Westinghouse Hittman Nuclear Incorporated

TOPICAL REPORT

STD-R-05-011

MOBILE INCONTAINER DEWATERING AND SOLIDIFICATION SYSTEM (MDSS)

Submitted to:

Standardization and Special Projects Branch
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

July, 1986

Revision 1

☐ Proprietary Version Copy (STD-R-05-011P)

☒ Non-Proprietary Version Copy (STD-R-05-011NP)

By

Westinghouse Hittman Nuclear Incorporated
Columbia, Maryland

WESTINGHOUSE HITTMAN NUCLEAR INCORPORATED	Document Number: STD-R-05-011	Rev: 1	Rev Date: 7-23-86
	Title: Mobile Incontainer Dewatering and Solidification System (MDSS) - Topical Report		

Rev.	Rev Date	Director Engr.	Project Manager	Q.A. Manager			
1	7-23-86	[signature]	[signature]	J Pantek for B ROWE			ECN 86-181

FORM-01(B)

PROPRIETARY NOTICE

This document describes the process and equipment that Westinghouse Hittman Nuclear Incorporated furnishes for solidifying and dewatering radioactive waste produced by light water reactors. As such it contains proprietary information and its contents may not be disclosed or used for other than the express purpose for which it was provided.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

List of Tables

List of Figures

ABSTRACT

The Westinghouse Hittman Mobile Incontainer Dewatering and Solidification System (MDSS) is the result of over eight years of development and several years of operation at nuclear utilities. Westinghouse-Hittman's broad experience in the nuclear industry provides a unique insight into practical design considerations. This report shows the system to be an effective means of preparing radioactive wastes for permanent disposal. The system is designed consistent with principles of ALARA and conforms to applicable portions of industry standards and Federal regulations.

The incontainer solidification system uses a batch mixing technique where concentrated liquid or wet solid wastes are preconditioned and mixed with dry cement and additive inside the shipping container. The final product is a solidified free-standing monolith which is non-flammable and has sufficient compressive strength to exceed any existing or proposed disposal requirements.

The incontainer dewatering system is used to dewater steel liners equipped with underdrains to less than 1/2% free liquid, and high-integrity containers (HICs) containing wet solid wastes to less than one percent drainable liquid.

All equipment is located and installed to comply with ALARA criteria. Worker exposure averaged less than 500 mrem per quarter for 1983 and 1984. Several accident scenarios have been evaluated and it is concluded that the Hittman MDSS can be operated with minimal risk to public health and safety.

1.0 INTRODUCTION

1.1 Purpose

As required by Federal regulations, liquid radioactive wastes generated by nuclear power plants and utilities must be solidified before shipment to a disposal site. Wet solid wastes such as resin slurries and filter sludges may either be solidified or dewatered prior to shipment for burial. The purpose of this report is to present the necessary data on the Westinghouse Hittman Mobile Incontainer Dewatering and Solidification System (MDSS) for the U.S. Nuclear Regulatory Commission (USNRC) to evaluate the system for use at nuclear utilities.

1.2 Background

Westinghouse Hittman Nuclear Incorporated has been in the business of processing, solidifying, and transporting radioactive wastes for over eight years. The company was purchased by the Westinghouse Electric Corporation in November 1982 and now operates as a wholly owned subsidiary of Westinghouse as a component of the Waste Technology Services Division (WTSD).

In the mid-1970's, Hittman received orders to provide thirteen in-plant urea-formaldehyde (UF) solidification systems. It also began providing mobile solidification services using UF. By 1977, however, it became apparent that UF had significant deficiencies and a better method was needed to solidify liquid and wet low-level radioactive wastes. At that time, Hittman assumed a leadership role in developing cement solidification technology. By 1978, it had sold seven in-plant cement solidification systems and had filed a Topical Report with the USNRC describing that system.

In 1978, Hittman also began developing its mobile cement solidification system. The process was initially developed for solidifying bead resins but it was readily adapted to solidifying liquids and wet solid wastes. By 1979, Hittman was offering this service on a commercial basis. Since then, Hittman has solidified almost two million gallons of liquid and wet solid low-level radioactive waste (liquid concentrates, bead and powdered resins, etc.) for over thirty different customers. The process consistently produces a free-standing solidified monolith which is accepted at all commercial radioactive waste disposal sites.

1.3 Summary and Conclusions

Waste transfer and dewatering operations using the Mobile Incontainer Dewatering and Solidification System (MDSS) are conducted in radiologically controlled areas. Additionally, solidification operations for all waste types are performed under negative pressure. Any airborne radioactivity would be released to the in-plant building ventilation system. Should any part of the in-plant building ventilation system fail, waste transfer and/or dewatering operations can be terminated until the appropriate repairs have been made. There is, therefore, no credible accident during normal system operations which could result in increased off-site doses.

Liquid waste handling operations are conducted within the double barrier of the cask and liner, or in a liner contained within a curbed area having a drain collection system, thus eliminating the possibility of a liquid release to the environment.

Use of the Westinghouse Hittman Mobile Incontainer Dewatering and Solidification System does not significantly increase off-site doses during normal operations. The concentrations of radionuclides in the air are only a fraction of the maximum permissible concentrations, even under the conservative assumptions used in the accident analyses in Section 8.0.

2.0 PROCESS DESCRIPTION

Westinghouse Hittman Nuclear Incorporated has addressed the problem of processing liquid radioactive waste for disposal with its Mobile Incontainer Dewatering and Solidification System. The process, field-proven through more than seven years of power plant experience, is effective in solidifying bead resins, powdered resin and filter sludges, concentrated aqueous wastes and other liquid wastes, including contaminated oil. The incontainer cement solidification system allows solidification of radioactive waste within a shielded cask which can be used for shipment to the disposal site. Dewatering wet solid wastes such as resins, sludges, etc., can also be accomplished inside the shipping cask. This eliminates intermediate waste handling steps and associated personnel radiation exposures.

2.1 General Process Description

Hittman's mobile waste solidification equipment is shown in Figures 2-1, 2-2, and 2-3. It consists of a) a control panel with indicators, b) a liner with internal mixing blades, c) a fill-head with a dewatering line and mixing motor, d) a dry material storage hopper and cement feed system, e) a dewatering pump skid, and f) an off-gas line connected to a dust collector for controlling cement dust.

The dewatering system uses the same dewatering pump skid connected to a Hittman steel liner (with underdrain) or a RADLOK high-integrity container via the waste receiver tank. A vacuum pump is included to maintain a vacuum inside the waste receiver tank.

2.2 Process Control Program

Hittman's analytical chemistry and laboratory test facilities are used to develop process and test solidification procedures tailored to the types of wastes being solidified. These procedures ensure that the waste is consistently solidified in full compliance with regulatory and burial site requirements as required by the Hittman Process Control Program. To support its solidification activities, Hittman has completed a program qualifying selected cement solidified waste forms to meet the stability requirements of 10CFR61 for shallow land burial. The selected waste forms have undergone extensive testing to demonstrate that they meet the requirements established by the NRC for radiation, biodegradation, leachability, thermal cycling, immersion and compression. Waste classified as Class A Stable, Class B or Class C according to radionuclide content must be solidified to meet the stability criteria.

The Process Control Program requires periodic sampling and a test solidification of at least every tenth batch of each type of wet radioactive waste. Based upon this characterization, a specific process and test solidification procedure is selected which is used to calculate the proper proportions of cement and additives. These process and test solidification procedures were originally titled as Process Control Programs for each waste type. To avoid confusion with the generic Process Control Program, these procedures will be retitled as Process and Test Solidification Procedures.

Process and test solidification procedures are available for such wastes as 0 to 50% boric acid (unstable); 0 to 30% sodium sulfate, bead resin, powdered resin, grit, diatomaceous earth, miscellaneous chemical wastes, and many other wastes including combinations such as boric acid with bead resins or filter sludge with sodium sulfate. For stable wastes the test results for nineteen different wastes which demonstrate compliance with the stability criteria of 10CFR61 are found in Hittman's "Topical Report: Cement Solidified Waste to Meet the Stability Requirements of 10CFR61", Report No. STD-R-05-007. The formulations tested are in a proprietary attachment to that report.

Formulations for wastes which do not require stabilization are developed on an as needed basis and may be used after it is demonstrated that these formulations meet the minimum requirements of 10CFR61. Waste classified as Class A Unstable must be solidified to meet these minimum requirements.

2.3 Incontainer Solidification

2.3.1 Configuration

A typical configuration of the Hittman MDSS is shown in Figure 2-3 for a solidification performed with the liner on a truck. An equipment arrangement for a combined solidification and dewatering system is shown in Figure 2-4. The design and operational features of the system, are as follows:

(a) Solidification operations can be performed with the liner inside a shipping cask or in a separate process shield or shielded vault. The liners are specifically designed to fit inside Hittman shipping casks. The liners are equipped with internal mixing blades which are sacrificed when the liner is buried.

(b) The mixer head drive assembly bolts to the liner opening forming a sealed gasketed closure. The mixer drive unit couples with the internal mixer shaft inside the liner and remains in place during transfer and dewatering operations.

(c) Vent and overflow lines are used to prevent over pressurization of the liner and overflow into the cask, respectively. The vent line is directed to a filter/dust collector. The overflow line can be directed to a plant return line, the plant drain system, or to a separate container.

(d) Level probes provide audible and visual indication of two operating levels within the container. A third probe provides similar indication of the potential overflow.

(e) Waste is transferred into the liner through the waste inlet connection in the mixer head drive assembly. An automatic shutoff valve is provided on the waste feed line which prevents overfilling the liner. For slurry transfer a 3-way valve is provided which allows recirculation back to a plant tank to prevent plugging transfer lines.

(f) Water, cement, and additives are added in the amounts dictated by the process and test solidification procedure to produce the desired solidification formulation.

2.3.2 Process Parameters

The incontainer solidification system can be used to solidify both wet solid wastes and liquids. Process limitations such as maximum concentrations of dissolved chemicals (i.e., boric acid), the maximum oil contamination, the maximum solid content of slurries, pH range, etc., are given in the specific process and test solidification procedure for the waste to be solidified.

2.3.3 Process Flow Diagram

Figure 2-5 shows the basic setup of the incontainer solidification system with typical process flow rates. It should be noted that waste feed and cement feed DO NOT occur simultaneously. As stated elsewhere the total quantity of cement, or other additives, to be mixed with a given waste is calculated on the process and test solidification procedure data sheets for the specific waste being processed.

Using a single shift, five days per week, and a crew of three or four operators the Hittman MDSS is capable of processing two containers per day each containing an average of 100 cubic feet of waste. This equates to an annual process capability of over 50,000 cubic feet. Volumes greater than this can easily be handled by using additional operators on additional shifts. Current operations at a two unit 1000 Mwe each, BWR requires 100 to 150 solidifications or dewaterings per year, well below the system capability.

2.3.4 Solidification Agent

Hittman has used cement to solidify many different types of waste and continues to use cement because it offers the following significant advantages:

(a) Cement, with additives, can solidify a wide variety of low-level radioactive wastes, over a broad range of chemical compositions.

(b) Cement chemically combines with liquid wastes rather than merely encapsulating the liquid.

(c) Cement solidification consistently produces a free-standing solid monolith.

(d) Cement is an environmentally acceptable material and requires no unusual handling or safety procedures.

(e) Cement solidification offers high waste packaging efficiency.

(f) Using cement and additives costs significantly less than other currently available solidification processes.

The use of cement is addressed in a separate topical report, STD-R-05-007, "Topical Report: Cement Solidified Waste to Meet the Stability Requirements of 10CFR61". This report contains data demonstrating the stability of cement solidified wastes. Results from the compression of simulated waste samples following initial cure, 90-day immersion, thermal cycling, biodegradation, and irradiation testing are presented. Waste types such as bead resin, powdered resin, filter sludge, diatomaceous earth, boric acid, sodium sulfate, and a grout mix were tested. All compressive strengths exceeded the 50 p.s.i. criteria by at least a factor of 4 and up to a factor of 25 times the minimum criteria.

Leachability testing was also performed on samples of these waste types and demonstrated leachability indecies above the criteria value of 6. Resulting leachability indecies ranged from above 6 up to 13.

2.3.5 Filter Encapsulation

Using a specially designed mixing tank and pumping system a cement slurry can be mixed and injected into various size liners to encapsulate filters or other mechanical components. The grout formulation was developed specifically for wastes requiring stability and is included in the Topical Report: Cement Solidified Wastes to Meet the Stability Criteria of 10CFR61, STD-R-05-007.

Procedures governing the preparation of the grout and grout injection are STD-P-05-026, PCP for Preparation of Cement Grout to Meet the Class B or C Criteria and STD-P-05-036, Preparation and Transfer of Grout.

2.4 Dewatering

2.4.1 Configuration

Hittman has developed a unique dewatering system for use in high integrity and steel containers. The dewatering system uses a newly developed porous plastic pipe with effective pore sizes no greater than five microns. With this material, it is possible to dewater powdered resins and diatomaceous earth inside the liner or high integrity container. Previously, centrifuges or flat-bed filters were used to dewater fine-grained materials to meet the limits for free-standing water. The Hittman dewatering system as shown in Figure 2-6 includes a vacuum receiver tank which allows wet solid waste to be dewatered simultaneously at several levels within the container. A similar system is used for dewatering such wastes as bead resin or activated carbon. The bead resin system uses a single layer dewatering underdrain with a final dewatering connection.

2.4.2 Process Parameters

The incontainer dewatering system can be used to dewater all types of bead resin, granular or powdered carbon, powdered resins and other filter precoat wastes and several miscellaneous waste sludges. For sludges of unknown composition, laboratory scale or drum scale tests are conducted to verify the systems ability to accomplish the dewatering in conformance with regulatory and burial site criteria. These tests are performed in accordance with Hittman Procedure STD-P-03-016, Verification Tests for Dewatering Powdered Resins and Filter Sludge Using Porous Pipe.

Other than a demonstrated ability to adequately dewater the waste material the only other restrictions that apply are pH and temperature. In both steel containers and HICs the pH must be between 4 and 11 with a maximum temperature of 140°F. In steel containers using the single layer underdrain higher temperatures would be acceptable, up to 170°F, but have never been experienced.

2.4.3 Process Flow Diagram

Figure 2-6 shows the basic setup of the incontainer dewatering system with typical process flow rates. Waste feed to the container proceeds on a batch basis while the dewatering operation proceeds on a continuous basis. Level control instrumentation on both the liner level control panel and the vacuum receiver tank level control panel provide the operator with both visual and audible indication of both the high and low operating levels in each container. A high-high level alarm is also provided on both vessels providing the operator a warning of a potential overflow. A backup to the container overflow alarm is provided by a high level alarm on the overflow drum.

2.4.4 Dewatering Test for Steel and High Integrity Containers

During the development of the dewatering systems, various tests were conducted to verify that the criteria of less than one percent drainable liquid (0.5 percent for steel containers) is satisfied. Bead resin, powdered resin, diatomaceous earth, and activated carbon were the basic waste types tested. Containers used ranged from 55-gallon drums to HN-600 liners (approximately 59 cubic feet of waste) to HN-100 liners (120 cubic feet of waste), both steel liners and high integrity containers.

These tests entailed performing the dewatering operation and measuring the quantity of water removed at various time intervals. Holes were drilled at various locations on the containers and monitored for drainable (free) liquid. Vibration of the containers was also conducted to investigate the effect of transportation on the amount of drainable liquid collected. Laboratory tests were conducted to determine the dry weight percent solids at which there is no free drainable liquid. Core samples were then taken from the full scale tests and dried to determine if the dry weight percent achieved was greater than that determined in the laboratory tests.

In all cases, the testing proved that the dewatering system is capable of removing water from various waste streams and of meeting the criteria for drainable liquid. Documentation of these tests is found in various Hittmn documents including STD-R-03-001, Report on Dewatering and Bead Ion Exchange Resin and Activated Carbon; STD-R-03-002, Report on Dewatering of Bead Ion Exchange Resin and Activated Carbon for RADLOK HICs; STD-R-03-003, Powdered Resin Dewatering Report (RADLOK-100); STD-R-03-005, Summary Report of Powdered Resin Dewatering in RADLOK Containers; and STD-R-03-006, Powdered Resin Dewatering in Containers having a Flat Bottom.

