HORIZONTAL EMPLACEMENT AND RETRIEVAL EQUIPMENT FOR REMOTE HANDLED TRANSURANIC WASTES AT THE WASTE ISOLATION PILOT PLANT

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ABSTRACT

Remote Handled transuranic wastes are planned to be disposed in horizontal boreholes in the underground bedded salt formations at the Waste Isolation Pilot Plant (WIPP). All transuranic wastes emplaced at WIPP have to be retrievable during the initial five years of the plant operation. The equipment for emplacement and retrieval of Remote Handled transuranic waste packages has been designed and built and is currently undergoing performance verification testing at the manufacturer's facility. The unique design requirements for this first-of-a-kind equipment, the design considerations and approach used, and a description of the equipment are presented in this paper. Also included are some of the interesting design features provided for recovery from off-normal operating conditions and a brief summary of the operating sequence.

INTRODUCTION

The Waste Isolation Pilot Plant (WIPP) is currently under construction in the bedded salt formations in New Mexico at a site approximately 40 kilometers east of Carlsbad. The purpose of WIPP is to demonstrate the safe disposal of transuranic (TRU) wastes generated by the defense programs of the United States. Both Contact Handled (CH) and Remote Handled (RH) TRU wastes will be handled at WIPP.

An important consideration relating to the WIPP mission is the requirement that until the facility is designated as a TRU waste repository, all emplaced TRU wastes shall be retrievable during the initial five year operating period. If retrieval is not required during that demonstration period, then wastes emplaced subsequently do not have to be retrieved. RH TRU waste packages will be emplaced at WIPP in horizontal boreholes. For the demonstration phase, these boreholes have steel sleeves that withstand salt lithostatic pressure to facilitate retrieval of the emplaced waste packages.

The Waste Technology Services Division of the Westinghouse Electric Corporation has the responsibility for the design, fabrication, and testing of the Horizontal Emplacement and Retrieval Equipment for RH TRU waste packages. The equipment has been fabricated and is currently undergoing extensive testing at the Westinghouse Advanced Energy Systems Division's manufacturing facility at Large, Pennsylvania. This paper discusses the requirements and considerations that were applied to the design of the equipment along with a description of the design and equipment operation.

WIPP FACILITY INTERFACES

Surface Facilities

The WIPP surface facilities include a receiving yard, where RH TRU waste packages arrive in shipping casks by truck or rail shipments, and a waste handling building, in which the waste packages are unloaded and transferred into a facility cask. A waste hoist with a 41 tonne payload capacity transfers the facility cask to the underground facility. The waste hoist cage is approximately 2.8 m wide by 4.6 m deep by 7.5 m high.

Underground Facility

The underground facility includes a waste shaft station, where the facility cask is transferred from the waste shaft conveyance to an underground transporter, access drifts to the emplacement area, and the emplacement rooms. Fig. 1 shows the arrangement of the underground facility. The WIPP has eight emplacement panels, each consisting of seven rooms. The rooms are separated by salt pillars that are 30 m wide, while the panels are separated by salt pillars that are 60 m wide. Each room is 10 m wide by 4 m high by 91 m long. The most restrictive access drift between the waste shaft station and the emplacement area is 6 m wide by 3.5 m high. The slope of the floor in the rooms is less than 3 percent.

RH TRU waste packages are emplaced in horizontal boreholes in the salt pillars. The borehole centerlines are located at a height of approximately 1.6 m above the floor. A nominal spacing of 2.4 m between boreholes is used.

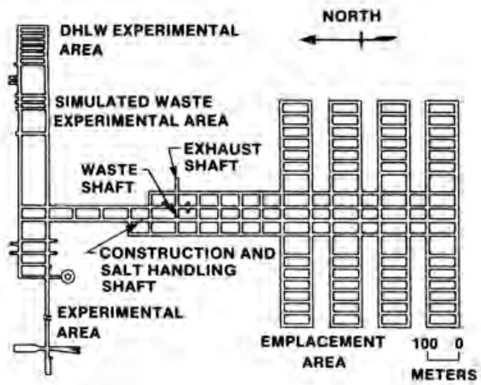

Fig. 1. WIPP Underground Facility Arrangement.

