The cask shield valves and the port shield valve will be opened, the grapple will be lowered through the facility cask into the canister shuttle car cell, and the canister will be drawn into the cask. The lower cask shield valve will be closed, and the canister will be lowered onto the valve and released. The grapple will be withdrawn into the grapple shield bell, and the upper cask shield valve will be closed. The port shield valve will be closed and the telescoping port shield will be lowered. The facility cask will be rotated to horizontal position on the facility cask car in a reverse sequence to that described in the preceding paragraph. The cask will be moved in the facility cask car into the waste conveyance, which will take the cask and car down to the mine.

The cask will be lifted off the car by a transporter which will transport it through the drifts to the storage room where it will be placed on the canister emplacing fixture. The emplacing fixture will insert the canisters into lined storage holes in the walls of the room. A maximum of two RH TRU canisters will be handled *during an 8-hour* shift, which will also handle CH waste.