For many wet solid radioactive wastes, the solids will settle out much faster than the water can be removed by conventional dewatering processes. For these wastes the preferred method of removing excess water is decanting or, the process of removing the supernate from above the bed of settled solid wastes. In the field this process is governed by Hittman procedure STD-P-03-022, Decant Procedure.

R&D testing was performed in which decanted waste was compared to dewatered waste to determine the relative difference in the percent solid present in the waste stream. With this information, adjustments can be made in the formulations for certain solidifications where the formulation was orginally based on dewatered wastes but actual waste processing is based on a decanted waste. In order to confirm this technique, additional testing was performed to ensure that the solids content of a decanted, full size solidification liner was equivalent to the solids content of a decanted lab sample.

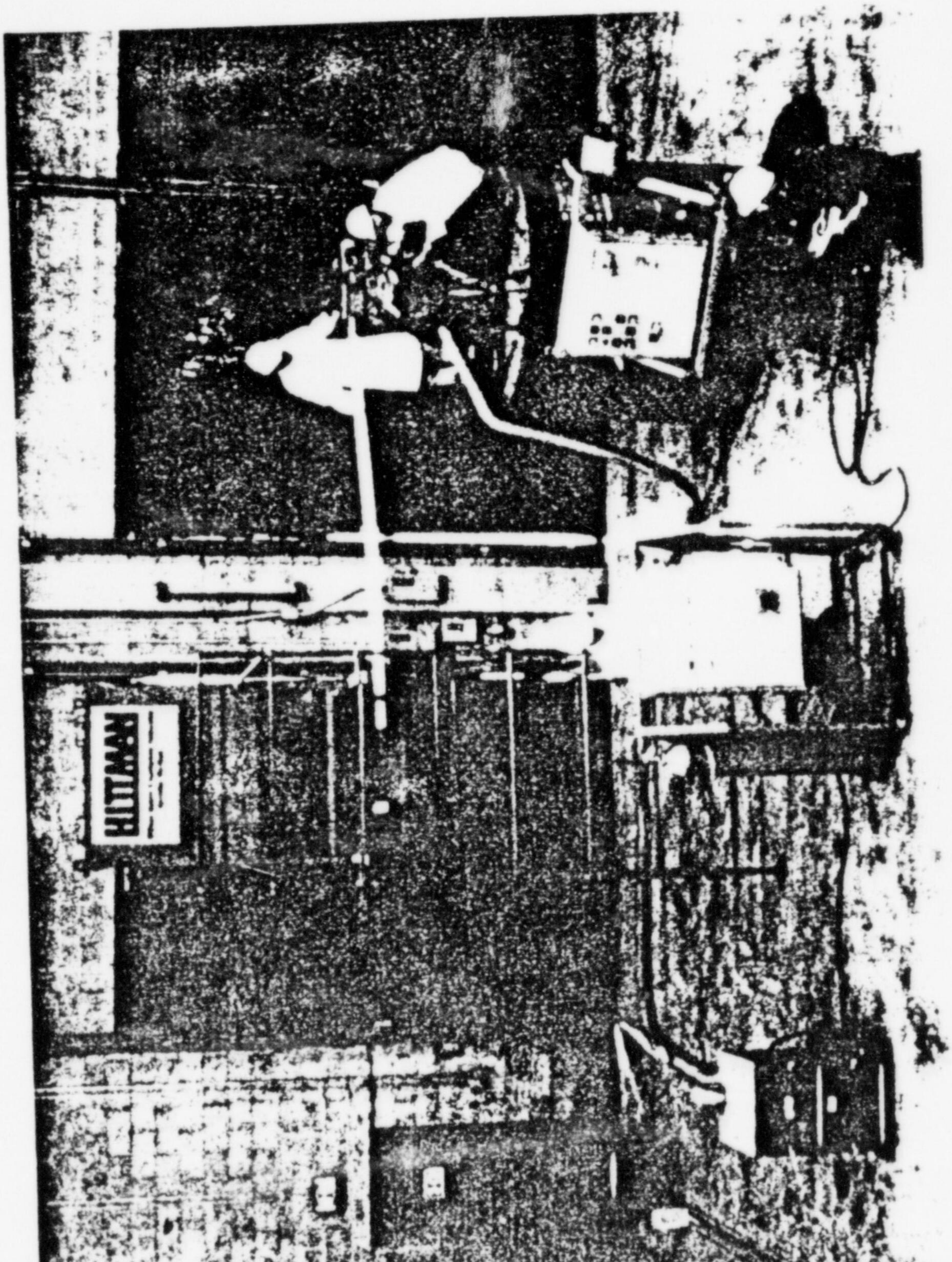


Figure 2-1. Hittman Mobile Incontainer Dewatering and Solidification System (MDSS)

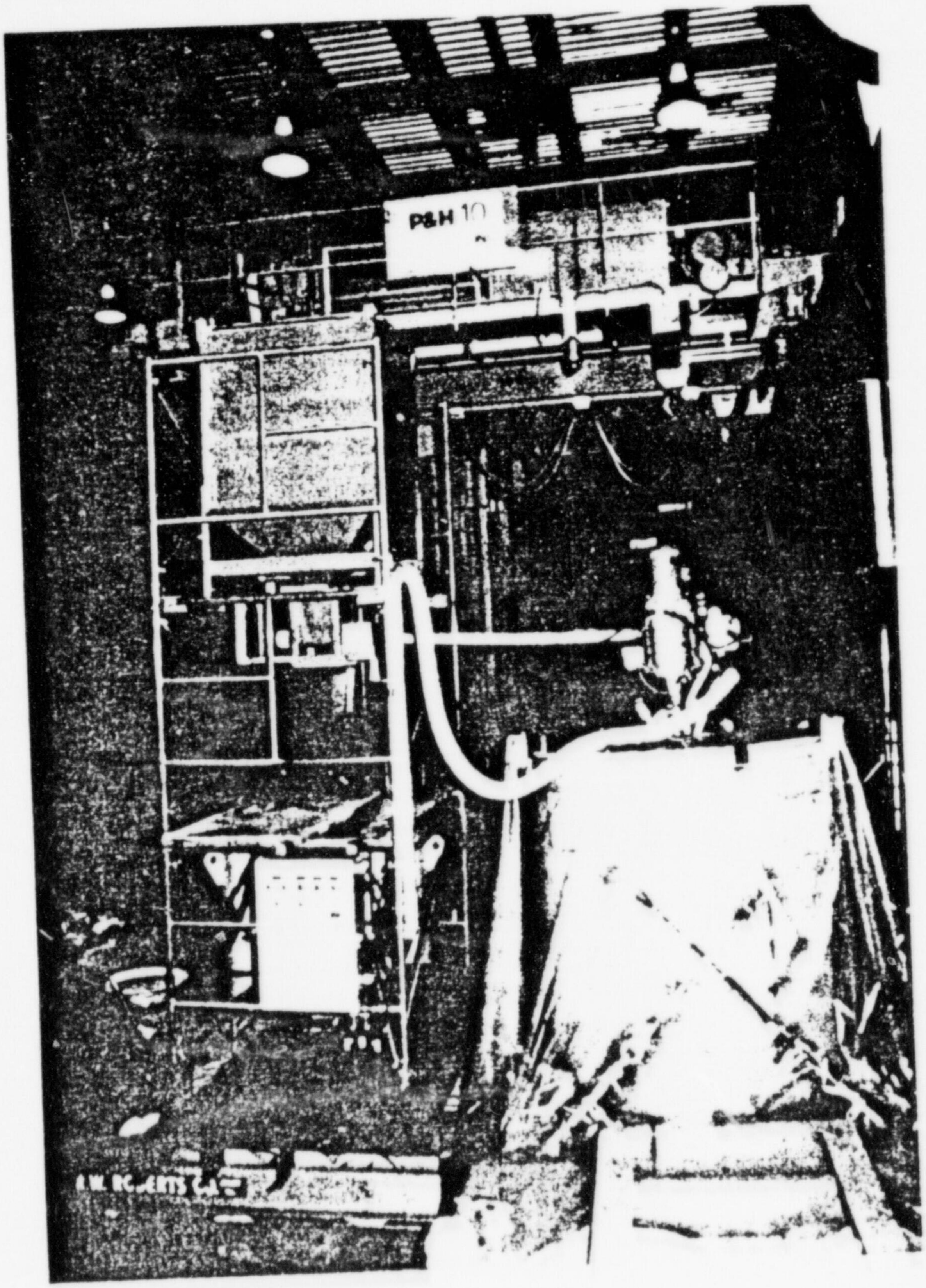


Figure 2-2. Hittman Mobile Incontainer Dewatering and Solidification System (End View)

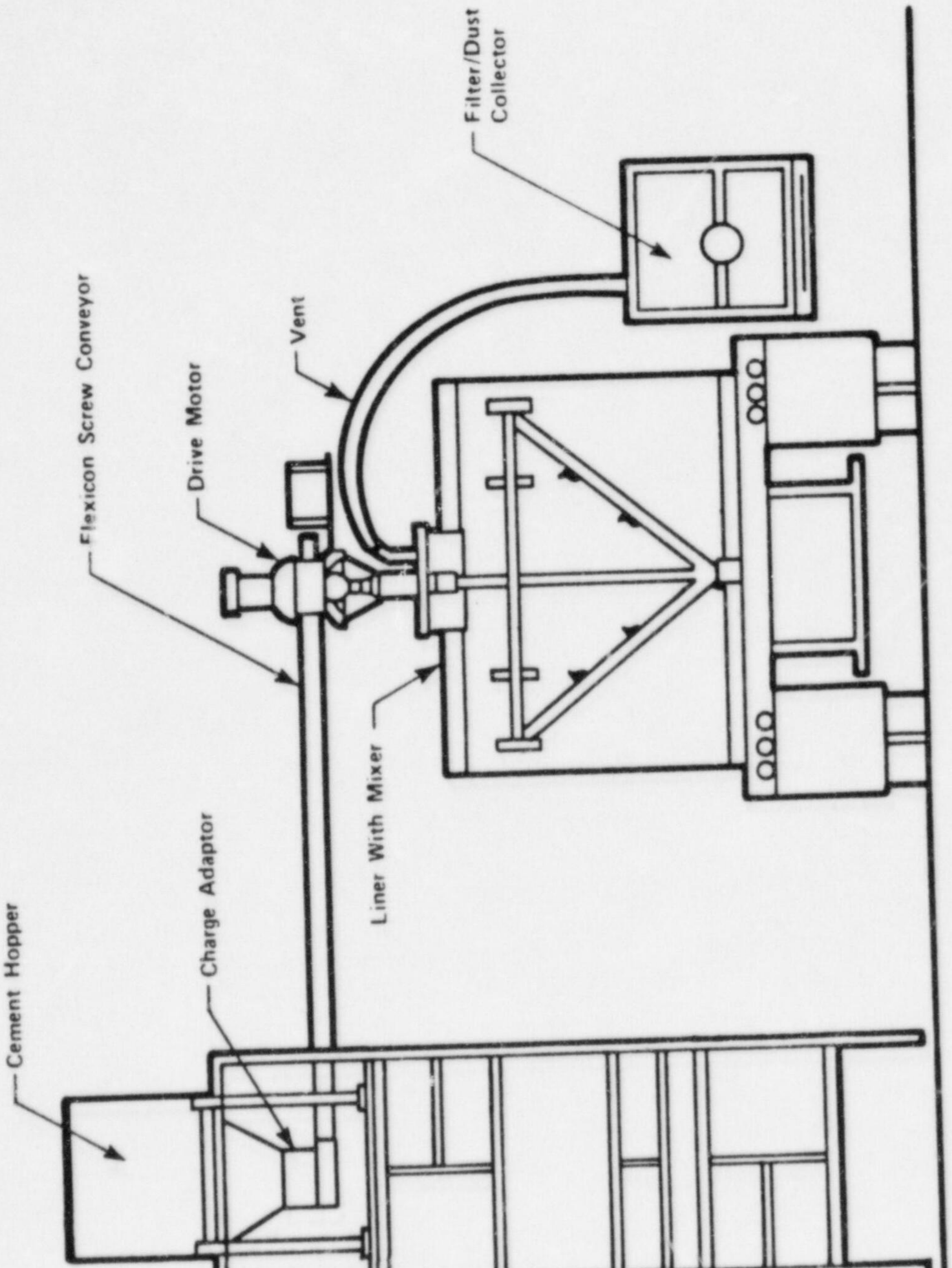


Figure 2.3. Hittman Mobile Incontainer Dewatering and Solidification System (MDSS)