Facility Cask

The facility cask, shown in Fig. 2, provides shielding for the waste package as it is transported from the surface facility to the underground emplacement area. The empty cask weighs about 30 tonnes. The cask is provided with two shield valves and has an 0.7 m diameter bore. The shield valves are actuated by electric motors. Pneumatically operated, spring-loaded lockpins on the cask lock the valve gates in the closed position to prevent unintentional opening of a shield valve with a waste package in the cask.

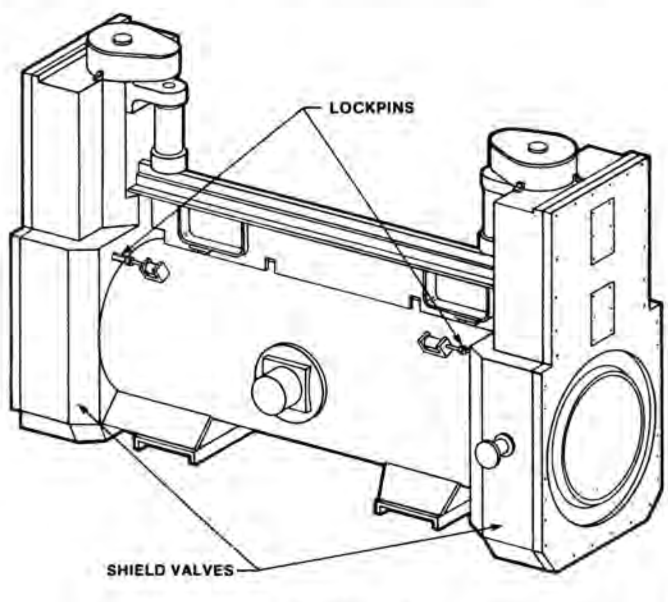

Fig. 2. Facility Cask.

DESIGN REQUIREMENTS

The design requirements for the RH TRU waste package emplacement and retrieval equipment are summarized below:

Interface Requirements

The equipment has to:

- Interface with a loaded, horizontally oriented facility cask.
- Have overall dimensions that permit transportation through the underground access drifts and allow operation in the emplacement rooms.
- Fit into the waste hoist conveyance, as a unit or as dismantled subassemblies, without exceeding its payload limit.

Functional Requirements

The equipment has to:

- Emplace an RH TRU waste package and a shield plug into a horizontal sleeved or unsleeved borehole. It also has to retrieve the shield plug and waste package from sleeved boreholes. The RH TRU waste package is 0.65 m in diameter and 3.1 m in overall length. It has a maximum weight of 3600 kg and a maximum surface dose rate of 100R/hr. A damaged or contaminated RH TRU waste package can be overpacked at WIPP, and the equipment has to handle the slightly larger overpacked waste package, which weighs a maximum of 4500 kg. All waste packages are provided with a standard lifting pintle design that is compatible with the surface facility handling equipment and the Savannah River Defense Waste Processing Facility.
- Include a steel sleeve (for sleeved boreholes only) designed to withstand a maximum salt lithostatic pressure of 15 MPa.
- Include provisions for retaining a shield plug in the borehole.
- Limit the equipment surface dose rate during emplacement and retrieval to a maximum of 100 mRem/hr. After emplacement of the waste package and shield plug, the maximum surface dose rate in the emplacement room is limited to 5 mRem/hr.
- Be designed to operate underground in a ventilated area in the presence of salt dust and humidity. The nominal ambient temperature is 30^{o}C and the relative humidity normally less than 60 percent.
- Allow emplacement of two RH TRU waste packages in an 8 hour shift.

DESIGN CONSIDERATIONS AND APPROACH

Retrievability

The requirement for retrievability of the waste packages during the demonstration phase of the WIPP facility represented a significant consideration in the design of the emplacement and retrieval equipment. As will be evident, the sophistication and complexity of the equipment was dictated to a large extent by the *required capability* for retrieval.