767112 1A

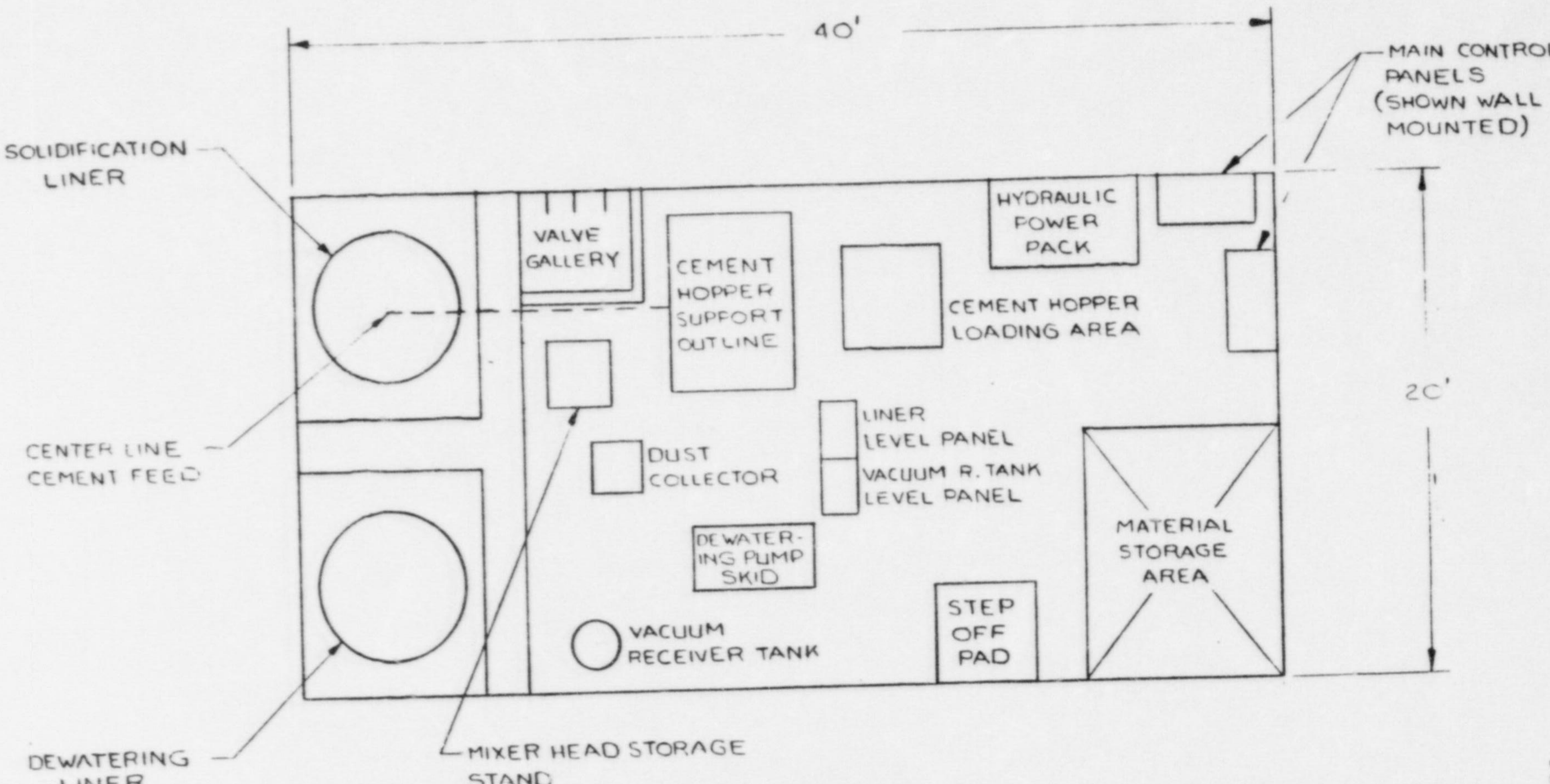
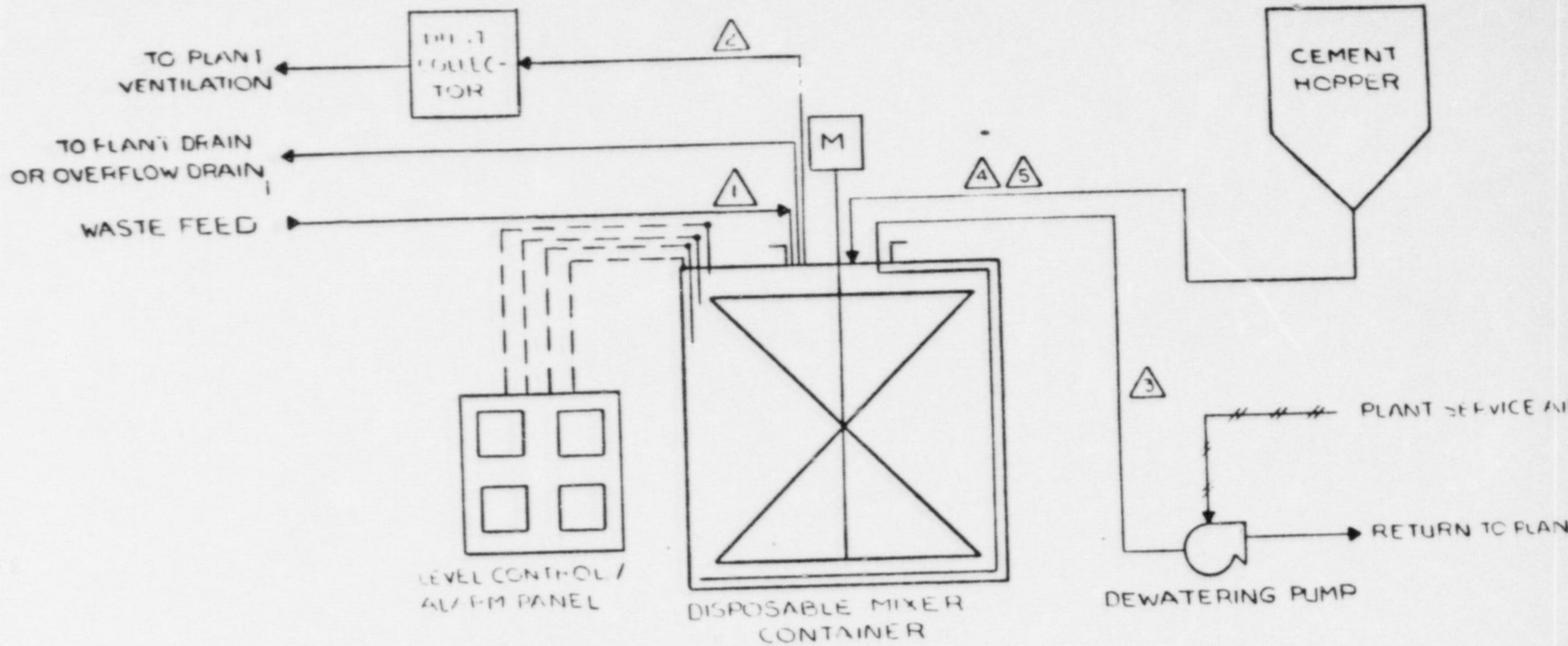


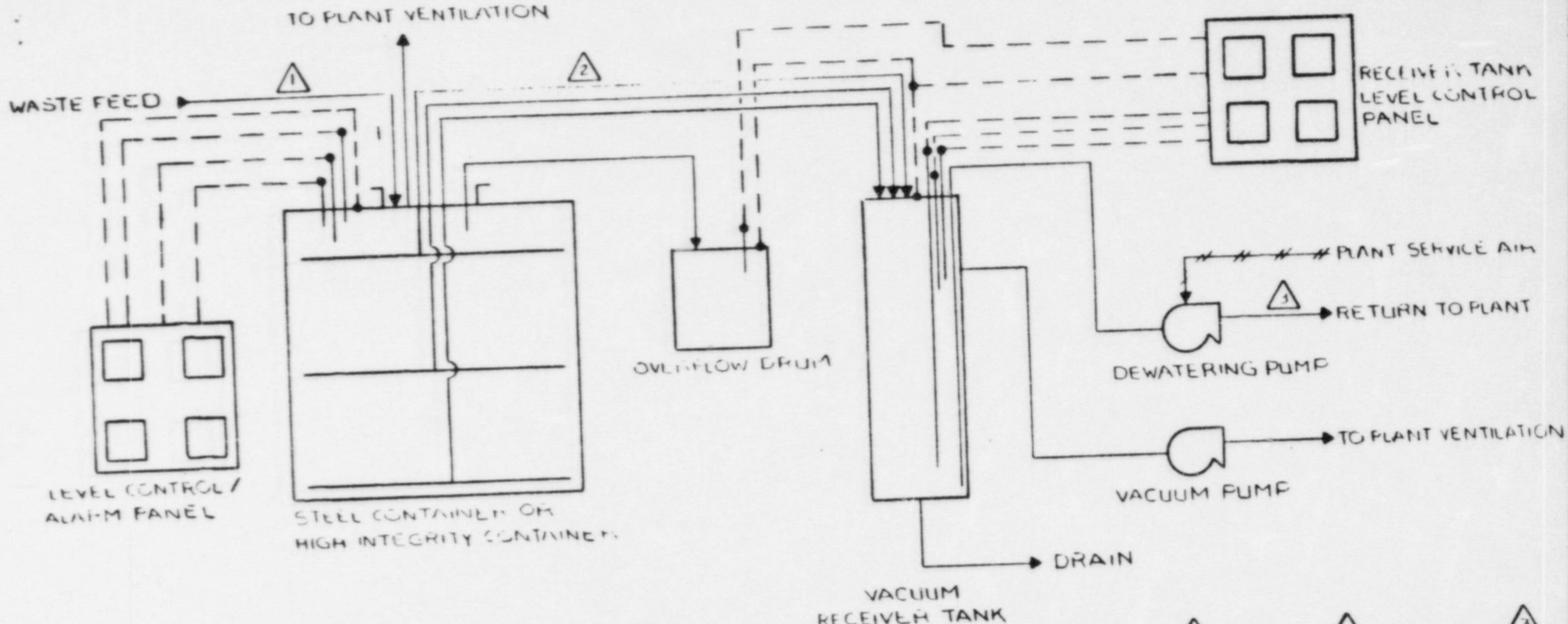
Figure 2-4. Equipment Arrangement For Combined Solidification and Dewatering System



	1 WASTE FEED	2 VENT	3 DEWATERING	4 ADDITIVE FEED	5 CEMENT FEED
FEED RATE	20-50 GPM	50-300 CFM	0-20 GPM	0-50 LB/MIN.	0-100 LB/MIN.
TEMP, °F	40-150	40-150	40-150	AMBIENT	AMBIENT
PRESSURE, PSI	ATM	-3 IN. H_2O	0 TO 15 PSIG.	ATM.	ATM.

BATCH SIZE (GALLONS) 15 WGT % SLURRY BEAD RESIN		1	2	3	4	5
	HN-100	3200		3400	200 LB	5000 LB
	HN-600	1980		1720	104 LB	2600 LB
	HN-200	1680		1460	88 LB	2200 LB

Figure 2-5. Incontainer Solidification Process Flow Diagram



	1 WASTE FEED		2 DEWATERING		3 WATER RETURN
FLOW RATE	0-50 GPM		0-10 GPM		20 GPM
TEMP °F	40-140		40-140		40-140
PRESSURE PSIG	ATM		20-27 IN. HG VAC.		20-27 IN HG VAC.

		1		2		3
BATCH SIZE TYP. POWDERED RESIN 15 WGT % SLURRY (GALLONS)	HN-100	5000		3800		3800
	HN-600	2500		1900		1900
	HN-200	2150		1630		1630

Figure 2-6. Dewatering Process Flow Diagram

3.0 EQUIPMENT DESCRIPTION

The Westinghouse Hittman Mobile Incontainer Dewatering and Solidification System (MDSS) is composed of several subsystems and major components. This section describes those subsystems and components.

3.1 Design Considerations

The Hittman system is constructed of commercial grade materials. Piping, valves, and pumps are fabricated in accordance with industry standards as identified in Section 5.3, Standards. Material selection is based on the expected operating conditions.

Pressure retaining components include the two way solenoid-operated shutoff valve, three-way solenoid-operated feed and recirculation valve, interconnecting piping and hoses, and a dewatering pump. All other equipment containing or transporting radioactive waste operates at or below atmospheric pressure and is, therefore, not classified as pressure retaining. Pressure retaining connections have threaded joints that are easier to disconnect and decontaminate than flanged or welded joints.

Skid-mounted modules are used to the maximum possible extent. Arrangement and design of skid-mounted components consider maintenance requirements and access limitations. Skids, supports, cradles and base plates are carbon steel.

All external surfaces are smoothly contoured and free from dents, gouges, sharp corners or rough edges. Carbon steel surfaces are painted; stainless steel parts are bare.

Hoses, other than hydraulic hoses, are procured or assembled by Hittman according to the specifications of STD-S-01-006, Hose Specification. This includes requirements for procurement, pressure testing, end connection assembly, and labeling. Use of these hoses is then governed by STD-P-01-001, Hose Control Procedure. This procedure describes the actions required to ensure that quality hoses are in use at all Hittman customer sites. The service life, storage, inspection, care and maintenance of these hoses are contained in this procedure.

3.2 Control Panels

The control panels provide a display of the operating condition of the system, using equipment status lights and readout devices. Pushbutton starters are provided for manual and automatic operation.

3.2.1 Power Distribution and Level Control Module

The Power Distribution and Level Control Module provides the electrical power and level controls for the Incontainer Solidification System. The module is a small control panel which has the appropriate exterior connections to provide power to the following subsystems:

(a) Hydraulic mixer power pack (H-1 System only)
(b) Mechanical screw or air cement feed system
(d) Primary level control
(e) Secondary level control
(f) Radwaste feed and divert valve

The waste transfer and dewatering process is controlled from this panel using the process start and stop buttons with the other controllers placed in the automatic position.

The power distribution module is supplied with 480 VAC, 3-phase power from the customer's 60 amp source, usually a welding receptacle. Auxiliary equipment that is plugged into this panel may include (a) the fill/divert valve, (b) primary and secondary level probes, (c) the standard dewatering pump skid, (d) a customer interface, (e) the waste pump, and (f) the cement feed panel. The power connections are made using twist-lock type connectors at the designated receptacles. Proper phase rotation is indicated by a light on the front of the panel.

The level control system is divided into two subsystems: primary and secondary. The primary level control system is basically used to control the desired operating level during resin transfer and dewatering. The secondary level control system is used to indicate, by sounding an alarm, a high level in the liner during transfer, dewatering, and solidification of any waste type. The level control system operates by sensing the conductivity between electrodes.

The level control functions of this module are:

Indication	System Response
(a) High Level Electrode	The two way control valve closes, or the fill/divert valve shifts to the divert position, stopping waste flow to the liner. The Hittman supplied waste feed pump (if used) stops. An alarm sounds on the Level Control Module.
(b) Divert Electrode	When the waste level contacts the divert electrode for a preset time, the two way valve closes or, the fill/divert valve shifts to the divert position, stopping waste flow to the liner.
(c) Fill Electrode	When the waste level drops below the fill electrode, the two way valve opens or, the fill/divert valve returns to the fill position, permitting waste flow to the liner.

3.2.2 Cement Feed System Control Panel

3.2.2.1 Mechanical Screw Transfer System Control Panel

This panel controls the equipment used to deliver the dry cement from the cement hopper to the solidification liner. The components controlled from this panel include:

(a) Electric mixer
(b) Feed conveyor
(c) Vibrator
(d) Dust collector

The cement feed control panel is supplied with 480 VAC, 3-phase power from the Level Control Module through a 30 amp circuit breaker. Power is provided to the various components through receptacles on the sides of the panel. A 1.5 kVA transformer provides 120 VAC for control relays, status indication, and to a 120V receptacle. Proper phase rotation is indicated by a light on the front of the panel.

3.2.2.2 Air Transfer System Control Panel

This panel provides control for the operation of the air transfer system. The panel is supplied with 120 VAC power, usually from the power distribution and level control panel. On the front of the panel, a light indicates proper power supply, two gauges indicate operating and supply air pressures, and other lights indicate each phase of the transfer cycle.

3.2.3 Hydraulic Mixer Panel

The hydraulic mixer control panel provides the controls necessary for both the hydraulic mixer and the hydraulic power supply. The components controlled from this panel include:

(a) Hydraulic pump
(b) Tank heater
(c) Hydraulic mixer control
(d) Oil cooler

The panel receives power from the customer's 480 VAC, 3-phase service through a 100 amp circuit breaker. 120 VAC power is provided for controls and the oil cooler fan through a 1.5 kVA step-down transformer. Proper phase rotation is indicated by a light on the front of the panel.

3.3 Dry Cement Feed Systems

The cement feed systems is an integral part of the Hittman Incontainer Solidification System. Two types of cement feed systems are used: the mechanical screw system and the air transfer system.

3.3.1 Mechanical Screw Transfer System

The mechanical screw transfer system transports dry cement from a prefilled hopper to the discharge adaptor on the fill head and into the solidification liner.

The system consists of a spiral auger rotated by a motor located on the fill head assembly. The auger receives dry cement from the charging adaptor under the prefilled cement hopper. An air-driven vibrator is used to maintain cement flow from the hopper into the charging adaptor. During the cement transfer operation a dust collector is connected to the vent on the fill head. The dust collector contains fabric filters which remove cement dust from the discharged air.

3.3.1.1 Cement Hoppers

The cement hopper, Figure 3-1, is a rectangular carbon steel bin. The hopper is prefilled with cement and installed on a scaffold adjacent to the liner. The hopper has a sloped bottom and is equipped with a slide gate which opens to allow dry cement into the charging adaptor. An air-driven vibrator is attached to the sloped bottom to keep the dry cement fluid. Two sizes of hoppers are available: 65 and 110 cubic feet, depending upon the amount of dry cement required.

3.3.1.2 Charging Adaptor

The charging adaptor is the housing that receives the cement from the hopper. It is coupled to the Flexicon Screw Drive.

3.3.1.3 Flexicon Screw Drive

The cement in the charging adaptor is removed using the screw drive assembly. The assembly is complete with ultra-high molecular weight polyethylene outer tubing, plastic inner tubing, carbon steel discharge weldment, and a carbon steel spiral driven by a 1.5 horsepower motor.

The inner and outer tubing act with the spiral to create a progressive cavity which pushes the cement toward the carbon steel discharge weldment. This unit is capable of transferring approximately 100 pounds of cement per minute.

3.3.2 Cement Air Transfer System

The cement air transfer system is the other type of system used to transport dry cement from a prefilled hopper to the cement feed inlet on the mixer head drive assembly and into the solidification liner.

The system consists of a fluidizer tank mounted on the base of the cement feed stand. The fluidizer tank is fed by a prefilled cement hopper positioned directly above it. Two air driven vibrators, attached to the hopper, are used to aid the gravity feed of cement from the hopper into the fluidizer tank during the charge cycle. The cement is then pneumatically transferred through the transfer lines to the liner. The system then recycles back to the charge cycle and continues until the cement hopper is empty. The controls for operation of the system are located on the cement feed control panel. A dust collector is connected to the mixer head drive assemby and is operated during the cement transfer to remove cement dust from the discharged air.