The phenomenon of creep is of particular significance in salt. Creep data recorded at WIPP during the mining of the access drifts and experimental rooms show the salt walls closing in by several centimeters within months of their excavation. The creep rate is accelerated by increased salt temperatures that result from the thermal output of the waste packages. Thus, the horizontal boreholes in which waste packages are emplaced could, over a period of time, close in around the package and render retrieval difficult.

It may even be necessary to use salt overcoring equipment to extricate the package. Therefore, waste packages are emplaced during the demonstration phase in boreholes provided with steel sleeves that are designed to withstand the maximum anticipated salt lithostatic pressure.

The provision of sleeves in the borehole only assures that sufficient clearances will be available around the waste package and shield plug for retrieval. The salt lithostatic pressures on the sleeve outside diameter could still shift the sleeve and cause it to tilt from its initial horizontal position. The equipment, therefore, has to locate the new orientation of the sleeve and align itself with the sleeve axis. The approach that was selected used an alignment fixture that, when installed on the sleeve, provided the planes of reference and a means for precisely aligning the waste transfer equipment with respect to the sleeve. The alignment fixture approach permitted the development of a single set of equipment that is used for both emplacement as well as retrieval.

Transportation and Handling

The transportation of emplacement and retrieval equipment from the surface to the underground facility using the waste hoist represented another important consideration. The hoist cage space and payload are limited, as are the facilities available underground for handling and assembly of heavy mechanical equipment. Hence it was essential that the equipment be designed to permit easy dismantling and reassembly. The waste transfer equipment, which is the only assembly that requires dismantling, consists of three modules that are completely separated by loosening a few fasteners and electrical connectors. Also, careful attention was given to the provision of conventional lifting and handling features in all assemblies and subassemblies.

The transportation of the assembled equipment from the underground waste shaft station to the emplacement area presented another interesting design challenge. Low access drifts and right angled drift intersections precluded the use of a conventional tractor and trailer unit for this application. The approach used provides for the temporary attachment of wheels and steering features directly on the equipment, which is then towed by a forklift or tractor.

Equipment Operating Envelope

Special consideration was given to minimizing the equipment operating envelope in the emplacement room. The limited room dimensions and the relatively large height of the facility cask required a design that was structurally adequate for carrying the loadings, while maintaining a low profile for installing the facility cask. The design of shield plug transfer features, waste transfer mechanism, leveling and drive mechanisms, etc., which will be described later, all reflect the efforts that went into minimizing the equipment envelope.

Safety

The safety of operating personnel, the prevention of inadvertent radiation exposure, and the provision of features to permit the safe and correct sequential operation of the equipment were paramount design considerations. The approach was to develop an emplacement and retrieval system that, barring a catastrophic collapse of the mine floor, made it virtually impossible for inadvertent exposure to operating personnel as a result of postulated equipment failures. A redundant instrumentation and control system, implementing a sophisticated interlock logic that is integrated with the facility cask operation, assures that the operations are performed only in the intended sequence.

Special features are provided for recovery from off-normal operating conditions. These include the provision of manual overrides for all drives and leveling systems, features for manual release of the waste package grapple and retraction of the waste transfer mechanism, and an administratively controlled override for the control system.

HORIZONTAL EMPLACEMENT AND RETRIEVAL EQUIPMENT DESCRIPTION

The Horizontal Emplacement and Retrieval Equipment, shown in Fig. 3 with the facility cask on it, consists of the following:

- Sleeve (for sleeved boreholes only)
- Alignment Fixture and Shield Collar
- Waste Transfer Machine
- Shield Plug Carriage
- Shield Plug
- Transport Equipment