3.3.2.1 Fluidizer Tank

The fluidizer tank is the vessel which receives the gravity fed cement and pneumatically transfers cement to the liner. The fluidizer tank is mounted on the base of the cement feed stand. This system is capable of transferring cement at approximately 100 pounds per minute.

3.3.2.2 Cement Hopper

The cement hopper used with the air transfer system is very similar to that used with the mechanical screw system. This hopper is prefilled with cement and positioned atop the cement feed stand. The hopper is equipped with an air operated slide gate valve which opens to allow the flow of cement into the fluidizer tank. Two air-driven vibrators are attached to the hopper to ensure the flow of cement into the fluidizer tank.

3.3.2.3 Cement Feed Stand

The cement feed stand acts as the base support for the fluidizer tank and cement hopper. All metal piping for control and transfer lines are positioned on the stand.

3.4 Mixer Head Drive Assembly (Electric)

The Electric Mixer Head Drive Assembly delivers power to the mixing blade assembly in liners used with the Incontainer Solidification System. The electric motor mounts on a flange and engages the internal mixer blade.

The control panel is energized either from the plant's receptacle or a power distribution panel supplied by Hittman.

The electric drive can be considered to have two basic components. These components are described briefly below.

3.4.1 Electric Motor

Either a five or seven and a half horsepower, three phase electric motor and reduction gear are coupled to the mixing blade assembly via a keyed shaft connection. The motor is bolted to the fill head that in turn secures it to the neck of the liner. Power is delivered to the electric motor from the control panel and it can be operated in the forward or reverse direction.

3.4.2 Control Panel

The function of the control panel is to energize and supply the operating control for the electric motor, cement conveyor and dust collector. It receives power from either the Hittman panel or from an appropriate plant receptacle.

3.5 Mixer Head Drive Assembly (Hydraulic)

The Hydraulic Mixer Head Drive Assembly delivers power to rotate the mixing blade assembly in the liners used with the Incontainer Solidification System. A hydraulic motor mounts on a flange and engages the internal mixer blade. It is operated by high-pressure oil which is supplied by the Portable Hydraulic Power Unit (power pack). The hydraulic mixer drive provides a high torque, compact drive unit.

The Hydraulic Mixer Drive assembly can be considered as three basic components. These components are described briefly below.

3.5.1 Portable Hydraulic Power Unit (Power Pack)

The power pack (Figures 3-2 and 3-3), consists of an electric motor, hydraulic pump, oil reservoir and control panel mounted on a common skid. It converts electrical power to hydraulic power by driving the hydraulic pump with an electric motor. The output is directed through an electrically operated 4-way valve and through 50-feet of hydraulic hose to the hydraulic motor on the mixer head drive assembly. The power pack is also equipped with automatic devices that regulate oil temperature within an operating range.

3.5.2 Hoses

The hydraulic pump circulates oil through two 1-inch or 1-1/2 inch hoses that have male and female quick-disconnects. There is also a one-half inch hose with quick-disconnects that drains the case of the hydraulic motor. The quick disconnects allow the hoses to be removed and stored after each use without draining them.

These hoses and quick-disconnects are pressure tested by the vendor after assembly. Prior to each use in the field, they are visually inspected for cracks or abrasions and pressure tested by running the hydraulic power unit while the hoses are disconnected from the hydraulic motor.

3.5.3 Hydraulic Motor

The oil that is circulated by the hydraulic pump is forced through the hydraulic motor producing mechanical energy which rotates the mixing blade. The hydraulic motor is permanently mounted to the mixer head drive weldment (Figure 3-4).

3.6 Dewatering Pump Skid

The Hittman Standard Dewatering Pump Skid is a multi-purpose unit designed to pump liquids, slurries, and which can be used to dewater wet solid wastes. It is intended primarily for use in the processing and packaging of low-level radioactive waste; it can, however be used independently as a general purpose pump.

3.6.1 Skid

The pump skid consists basically of an air-driven double diaphragm pump, surge supressor, valves, pressure and flow instruments. The entire pump assembly and all accessories are mounted on a self-contained, carbon-steel skid. The pump, surge supressor, and most materials are carbon steel for economy of construction. A drip pan with a drain plug is in the bottom of the skid to contain liquids which may be released. For protection of the unit during shipment or storage, a gasketed, bolt-on shipping cover is provided.

Interconnecting hoses are supplied as accessories with the pump skid. Each hose is approximately 50-feet long and is furnished with appropriate couplings.

3.6.2 Controls

An extension cord connects the pump skid to the control unit when automatic or remote-manual control is desired. When connected to the Level Control Module for dewatering waste, the pump starts automatically in response to commands from the Level Control Module. During solidification operations, the pump skid is electrically connected to the Cement Feed System Control Panel and it is operated remotely from that panel. For applications where neither automatic nor remote capability is required, the feature can be bypassed, enabling local control of the pump.

3.6.3 Pump

The pump is a double diaphragm, bottom-ported, air-driven reciprocating pump. The normal operating range for pumping liquids and slurries from 0 to 50 gallons per minute at a discharge pressure of 30 psi total dynamic head. Its operating speed, and therefore its discharge rate, is determined by the supply air pressure and volume. The maximum recommended air supply is 100 psi and 40-cfm. The surge supressor provides a nonpulsating pump discharge pressure. Pump output can be visually observed by means of a direct-view flow meter. The bottom-porting feature of the pump makes it self-draining and easy to decontaminate. The pump's output can be diverted in one of two directions by means of a ball valve. This allows continuous pump operation while changing the direction of flow.

3.6.4 Air Inlet Solenoid Valve

The air inlet solenoid valve is normally closed except when energized. When the valve is energized, air is admitted to the diaphragm, starting the pump. The air is dried and lubricating oil for the pump is supplied through a lubricator/dryer. The air is then passed through a throttle valve which can be modulated to adjust pump speed.

3.7 Solidification Liners and High Integrity Containers

The Hittman Mobile Incontainer Dewatering and Solidification System uses several types of waste containers depending upon the types of waste and intended use. The containers fall into two categories: steel liners and high-integrity containers.

3.7.1 Steel Liners

The Incontainer Dewatering and Solidification System uses specially designed steel liners. These liners are equipped with disposable internal mixer assemblies and fit into one of the various Hittman cylindrical shielded shipping casks. Figure 3-5 shows a cross-section of an HN-200 liner in place within an HN-200 cask. This unit is used to solidify Type B, Large Quantity shipments of resins, with the HN-200 cask accommodating liner contact radiation levels as high as 800 R/hr. Figure 3-6 shows the HN-600 liner and cask system for radiation levels as high as 100 R/hr contact dose rate on the liner surface, and Figure 3-7 shows the incontainer solidification liner designed for the HN-100 cask, for levels as high as 12 R/hr contact dose rate on the liner surface. As shown in Table 3-1, the HN-100, -200, and -600 liners and casks provide a full range of capabilities for dewatering and solidifying low-level radioactive wastes using cement and incontainer mixing. These casks are designed according to DOT 49CFR173 specifications and have been reviewed by the NRC. Certificates of Compliance have been issued for these casks for use as Type A or B shipping containers.

The steel liners do not meet the DOT design criteria as Type A containers but are strong tight containers. Before use each liner is subjected to a 3 psi hydrotest. Therefore all shipments that require a Type A package are shipped in a certified Type A cask even when the contact and 6 foot dose rate do not require shielding.

The maximum product volume of each liner specified in Table 3-1 is less than the liner internal volume, reflecting the space occupied by the internal mixer and underdrain as well as the freeboard required at the top of the liner. Waste volume reflects the packaging efficiency of the cement solidification process. Table 3-1 assumes a packaging efficiency (P.E.) of 80 percent, nominally the highest P.E. found in cement solidification systems for wastes such as bead resin or diatomaceous earth.

3.7.2 High Integrity Containers (HICs)

The RADLOK line of high integrity containers is constructed of high density, cross-linked polyethylene plastic. While cement solidification continues to be an acceptable, cost-effective, liquid free method of waste packaging, RADLOK high integrity containers provide an alternate method of packaging for certain waste types.

The RADLOK-100, shown in Figure 3-8 is sized to fit the cavity of Hittman's HN-100 cask. It can be equipped with an underdrain system for in situ dewatering of wet solid wastes or for use as a disposable demineralizer. The RADLOK-100, without underdrain, can receive dewatered material.

The RADLOK-200 (shown in Figure 3-9), and RADLOK-500 are sized to fit the cavity of Hittman's HN-200 or HN-500 cask, respectively. They can be equipped with an underdrain system for dewatering wet solid waste or for use as a disposable demineralizer. Either RADLOK, without underdrains, can receive dewatered material. All RADLOK containers feature a unique proprietary closure which does not require the use of additional sealants. The RADLOK containers have been tested and have successfully met both South Carolina's requirements for high integrity containers and the Department of Transportation requirements for Type A packaging.

Table 3-2 provides general specifications for RADLOK high integrity containers.

Table 3-1

Hittman Steel Liners

Liner Type	Burial Volume cu.ft)	Maximum Volume (cu.ft.)	
		Product (a)	Waste (b)
HN-100	172	156	125
HN-100LV	172	166	133
HN-600	95	85	68
HN-200	76	70	56

(a) Volume of dewatered or solidified waste.

(b) Actual waste volume for solidification assuming 80% packaging efficiency.

Table 3-2

RADLOK High Integrity Containers

Type	Burial Volume (cu.ft.)	Maximum Volume (cu.ft.) Internal	Maximum Volume (cu.ft.) Waste	Dewatering Method
100-plain	170	125	120	None
100 w/dewatering	170	125	120	Multi-filter Network
100-demin	170	120	100	Sand/Epoxy Bed
200-plain	76	63	61	None
200 w/dewatering	76	63	61	Multi-filter Network
500-plain	142	117	113	None
500 w/dewatering	142	117	110	Multi-filter Network

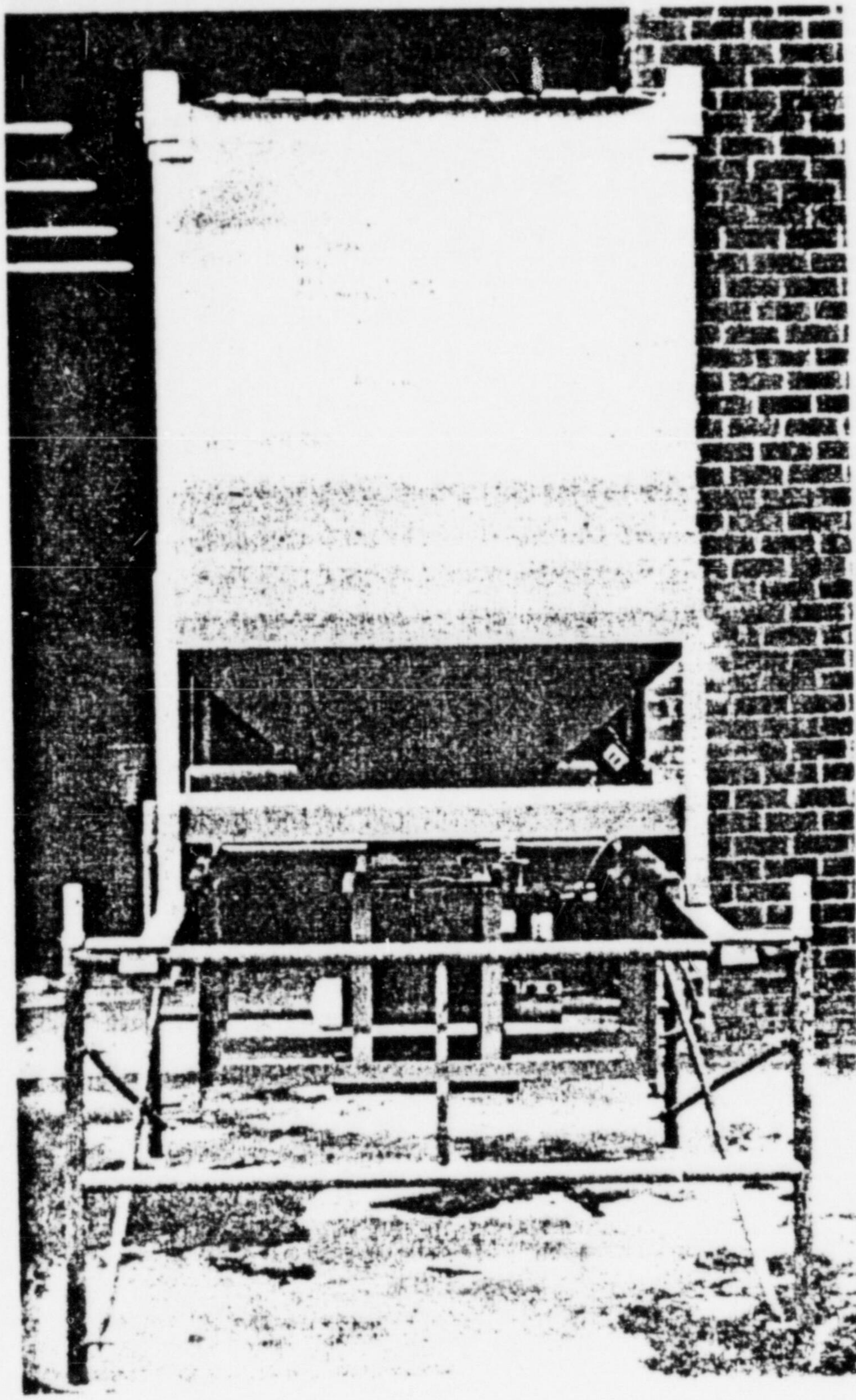


Figure 3-1. Dry Cement Feed Hopper (With Discharge Adaptor)

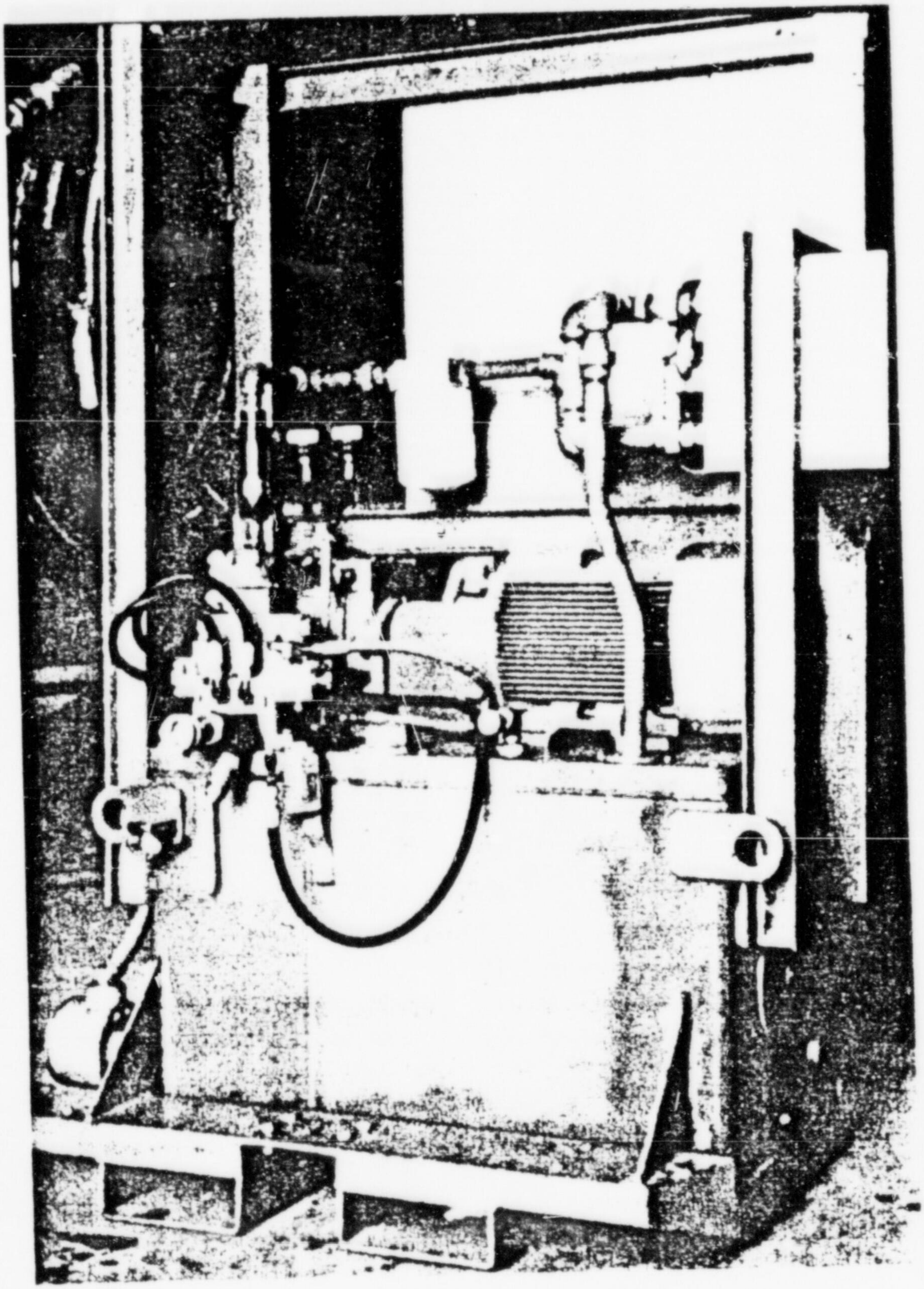


Figure 3-2. Portable Hydraulic Power Unit (Power Pack)