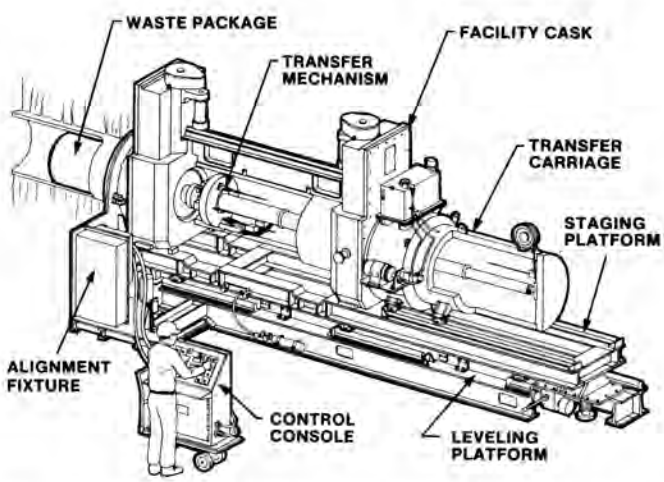

Fig. 3. Horizontal Emplacement and Retrieval Equipment.

Sleeve

The Sleeve performs the following functions:

- Withstands lithostatic pressure and thereby facilitates the retrieval of the waste package and Shield Plug
- Provides the planes of reference for installation and alignment of the waste transfer equipment

The Sleeve, shown in Fig. 4, is a 5.4 m long carbon steel cylinder with a 0.7 m diameter bore. The Sleeve wall is 8 cm thick except at the front end which is 18 cm thick. This additional thickness is required to limit the dose rate as the waste package is transferred from the facility cask into the borehole or in the reverse direction. The rear end of the Sleeve is closed with a steel plate to prevent ingress of salt debris.

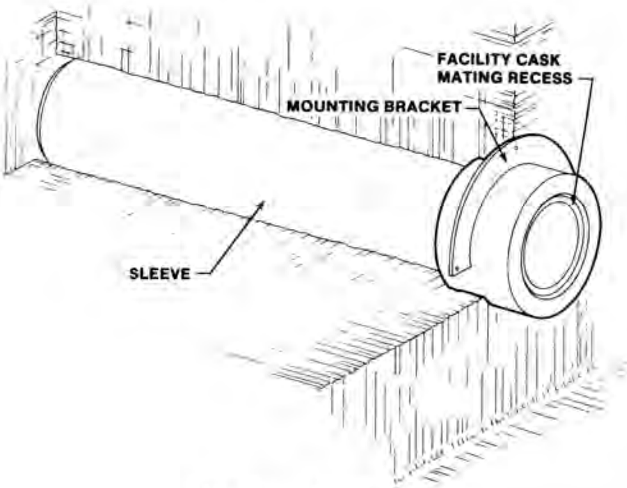

Fig. 4. Sleeve.

A semi-circular bracket is welded near the front end of the Sleeve. The front face of this bracket is perpendicular to the Sleeve axis. The Alignment Fixture is inserted over the Sleeve and bolted to the bracket to obtain the proper orientation.

Alignment Fixture

The Alignment Fixture provides the planes of reference and a means for aligning the Waste Transfer Machine with respect to the Sleeve or unsleeved borehole.

The Alignment Fixture, shown in Fig. 5, is used in conjunction with a sleeved borehole. The Alignment Fixture has an L-shaped configuration and is a welded steel structure. The vertical leg has an opening to allow it to pass over the Sleeve. The holes provided for bolting the Alignment Fixture to the Sleeve are slotted to permit circumferential adjustment of the fixture.

The base plate of the Alignment Fixture is provided with two alignment pins. These pins are located so that, when the Waste Transfer Machine is installed on the Alignment Fixture, the axes of the machine and the Sleeve are in the same plane (though not necessarily parallel). Two wedge-shaped bars, welded to the top of the Alignment Fixture base plate, engage with matching Vee blocks on the Waste Transfer Machine. This feature facilitates alignment and prevents the Waste Transfer Machine from accidental contact with the other components on the Alignment Fixture.

A leveling system consisting of three 18 tonne, electric-motor-driven, mechanical screw jacks is provided for the alignment and support of the Alignment Fixture. The screw jacks are provided with special swivel leveler feet to independently bear on a potentially non-uniform, sloping floor.

Electronic tilt sensors monitor the transverse and longitudinal tilt angles of the Alignment Fixture. These tilt sensors together with a tilt sensor mounted on the Waste Transfer Machine are used to properly align the equipment.

Proximity sensors measure the correct engagement of the facility cask with respect to the Sleeve. When the Alignment Fixture is used for emplacement operations in unsleeved boreholes, a Shield Collar is bolted to it. This Shield Collar performs the same function as the front portion of the Sleeve in limiting the surface dose rate.

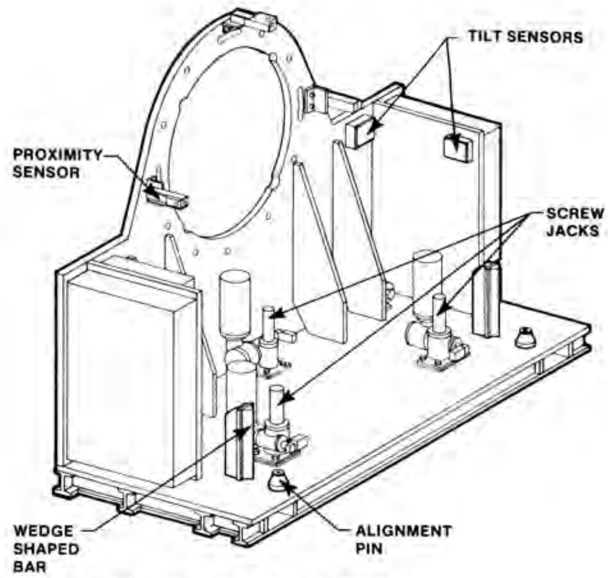

Fig. 5. Alignment Fixture.

Waste Transfer Machine

The Waste Transfer Machine, shown in Fig. 3, performs the following functions:

- Supports the facility cask
- Aligns the facility cask with respect to the Sleeved or unsleeved borehole
- Positions the facility cask against the Sleeve (or Shield Collar for the unsleeved borehole)
- Emplaces and retrieves the waste package and Shield Plug

The major components of the Waste Transfer Machine include the Leveling Platform, Staging Platform, and Transfer Carriage.

The Leveling Platform is a structural steel frame with a stepped down front end to reduce the overall height of the Waste Transfer Machine. Two alignment arms welded near the front end have the bushings and Vee blocks that engage with the alignment pins and wedges on the Alignment Fixture. An electric-motor-driven, 32 tonne mechanical screw jack is provided near the rear end of the Leveling Platform. Once the Waste Transfer Machine is installed on the Alignment Fixture and the facility cask set on it, the only operation required to align the axes of the cask and the Sleeve (or unsleeved borehole) is to lower or raise this screw jack.

The Staging Platform supports and positions the facility cask and Transfer Carriage. A system of shaft rails and roller bearings permit movement of the Staging Platform relative to the Leveling Platform for placing the cask against the Sleeve or Shield Collar. The mechanical drive system for this purpose is mounted on the Leveling Platform. The top of the Staging Platform is provided with guide blocks for positioning the facility cask on it. The Staging Platform also supports the mechanical drive system that moves the Transfer Carriage forward to bear against the facility cask, or retracts it for installing the Shield Plug Carriage. A regulated air supply system on the Staging Platform provides compressed air for the operation of the facility cask lockpins.

The Transfer Carriage houses a hydraulically-actuated Transfer Mechanism and provides shielding at the rear end of the facility cask to limit surface dose rates when the cask shield valves are open. The Transfer Carriage also houses a completely self-contained hydraulic system for operating the Transfer Mechanism. A system of shaft rails and roller bearings allow movement of the Transfer Carriage with respect to the Staging Platform. Proximity sensors on the Transfer Carriage measure the correct engagement of the carriage with the facility cask.

The Transfer Mechanism, in conjunction with the grapple, provides the capability for transferring the waste package from the facility cask into the borehole and vice versa. The mechanism also provides the same functions for Shield Plug emplacement and retrieval. The Transfer Mechanism consists of a 5-stage, double-acting hydraulic cylinder. The front face of the cylinder bolts to a support plate, which has a system of rollers that support the weight of the Transfer Mechanism. A reel-type potentiometer measures the position of the Transfer Mechanism during its travel.