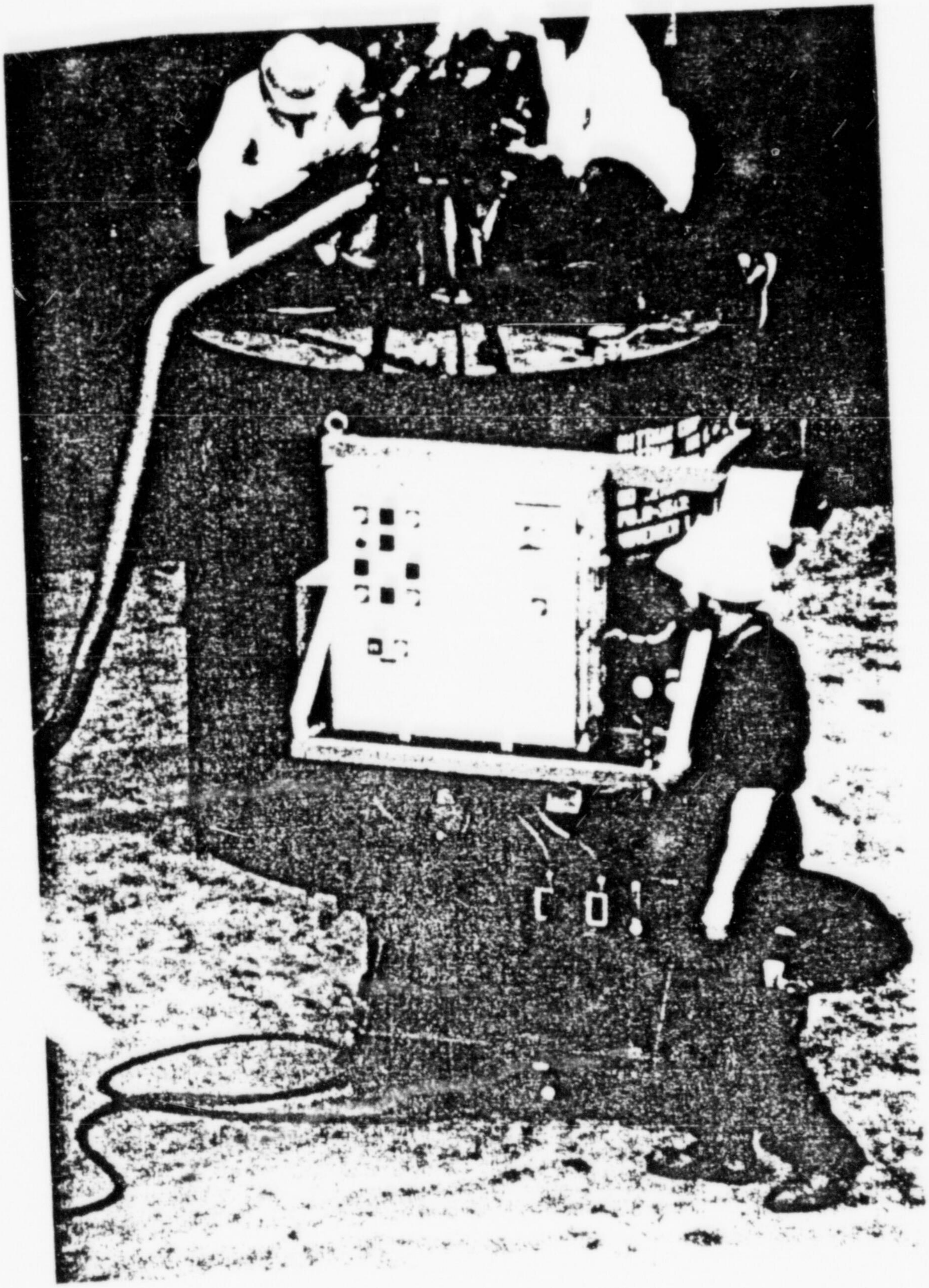


Figure 3-3. Portable Hydraulic Power Unit (Showing Control Panel)