If the hydraulic system malfunctions, the Transfer Mechanism can be manually retracted from a partially or fully extended position by pulling on two wire ropes attached to the support plate at one end and to a pair of torque reels mounted on the outside of the Transfer Carriage, as shown in Fig. 6.

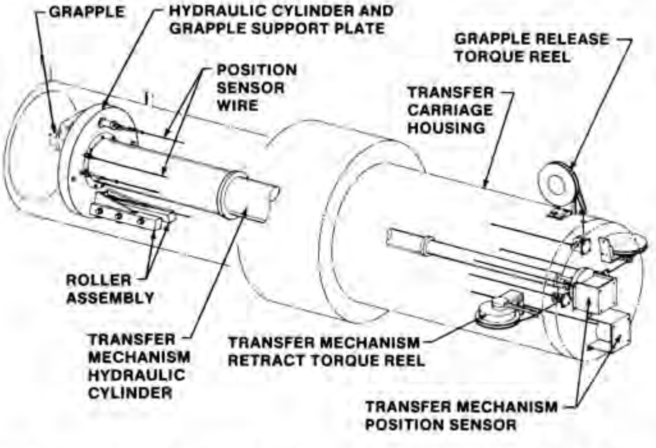

Fig. 6. Transfer Mechanism Retract and Grapple Release Features.

The Grapple, shown in Fig. 7, consists of a pair of traveling nuts on an electric-motor-driven mechanical screw jack provided with left-hand and right-hand screw threads. Extensions to the traveling nuts act as jaws for the Grapple. A pintle detection switch is provided on the Grapple to detect and stop the Transfer Mechanism prior to closing the Grapple jaws around a waste package or Shield Plug pintle. The Grapple design includes a manual release mechanism shown in Figs. 6 and 7. The back plate of the Grapple housing is bolted to the hydraulic cylinder support plate with a controlled clearance between them. Slots are provided on the back plate so that the entire Grapple assembly can slide down far enough for the jaws to clear the pintle when a spring-loaded pin holding the Grapple to the support plate is pulled out. The pin is secured to a wire rope connected to a torque reel mounted on the outside of the Transfer Carriage.

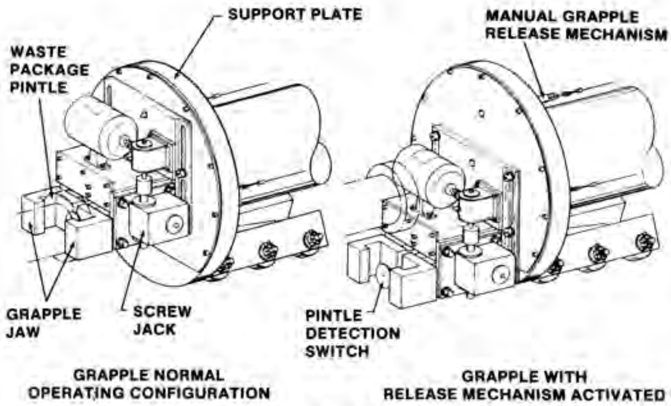

Fig. 7. Grapple Configuration.

Shield Plug Carriage

The Shield Plug Carriage, shown in Fig. 8, supports the Shield Plug in a horizontal position during emplacement and retrieval operations and aligns the Shield Plug with the facility cask bore. The Shield Plug Carriage is a welded steel cradle provided with roller bearings that ride on the Staging Platform shaft rails.

Shield Plug

The Shield Plug, shown in Fig. 8, limits the borehole surface dose rate to less than 5 mRem/hr after the emplacement is complete. It is provided with the same pintle design as the RH TRU waste package. The Shield Plugs for the WIPP demonstration phase are of all-steel construction; however, the plugs for subsequent emplacements will be made of concrete with a steel pintle.

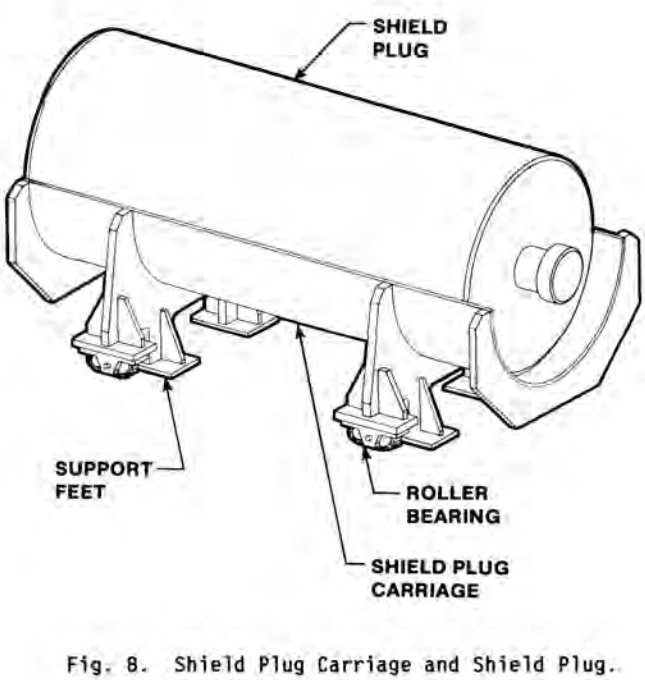

Fig. 8. Shield Plug Carriage and Shield Plug.

Transport Equipment

The Transport Equipment, shown in Fig. 9, provides a means to move the Waste Transfer Machine through the access drifts and to negotiate the drift intersections. The equipment is designed to enable the machine to be pulled by a facility forklift or tractor in a manner similar to an industrial trailer. All other pieces of equipment, such as the Alignment Fixture, Shield Plug Carriage, etc. will be handled and transported by forklifts.

The Transport Equipment consists of a pair of rigid axles and a removable steering axle that are temporarily attached to the Leveling Platform. The steering axle includes a drawbar and a conventional Ackerman steering linkage arrangement. The axle housing is pinned to the Leveling Platform. This allows the axle to rotate in the vertical plane to accommodate uneven or sloping floor conditions. The wheel assemblies consist of high load bearing polyurethane tires on steel wheels.

When moving the Waste Transfer Machine within an emplacement room from one location to the next, or over short distances in the emplacement area, the equipment will be lifted and transported by a forklift.

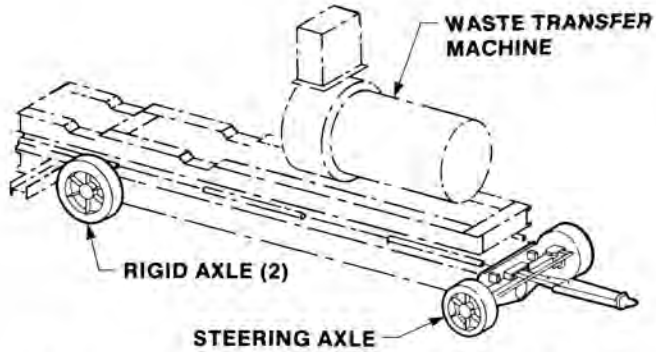

Fig. 9. Waste Transfer Machine Transport Equipment.

OPERATING SEQUENCE

The operating sequence for the emplacement of a Waste Package and Shield Plug in a sleeved borehole is shown pictorially in Fig. 10. The same sequence is used for emplacements in unsleeved boreholes, except that the Alignment Fixture is first installed and visually aligned with the borehole. The reverse sequence is followed for retrieval.