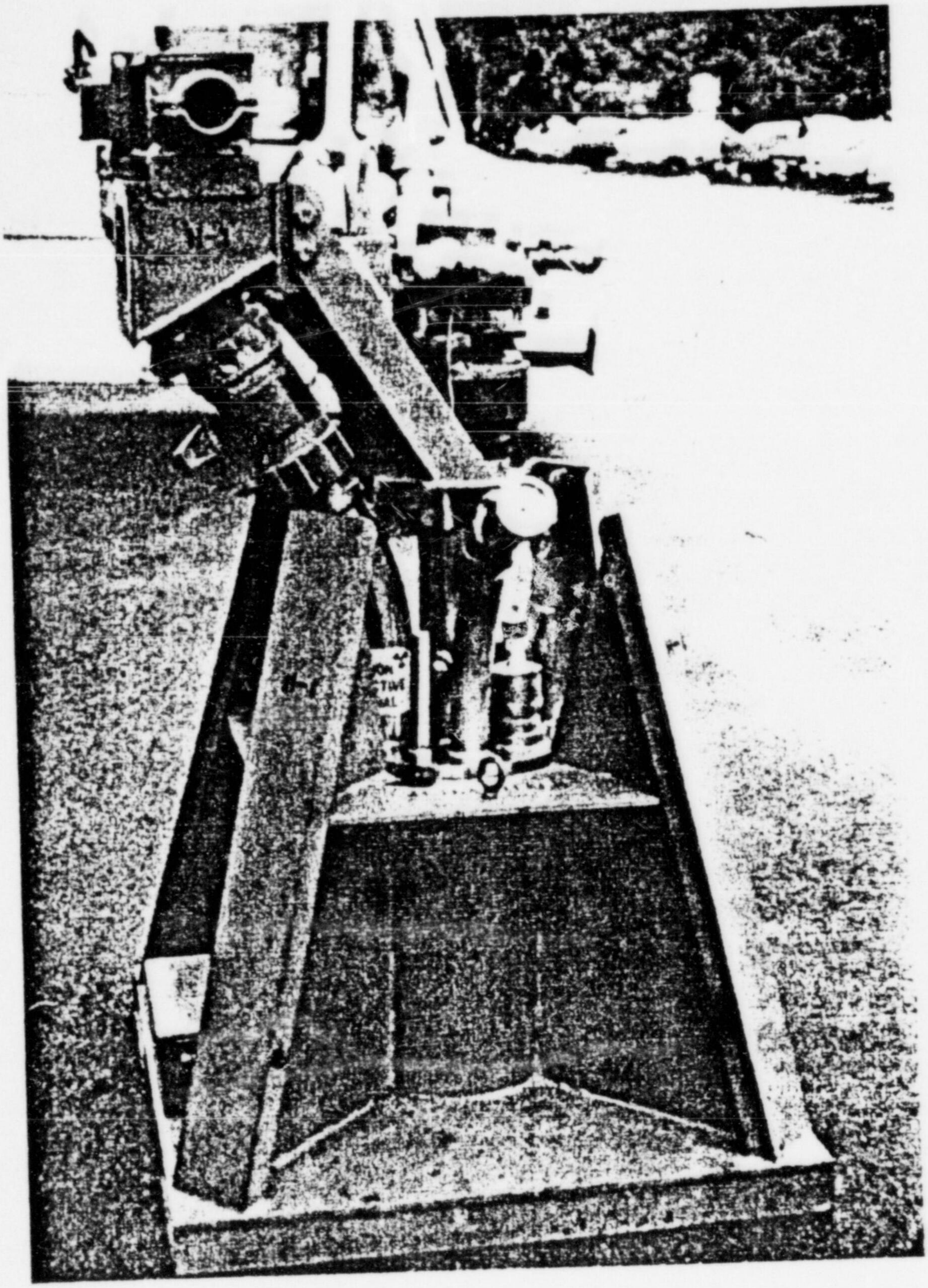


Figure 3-4. Mixer Head Drive Assembly (Hydraulic) on Storage Stand

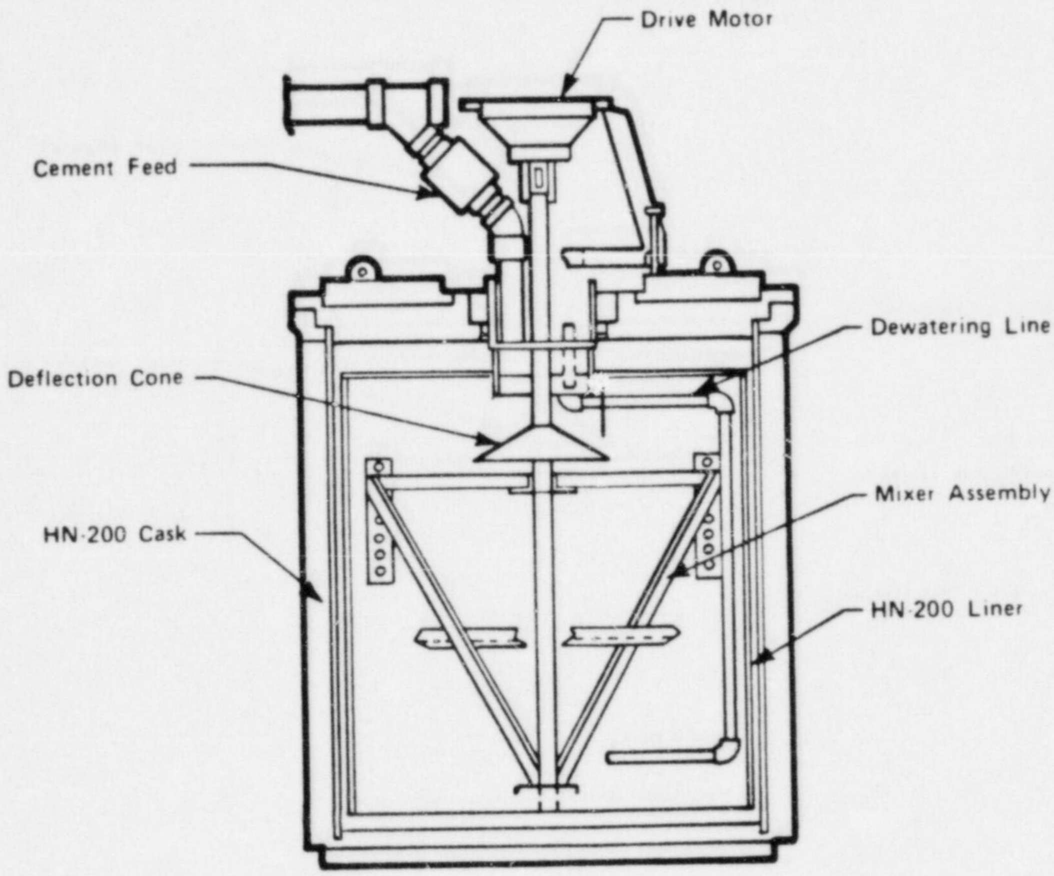


Figure 3-5. HN-200 Liner and Cask

767112-3A

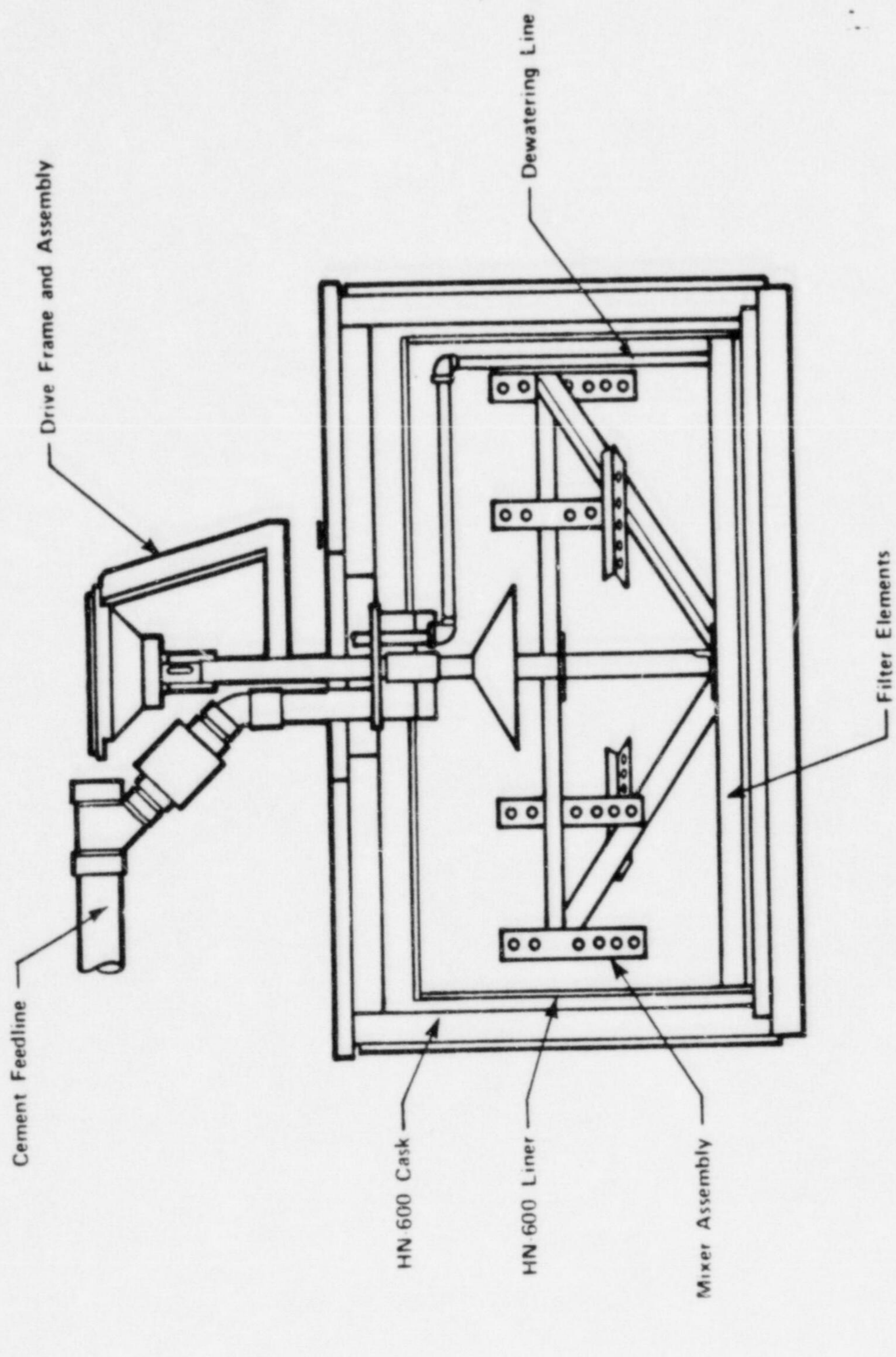


Figure 3-6. HN-600 Liner and Cask

767112 4A

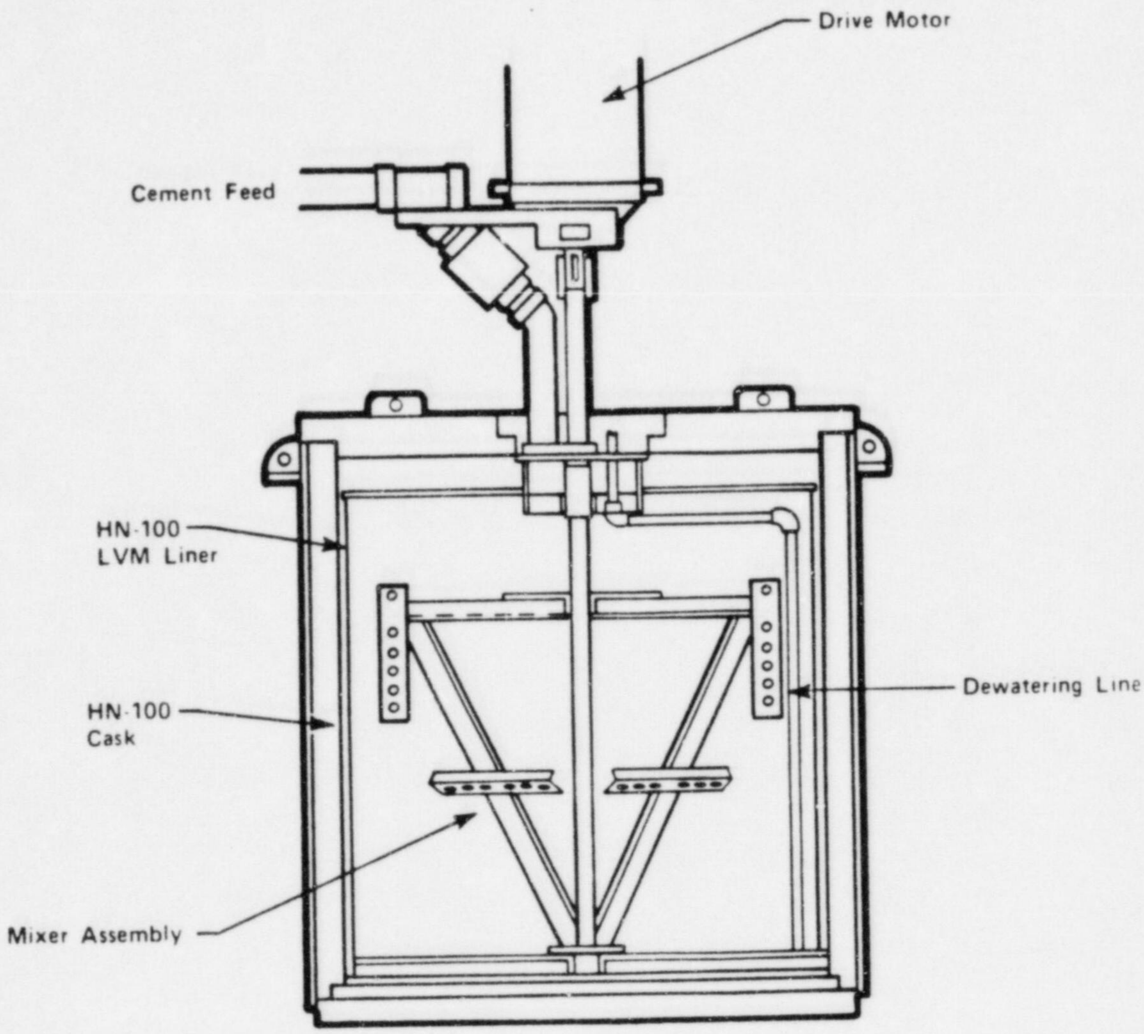


Figure 3-7. HN-100 Large Volume Liner With Cask

767112 5A

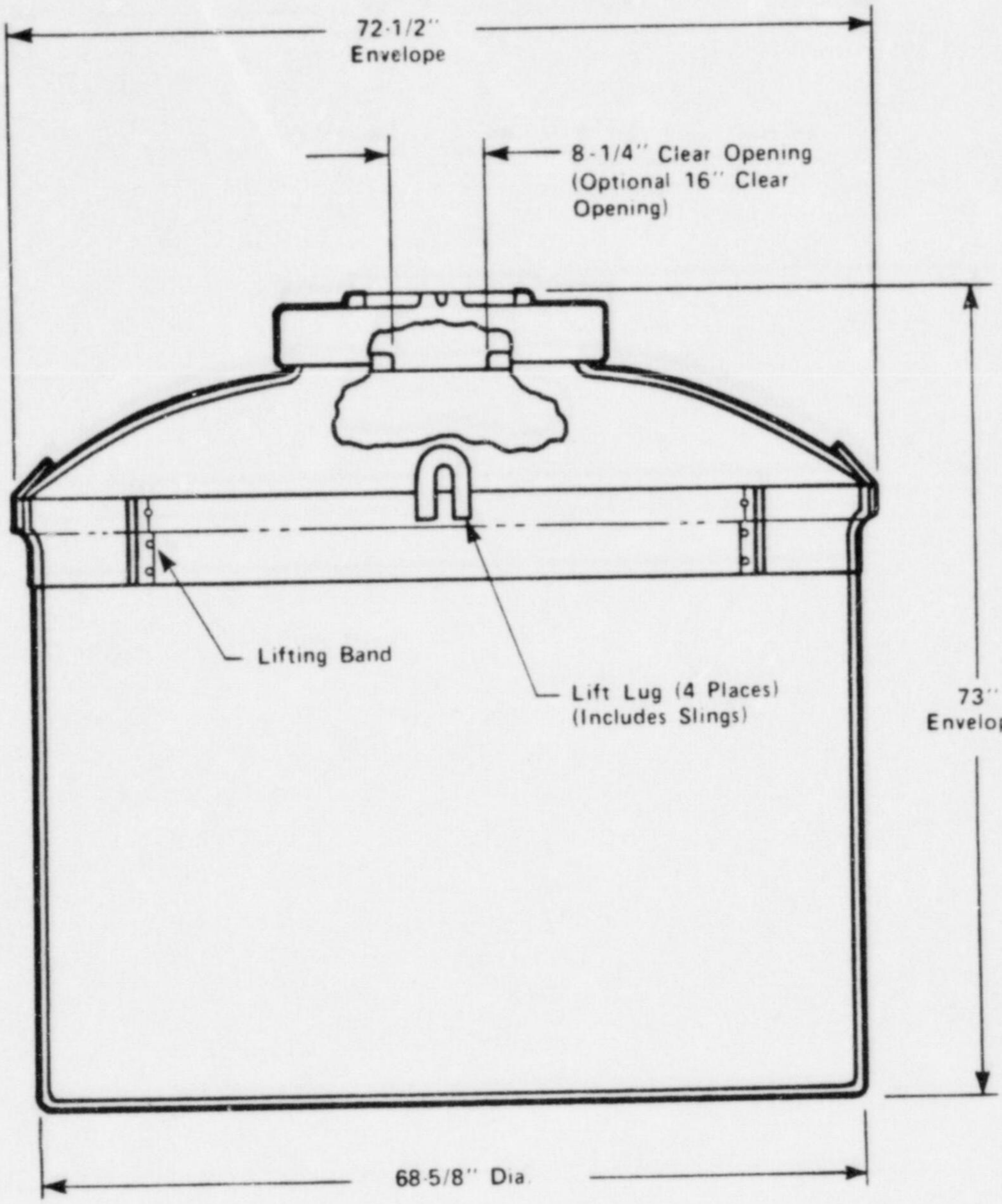


Figure 3-8. Hittman RADLOK-100 High Integrity Container

767112 6A

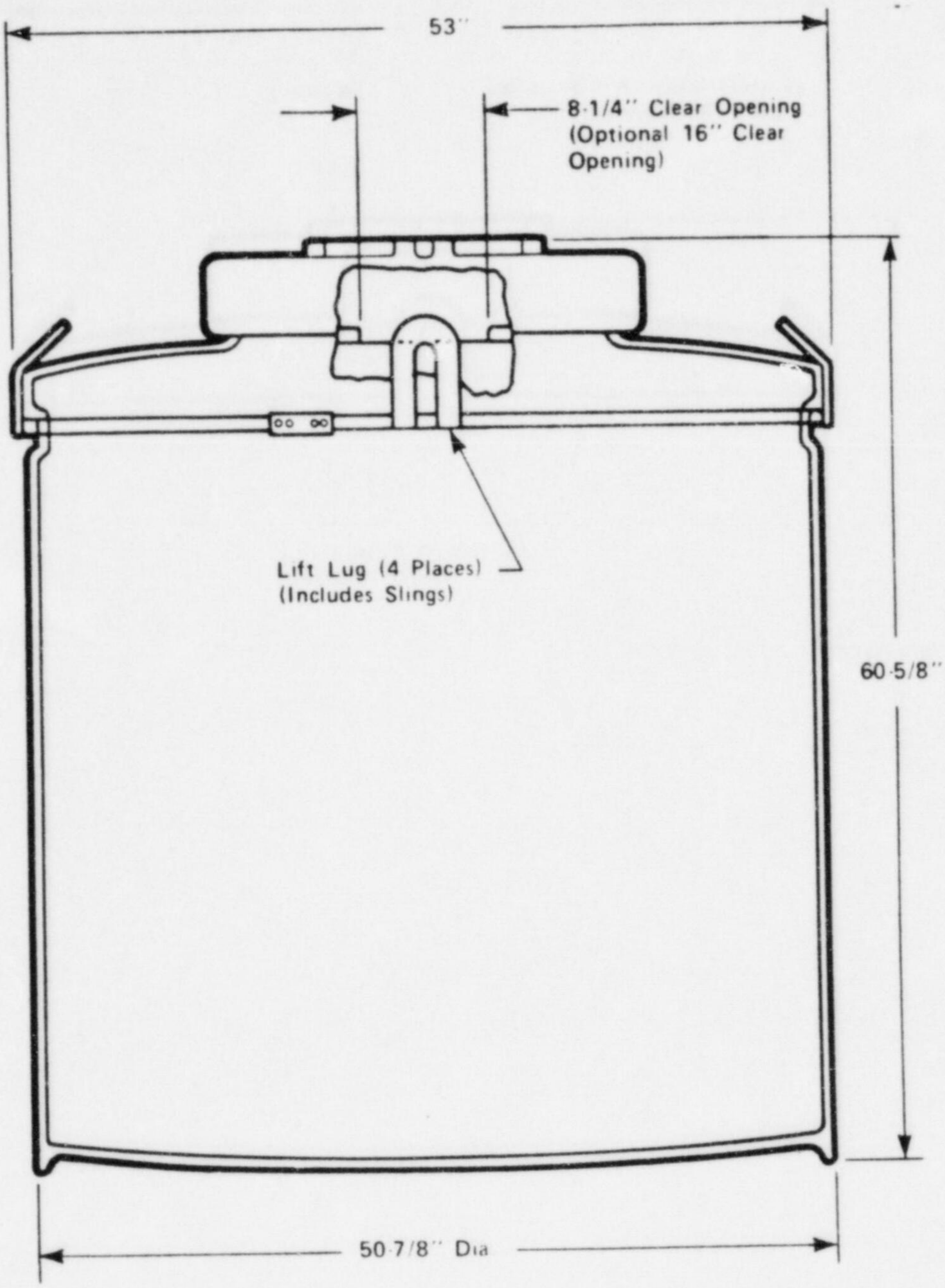


Figure 3-9. Hittman RADLOK-200 High Integrity Container

767112-7A

4.0 SYSTEM OPERATION

This section describes the operation of the Hittman Mobile Incontainer Dewatering and Solidification System (MDSS). Among the operations described are incontainer solidification, dewatering, and the process control program (PCP).

4.1 Incontainer Solidification

The Hittman system uses a batch mixing technique where a concentrated liquid or a wet solid waste is mixed with dry cement and additives inside the liner. The final product is a solid free-standing monolith. The operational steps required for this procedure are described in the following text. (The procedure for solidifying bead ion exchange resin is described. The processes for other wastes are similar except dewatering may or may not be required.)

4.1.1 Preparations

Depending upon the specific activity of the waste, an empty liner containing a mixing blade assembly and appropriate drain system may be placed inside a shielded shipping cask, separate process shield, or in a shielded vault. Proper alignment of the bolt holes in the liner flange assures proper positioning of the liner with respect to the dry cement feed system. The mixer head drive assembly is installed on the liner and bolted to properly seat the gasket. After the unit is installed, it is connected to the appropriate power source.

With the mixer head drive assembly installed, the remaining system connections can be made, including:

(a) Vent and overflow lines. The vent line is directed to a filter/dust collector. The overflow line can be directed to a plant return line, the plant drain system, or to a separate container.

(b) Waste inlet line. The liquid waste or slurry is pumped into the liner via a flexible hose through the waste inlet valve. The valve is electrically connected to the level control panel.

(c) Level indicators/alarms. The level indication probes are connected to the power distribution and level control panel using twist-lock type connectors at the designated plug in.

(d) Dewatering pump skid. The suction of the dewatering pump is connected to the liner dewatering hose which is fed through a packing gland on the fill head. This dewatering hose is connected to the underdrain system located at the bottom of the liner. An electrically-operated air solenoid valve, for starting and stopping the pump, receives its power from the level control panel.

(e) Dry cement feed system. The Flexicon cement conveying system is properly aligned between the liner and the charging adapter. Electrical connections to the screw drive motor, mixer motor and dust collector are made using twist-lock connectors.

4.1.2 Waste Transfer and Dewatering

The waste transfer and dewatering process is operator initiated from the Level Control Panel by process start and stop buttons. All selector switches for the dewatering pump, fill/divert or control valve (if used) and the Hittman waste feed pump (if used) are placed in the "auto" position. To initiate the process, the operator depresses the process "start" button. The following actions occur (refer to Figure 4-1):

(a) Waste enters the liner through the fill/divert or control valve.

(b) Waste continues to enter the liner until the level reaches the "divert" electrode. The dewatering pump automatically starts removing excess water from the liner through the underdrain.[1] After a time delay, the fill/divert valve shifts to the divert position, or the two way valve closes, and waste flow to the liner stops.

(c) The dewatering pump continues to run and the waste level falls below the "fill" electrode. The fill/divert valve shifts to the fill position, or the two way valve opens, and waste flow into the liner resumes. The dewatering pump remains running. (Slurries which cannot be dewatered or for which dewatering is very slow are allowed to settle with the excess water removed by decanting.)[2]

(d) This process continues until the fill/divert valve remains in the divert position, or the control valve remains closed, and the dewatering pump loses suction. The pump must be stopped by the operator as it does not stop automatically.

(e) The transfer and dewatering operation is complete and the process "stop" button is depressed.

(f) It should be noted that not all of the Hittman solidification systems are equipped with an automatic fill/divert or control valve. In those instances, close communications between the Hittman and plant operators and operator diligence ensure safe and proper filling of the solidification container.

4.1.3 Solidification

The procedure described in the following text is the final step in the incontainer solidification process. The procedure contains

(1) The underdrain is a dewatering system covering the bottom of the container. A metal standpipe connected to the underdrain is also connected to a dewatering hose which exits the top of the container through the mixer fill head or fill/dewatering head.

(2) Decanting is accomplished using Hittman procedure STD-P-03-022, Liner Decanting Procedure.

the steps necessary to assure an acceptable solidified product of maximum allowable volume.