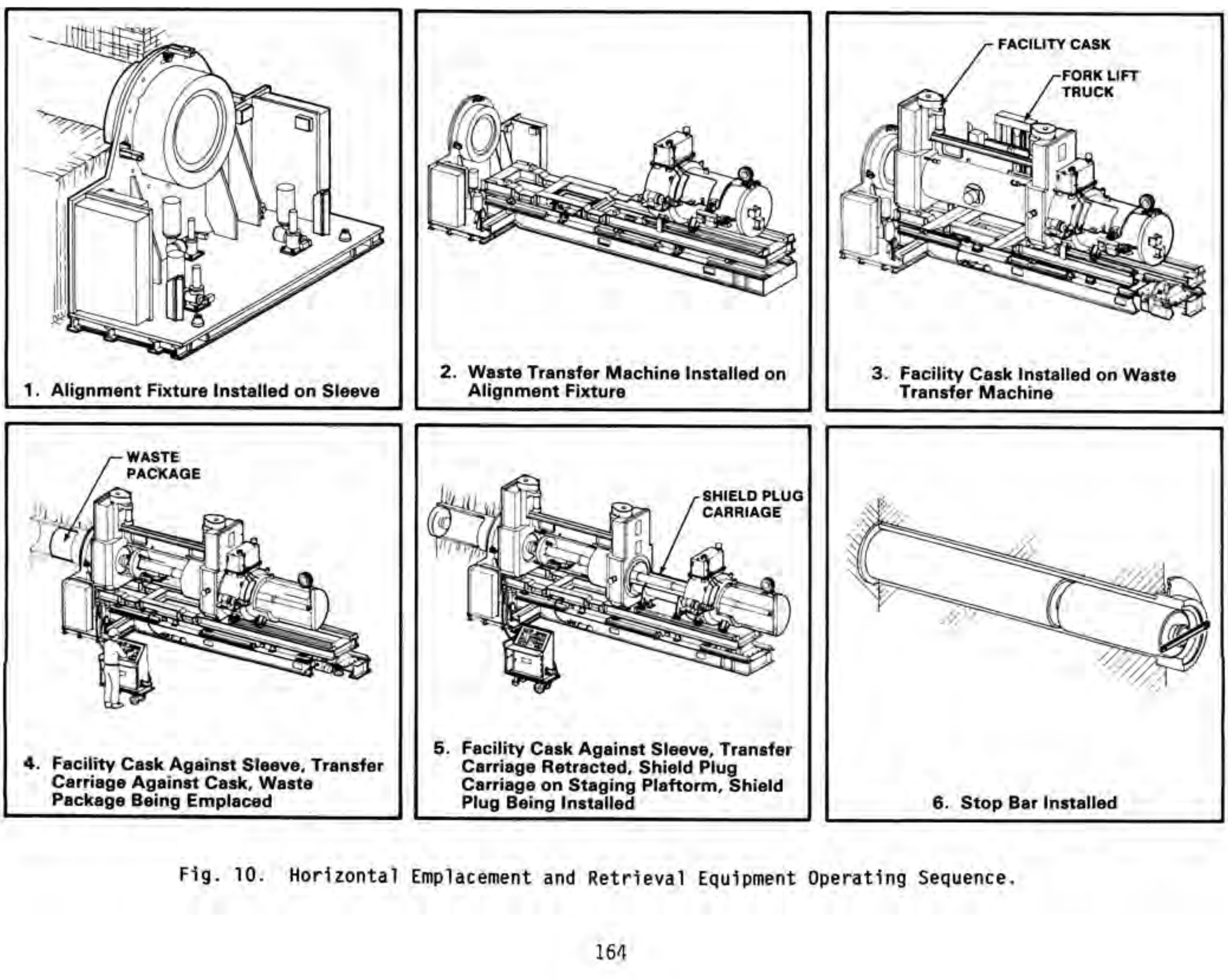

Fig. 10. Horizontal Emplacement and Retrieval Equipment Operating Sequence.

CONCLUSIONS

This paper has described the design considerations and the approach used in the design of the first-of-a-kind equipment for the emplacement and retrieval of RH TRU wastes at WIPP. The equipment for performing such operations in a commercial waste repository will certainly be different and involve a higher degree of automation. However, the WIPP design experience has provided a valuable insight into repository needs and their unique interface requirements, which can be meaningfully applied to the design of commercial repository equipment.

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