The proper amount of water, less ten gallons, is initially added to the dewatered wet wastes (i.e., bead resin, powdered resins, etc). For liquid wastes and decanted wet wastes no additional water is added. The correct quantity of cement and additives is loaded in the cement feed hopper. Liquid additives are added directly to the liner. The amount of each is predetermined and premeasured to assure correct mixing ratios. (See Section 4.3 - Process Control Program.) The pH of the waste is adjusted prior to solidification, if necessary.

(a) The mixer drive unit is started in the forward direction and the cement feed system is operated until all the cement and additives have been added. This transfer requires 30 to 90 minutes depending on the liner size and quantity of cement and additives to be transferred.

(b) The dewatering pump discharge is directed into the top of the liner and the pump is started for three minutes to draw cement-laden liquid into the underdrain system. Immediately after this step, ten gallons of clean water are pumped through the dewatering system to flush any cement from the system.

(c) The mixing process is continued for a minimum of thirty (30) minutes following completion of the cement addition or until the mixer stalls, whichever occurs first.

Numerous full scale test solidifications, including two reported in the Cement Solidification Topical have demonstrated that the 30 minute mix time is adequate to yield homogeneous mixing of the waste, additives and cement in addition to producing a solidified product meeting the stability criteria of 10CFR61 where needed.

(d) At that time, the screw conveyor of the cement feed system or transfer line from the air system is removed from the mixer head drive assembly, and the mixer head drive is removed from the liner and properly stored.

(e) The liner is capped and the shield plug of the cask lid is replaced.

4.2 Dewatering

Dewatering can be accomplished either using steel liners equipped with underdrains, or RADLOK high integrity containers equipped with the Hittman dewatering system, depending upon the type of waste being dewatered.

4.2.1 Dewatering in Steel Liners

This section is applicable for HN-100, -200, or-600 liners with dewatering underdrains. The procedure for steel liners containing the tiered dewatering system is similar to that described in the next section. The liner will be dewatered to meet the burial site criterion of less than one-half percent drainable liquid. The waste is transferred into the liner and initially dewatered as described in Section 4.1.2.

Twenty-four hours after completion of initial dewatering, the liner is again dewatered using the air-operated pump. Pumping continues for several minutes after the initial loss of suction. The procedure is repeated once more forty-eight hours after resin transfer.

A vacuum hose is then connected from the final dewatering connection through a 2-gallon collection bottle to a vacuum pump. (Figure 4-2). When the vacuum pump is started, liquid is drawn from the bottom of the liner into the bottle. The vacuum pump exhaust is vented to an environmentally controlled area or discharged directly into the building ventilation system. Should the liquid level in the bottle get close enough to the top to risk water being drawn into the vacuum pump, the pump is stopped and the collection bottle is emptied using proper radiological procedures. This method continues for about 1-hour after continuous flow is lost.

The procedure is repeated at 24-hour intervals for three days. Upon terminating the dewatering process, the vacuum hose is disconnected and openings are sealed with the fittings provided. The liner is then ready for shipment to the burial site.

4.2.2 Dewatering in High Integrity Containers (HICs)

This procedure is applicable to Hittman RADLOK high-integrity containers equipped with the multi-layered dewatering system. General instructions are provided to dewater the containers to meet the burial site criterion of less than one percent drainable liquid upon receipt at the site. The procedure also assures that there is no drainable liquid at the time of shipment from the plant, as specified in ANSI/ANS 55.1-1979, Solid Radioactive Waste Processing Systems for Light Water Cooled Reactor Plants, (sections of which are applicable to dewatered wastes.) Refer to Figure 4-3 for the relative positions of the level indicators.

Pipe extensions are installed in the top of the HIC and connected to the vacuum receiver tank. The tank is connected to the air-operated diaphragm pump on the dewatering skid. An additional pipe extension is connected between the HIC and an overflow drum containing a high-level alarm. The fill pipe extension is connected to the plants waste feed system.

After setup of the equipment is complete, the waste transfer is initiated. After a predetermined volume of waste has been pumped into the container the bottom underdrain will be covered. At this time a recommended vacuum of 15 inches of Hg is established in the vacuum receiver tank and dewatering commences from the underdrain. When the first underdrain is covered with waste suction is initiated from that layer. This procedure is repeated for each additional layer. When the waste level reaches the low operating level, an alarm will sound on the indicator panel. Shortly thereafter, the high operating alarm will sound. At that point, the waste transfer is diverted or terminated so the RADLOK container is not overfilled. As dewatering continues, the high and low operating level alarms clear and filling the container with waste can resume. When the low operating alarm fails to reset, the container is full and the transfer is completed.

Dewatering continues through all layers until a loss of vacuum occurs. This indicates that the free water at the top of the container has been removed. The top layer is closed off from the system. If there is water at the next lower level, the system vacuum will re-establish itself. When vacuum cannot be maintained, that dewatering layer is closed off from the system. This process continues until a loss of vacuum occurs from the bottom dewatering element. The dewatering process is continued for a predetermined period of time after which the dewatering process is complete.

4.3 Process Control Program

The purpose of the Process Control Program (PCP) is to provide a program which will assure a product which meets the requirements of 10CFR61.56, Waste Characteristics.

The program consists of three major steps:

(a) Procedures for collecting and analyzing samples

(b) Procedures for solidifying and dewatering samples

(c) Criteria for process parameters for acceptance or rejection as solidified waste

4.3.1 Sample Collection and Solidification

As required by the Radiological Effluent Technical Specifications for PWR's and BWR's, the PCP is used to verify the solidification of at least one representative test specimen from at least every tenth batch of each type of wet radioactive waste. (For the purpose of the PCP a batch is defined as the quantity of waste required to fill a disposable liner.) If any test specimen fails to solidify, the batch being processed is suspended until such time as additional test specimens can be obtained, alternative solidification parameters can be determined in accordance with the Process Control Program, and a subsequent test verifies solidification. Solidification of the batch is then resumed using the alternate solidification parameters.

Prior to the test solidification, the waste type and isotopics must be known. This allows for the selection of the proper process and test solidification procedure to ensure that the final product meets the necessary criteria of 10CFR61 (either minimum or stability requirements). If a change occurres in the composition of the waste being processed, waste is resampled to determine if the change is significant enough to require use of a different solidification formulations and a new test solidification.

For high activity wastes where handling of samples could result in personnel radiation exposures, representative non-radioactive samples are tested. These samples should be as close to the actual wastes' chemical properties as possible. Two samples are taken for analysis. If possible, the samples are taken two days before the planned solidification procedure to allow adequate time to complete the required testing and verification of solidification. A Test Solidification Data Sheet (Table 4-1) is maintained for each test sample solidified. Each data sheet contains pertinent information on the test sample verifying solidification of subsequent batches of similar wastes without retesting.

The following criteria define an acceptable solidification process and process parameters.

(a) The sample solidifications are considered acceptable if there is no visible or drainable free water, and

(b) Upon visual inspection it appears that the waste would hold its shape if removed from the mixing vessel, and

(c) It resists penetration. The solidification shall be considered acceptable if a flat surfaced metal probe approximately 1/8 inch in diameter cannot break the surface and penetrate the sample core.

If the waste fails any of the criteria, the process is considered unacceptable and a new set of solidification parameters are established.

After successful completion of the test solidifications, the amounts of additives and solidification agents necessary per cubic foot of total waste are calculated using the Test Solidification Data Sheet.

4.3.2 Dewatering

The purpose of the Process Control Program (PCP) for dewatering is to provide a program which will assure that at the time of arrival at the burial site the disposable steel liner contains less than one-half of one percent free liquid, and that the RADLOK high-integrity container contains less than one percent free liquid. As required by the South Carolina Department of Health and Environmental Controls License No. 097, Amendment No.

30 for the Barnwell Waste Management Facility, the PCP is used to verify adequate dewatering of unsolidified wet radioactive wastes.

When adequate shielding can be supplied at the plant, the dewatering procedure can be accomplished prior to loading the liner onto the truck. When adequate shielding is not available, or for resins transferred to a liner already in the shipping cask, this dewatering procedure must be accomplished after the liner is loaded into the shipping cask.

For specific details of the dewatering procedure, refer to Section 4.2 of this report.

4.4 ALARA

Processing equipment is carefully engineered and tested to ensure efficient field operation. Of primary concern is the protection provided to operating personnel as they work in a highly radioactive environment. The system design and equipment arrangement is in compliance with the ALARA criteria set forth in USNRC Regulatory Guide 8.8.

Based on the design features of the Hittman Mobile Dewatering and solidification System, and shielding installed at the worksite, personnel radiation exposure during normal operations averaged less than 500 millirem per quarter in 1983 and 1984. Adequate shielding should be provided at the plant to maintain operator exposure less than 100 mR/week.

Hittman experience with mobile and portable solidification systems for several years has formed the basis for the portable system design. All equipment is located and installed to comply with ALARA criteria. Components are located to allow for semi-remote operation. The control panel, for example, is normally located at a distance from the solidification operation and operators receive little or no exposure while processing. Worker exposure is minimized by performing solidification in a liner within a process shield or shipping cask.

Exposure during system maintenance has been kept as low as reasonably achievable by separating non-radioactive equipment from that which is used to process waste. Those portions of the system which contact radioactive material have been designed to minimize retention and being portable, can be moved for maintenance to a low radiation area further minimizing operator exposure. The system incorporates quick disconnect features which allow for quick and easy access to the equipment for maintenance. The lengths of hose and piping runs is minimized to the shortest practical length between components. Decontamination of the system to reduce radiation fields is done by flushing with water. Additional manual decontamination of system equipment, using appropriate cleaning solutions, is performed as necessary.

Operators depend upon plant health physics personnel for monitoring exposure, e.g., personnel dosimetry, constant air monitors, radiation surveys, etc.

Area radiation monitors are supplied by the plant as part of the plant ARM system. Depending on the expected activity level of the waste, local monitoring of the transfer lines and container is performed using standard radiation monitoring devices supplied by and monitored by the plant's Health Physics staff.

The Hittman solidification and dewatering systems do not contain their own radiation monitoring equipment. This equipment should be used by, and monitored by, qualified HP personnel. It has been our experience that our utility customers prefer having their people perform this function and in those instances where Hittman supplied monitors have been used they are still supplemented by the plant HP staff. Although most Hittman field technicians are not qualified HPs they are all trained in the use of radiation monitoring equipment which can be supplied by Hittman if necessary.

Table 4.4.1 lists the majory processing steps involved in the processing of a solidification or dewatering operation. For each step the time to perform that step and the nominal radiation level in the area occupied by the operator is also listed. The last column gives the typical exposure that an operator could receive from processing a single container.

TABLE 4.4.1

ESTIMATED OPERATOR EXPOSURE

Solidification

Step	Area Dose Rate, mR/hr	Time, hr	Dose, mR
Container Fill	2 (1)	2	4
Dewatering (2) or Decanting (2)	2 10 (3)	1 0.5	2 5
Waste Pretreatment	2	0.5	1
Cement Feed & Mix	2	1.5	3
Mixer Head Removal	200 (4)	0.1	20
Capping	200	<0.01	2
		TOTAL	35 mR

Dewatering

Step	Area Dose Rate, mR/hr	Time, hr	Dose, mR
Transfer	2	1	2
Dewatering	2	2 hrs over 8 hr period	4
Verification	2	1	2
Capping	50 (5)	0.2	10
		TOTAL	18 mR

FOOTNOTES:

1. 2mR/hr is the maximum dose rate for a general area in which the control systems would be located.
2. Applicable to solid waste (i.e., bead resin, etc.) only, not liquids.
3. 10mR/hr is the maximum dose rate six feet from a shielded container that a technician operating a decant system would be exposed to.
4. 200mR/hr is the maximum dose rate on the surface of the shielding around a container. Operator exposure is momentary during mixer head removal and is generally to extremities (hands) only.
5. 50mR/hr is the nominal dose rate two to three feet from a container shielding where the contact dose on the shielding would be 200mR/hr maximum.

Actual exposures experienced by Hittman field personnel are presented below. Most of these individuals are stationed at both BWR and PWR facilities during a given year. For those individuals stationed at BWR facilities the annual exposure range from 1130 mR to 2340 mR with an annual average of 1790 mR. At PWR's the exposures range from 730 mR to 4980 mR with an annual average of 2610 mR. For all Hittman operators the annual exposures for a two year period were 2430 mR in 1983 and 1522 in 1984.

4.5 System Interface Requirements

The following in-plant capabilities are required to operate the Hittman Mobile Incontainer Dewatering and Solidification System:

1. Minimum floor space requirement is 20 feet by 20 feet, with a preferred area 20 feet by 40 feet. From 25 to 30 feet of overhead clearance is required depending upon the size of the processing liner being used. Weather protection for certain items of equipment is required.

2. Crane availability is required for setup of equipment. If the cask must be removed from the truck prior to solidification and replaced, the rated capacity of the crane must be approximately 60,000 pounds. If solidification can be performed with the cask on the truck, or in a separate process area, a crane rating of approximately 20,000 pounds is required.

3. Plant support is required in unloading, storing, and positioning equipment and materials (e.g., forklift and operator for handling cement hoppers, plant helper and polyethylene sheeting for covering cask and trailer, etc.).

4. Electrical power requirements for the Hittman electrical solidification system are 480 VAC, 60 amps, 3-phase, within 75 feet of the work area. For the hydraulic system, requirements are the same except an additional 100 amp service connection is required.

5. Plant service air, rated at 40 scfm and 90 psig is required.

6. Plant service water or condensate is required as makeup to the system.

7. A 2-inch ID hose is needed from the waste transfer pump to the liner. Hittman provides the fitting for the liner end of the hose.

8. The plant is to provide a connection between the transfer pump and waste storage tanks, with the capability to recycle if possible.

9. The plant will also provide a connection to the plant liquid waste system for returning water from resin dewatering. This could be either a pipe back to a collection tank or a local floor drain.

10. Adequate shielding is necessary to minimize radiation exposure to Hittman operators. Operator exposure should not exceed 100 mR per week.

The physical interface requirements for each of Hittman's systems are shown on Table 4-2.

In addition to these physical requirements, the following support activities are required to simplify the interface between the operator and the utility, due to the nature of a mobile service:

11. Plant health physics support is required, as is waste sampling and chemical analysis in support of Process Control Program verification.

12. Administrative support is necessary, particularly in the areas of badging and training Hittman personnel in plant procedures.

13. Telephone communications between the plant operator and mobile unit will be provided by the utility.

14. The utility will issue a radioactive work permit (RWP) according to its own procedures prior to commencing operations.

15. The utility will provide necessary contamination control measures such as establishing contamination control areas, issuing protective clothing, etc.

4.6 Scope of Supply

For each solidification campaign, Hittman supplies, personnel, services, materials and equipment as follows:

1. Field operations personnel including: a supervisor, who provides technical assistance during waste transfer and dewatering, and supervises and assists in solidification and dewatering operations; and, a technician who, with the supervisor, sets up the solidification and dewatering system and performs the work necessary to solidify or dewater the wastes.

2. Solidification and dewatering liners, as required.

3. Solidification materials, including any additives which may be required.

4. Equipment to be used in the solidification or dewatering process, including: pumps, valves, hoses and associated equipment for use in dewatering operations; and, liner level measurement equipment, including high level alarms, to facilitate the waste transfer process.

5. Process Control Program (PCP) and process and test solidification procedures for solidification or dewatering of the waste type(s) proposed.

(PROPRIETARY)

Table 4-1 Test Solidification Data Sheet (Typical)

(PROPRIETARY)

Table 4-1 Test Solidification Data Sheet (Typical) (continued)

TABLE 4-2

PHYSICAL INTERFACE REQUIREMENTS BETWEEN HITTMAN AND UTILITY SYSTEMS

System Type	Incontainer Solidification Electric Drive	Incontainer Solidification Hydraulic Drive	Dewatering
Interface			
Floor Space			
Minimum	20 ft. by 20 ft.	20 ft. by 20 ft.	10 ft. by 15 ft.
Preferred	20 ft. by 40 ft.	20 ft. by 40 ft.	15 ft. by 20 ft.
Overhead Clearance	25 to 30 ft.	25 to 30 ft.	25 to 30 ft.
Minimum Rated Crane Capacity			
For Liner Lift	20,000 lbs.	20,000 lbs.	20,000 lbs.
For Cask Lift	60,000 lbs.	60,000 lbs.	50,000 lbs.
Service Air	40 SCFM 90 psig	40 SCFM 90 psig	40 SCFM 90 psig
Service Water	Minimal	Minimal	Minimal
Electric Power	480 VAC 60 Amp 3 Phase	480 VAC 60 & 100 Amp 3 Phase	110 VAC
Water Return	Floor Drain or to Collection Tank	Floor Drain or to Collection Tank	Floor Drain or to Collection Tank
Waste Transfer	2 in. Line from Waste Transfer Pump	2 in. Line from Waste Transfer Pump	2 in. Line from Waste Transfer Pump
Adequate Shielding	Necessary shielding to be consistent with ALARA principles.		

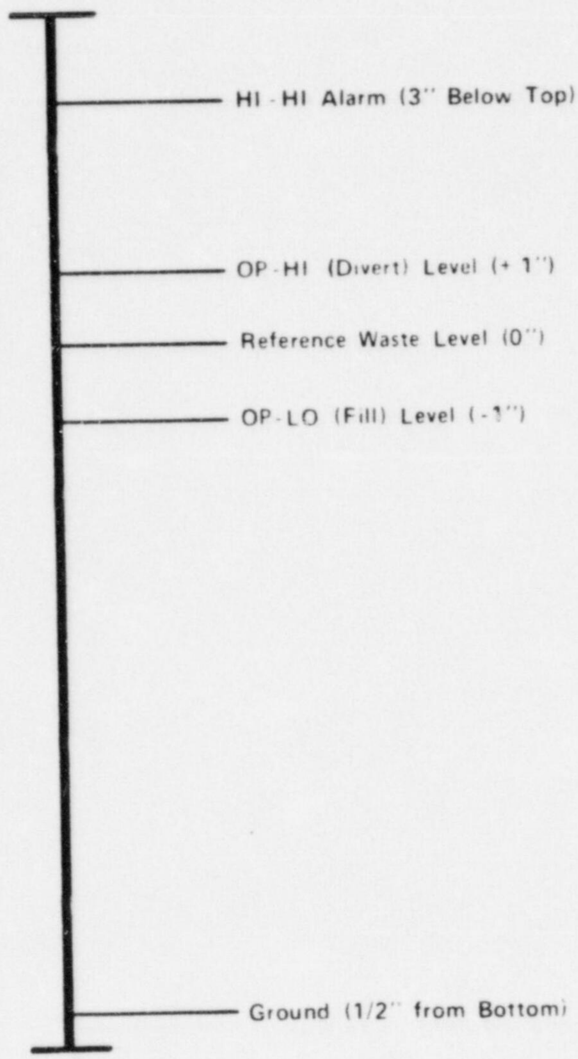


Figure 4-1. Incontainer Solidification Operating Levels

767146-1A

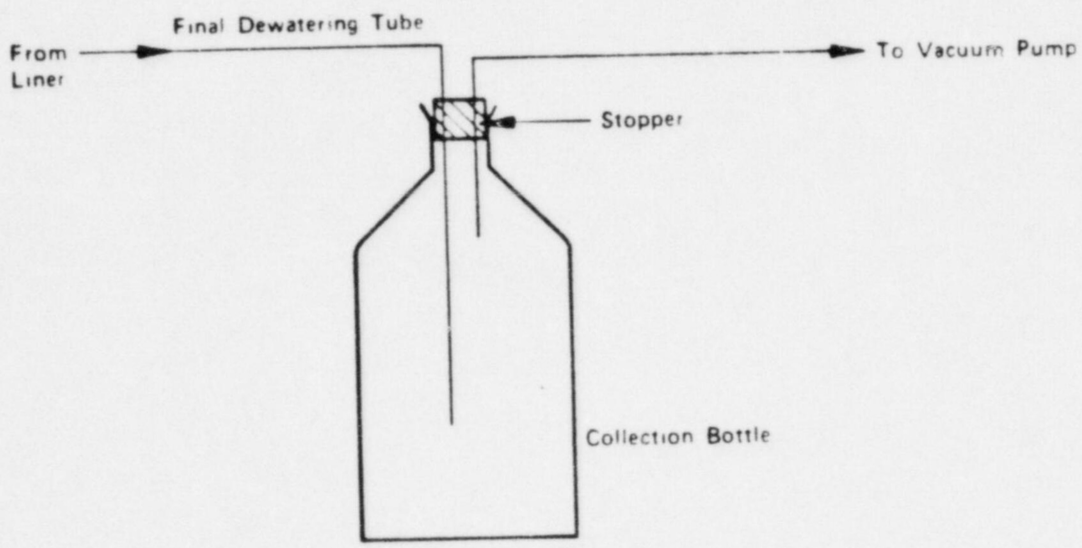


Figure 4-2 Steel Liner Final Dewatering Apparatus

767146 2A

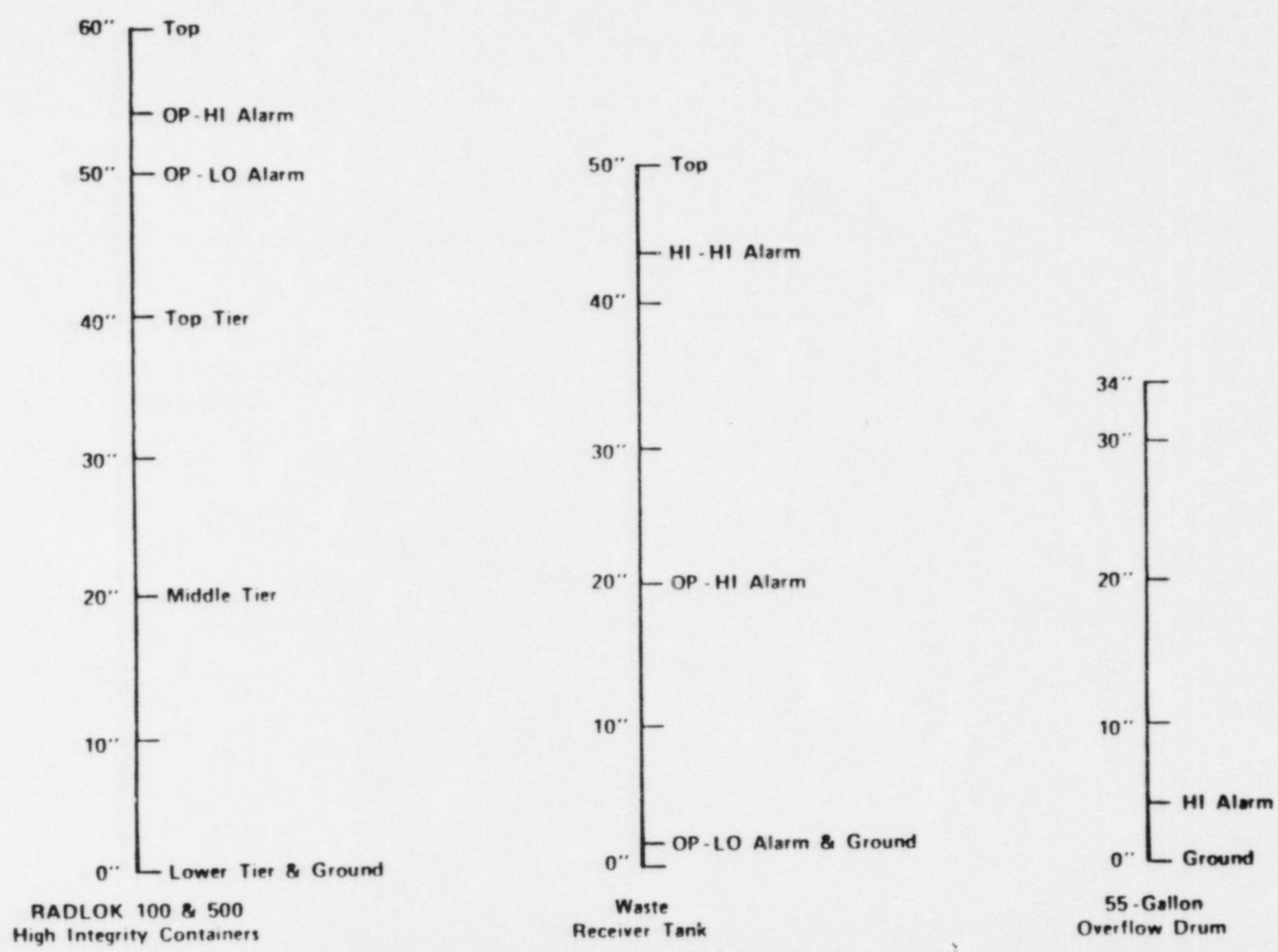


Figure 4-3. RADLOK De[illegible]ing Operating Levels

767146 3A

5.0 CODES, REGULATIONS, AND STANDARDS

Hittman's Mobile Incontainer Dewatering and Solidification System (MDSS) has been designed to comply with applicable portions of the following U.S. codes, regulations and industry standards.

5.1 Codes

(a) 10CFR20, Standards for Protection Against Radiation

(b) 10CFR50, Licensing of Production and Utilization Facilities

(c) 10CFR61, Licensing Requirements for Land Disposal of Radioactive Waste

(d) 10CFR71, Packaging of Radioactive Material for Transport, and Transportation of Radioactive Materials Under Certain Conditions

(e) 10CFR100, Reactor Site Criteria

5.2 Regulatory Guides

(a) USNRC, Regulatory Guide 1.110, Cost-Benefit Analysis for Radwaste Systems for Light Water Cooled Nuclear Power Plants

(b) USNRC, Regulatory Guide 1.143, Design Guidance for Radioactive Waste Management Systems, Structures and Components Installed in Light Water Cooled Nuclear Power Plants

(c) USNRC, Regulatory Guide 8.8, Information Relevant to Maintaining Occupational Radiation Exposures As Low As Reasonably Achievable (Nuclear Power Plants).

(d) USNRC, Regulatory Guide 8.10, Operating Philosophy for Maintaining Radiation Exposures As Low As Is Reasonably Achievable.

(e) USNRC, Standard Review Plan 11.4, Solid Radioactive Waste Management Systems.

5.3 Standards

(a) ANSI/ANS 55.1, Solid Radioactive Waste Processing System for Light Water Cooled Reactor Plants.

(b) ANSI B31.1, Power Plant Piping.

(c) ASME Sec. IX, Boiler and Pressure Vessel Code.

(d) AWS D1.1, Structural Welding Code.

(e) ASTM A 182 (Type 304 S.S.)

(f) National Electrical Manufacturers Association (NEMA) and National Electrical Code (NEC).

(g) National Fire Protection Association (NFPA) Standards.

(h) Factory Mutual Insurers (FM).

(i) Underwriters Laboratories (UL).

6.0 QUALITY ASSURANCE

This section describes the Quality Assurance program and documentation that supports the installation and use of the Hittman MDSS for radwaste handling at a nuclear power plant.

6.1 Responsibilities

The Hittman Manager of Quality Assurance has the responsibility to ensure the activities which affect the quality of services which Hittman is contractually responsible to deliver are performed and verified in a manner commensurate with safety and reliability. He also has authority to stop work or to control further operations where significant conditions adverse to quality are identified and may require immediate corrective action.

6.2 Design Control

Engineering drawings and specifications define all design requirements including designation of appropriate quality standards. These documents are reviewed and approved by cognizant departments including Quality Assurance. All changes to the system are reviewed by the same individuals or organizations who reviewed and approved the original document.

Design drawings, specifications, instructions and procedures directly control all operations and activities including the design, fabrication, inspection, and testing. The Hittman Quality Assurance Manual requires that items, services and valid test/program data be provided and shown to be in compliance with applicable requirements. Those responsibilities are fulfilled by establishing Quality Assurance policies and by reviewing, approving and auditing procedures, drawings, and other documents.

Quality Assurance identifies areas requiring corrective action based on evaluation of problems identified from such sources as nonconformances, failures, malfunctions, and other deviations from requirements. Problems are also identified from audit, inspection, and surveillance activities. Corrective action emphasizes determining and correcting the underlying causes of the problem, especially for any recurring conditions. Quality Assurance has the authority to control work until corrective action has been taken in situations where it judges that existing conditions may compromise the quality of work.

6.3 Procurement

Hittman's procurement is initiated by the cognizant design or services engineers or other cognizant personnel by means of purchase requisitions and other standard Hittman procurement documents.

Quality Assurance exercises controls such as source evaluation and selection, evidence of quality furnished by the supplier, inspection to written instruction, and/or examination of the items upon delivery to assure that the supplier's materials, parts, or services meet the requirements specified in the procurement documents. The application of these controls is based upon the complexity of the item, standardization of the item, and how critical the function of the item is in the system.

6.4 Document Control and Records

Engineering drawings and document lists are controlled by the design organization. Where controlled distribution is required, these lists are updated and distributed as required to preclude the use of superseded documents.

Quality records provide documentary evidence of conformance to contract requirements. Records are required to be legible, identifiable, retrievable, and protected against damage, deterioration or loss. The records systems for the overall contract is defined, implemented, and enforced in accordance with written procedures, instructions, or other documentation.

6.5 Material Control

Requirements for identification and control materials, parts, equipment, and components are established by engineering drawings, specifications, test plans, etc., and, when required, are implemented using written procedures.

During in-house processing of materials, parts, and assemblies, the operation and inspection status is generally maintained by tags or stickers. Items that do not conform to documented requirements are identified and segregated to prevent further use. Quality Assurance oversees implementation of documented procedures and methods to assure positive identification of nonconforming items.

Nonconformance and receiving inspection reports are used for identification, disposition, and for follow-up corrective actions. Quality Assurance reviews and concurs in the disposition of each reported nonconformance.

Handling, storage, and shipping activities are conducted in accordance with documented instructions and procedures. These instructions, enforced by Hittman Quality Assurance, are developed by the responsible engineer, or by the suppliers, to prevent damage or deterioration. Cleanliness of the components are visually verified prior to preparing the components for shipment.

6.6 Inspections and Audits

Quality inspection instructions are prepared for specified material, equipment, components, assemblies, and test plans. When necessary, these instructions list appropriate characteristics requiring inspection, the inspection techniques to be used and, where applicable, acceptance/rejection criteria and recording requirements. These instructions are used in conjunction with drawings and specifications to fulfill the inspection requirements.

When commercial tolerances are not acceptable, measuring and test equipment used in activities affecting quality are controlled and calibrated at suitable intervals to ensure that test and inspection results are accurate. Calibration is traceable to nationally recognized standards and documented according to written procedures that specify conditions such as frequency, methods of calibration, records to be maintained, and identification of equipment.

An audit program is maintained and implemented to verify adequacy of systems and procedures and compliance to these systems and procedures. Quality Assurance conducts audits of subcontractors (as noted in Section 6.3) and performs internal audits of Hittman activities. These audits cover activities and areas which come under the provisions of the Quality Assurance Plan.

6.7 Control of Special Processes

Special processes, such as welding, are performed in accordance with approved procedures, by personnel qualified in accordance with Quality Assurance procedures for the tasks being performed. Documentation of personnel qualifications and approved procedures are maintained and controlled as described in Section 6.4, Document Control and Records.

6.8 Procedures

Procedures governing the testing and operation of the Hittman MDSS are written, revised, and approved by cognizant departments including Quality Assurance. As the need for revisions to existing procedures or for new procedures is identified, a work request is issued describing the desired documentation. When a document revision is made, a change notice is completed listing the revisions performed and reasons why these changes were necessary. The work request, change notice and procedure are then circulated for review by cognizant departments. Upon sign-off by each department, the work request and change notice are filed for future reference and the procedure is issued. The procedures are then subject to control as described in Section 6.4.

A list of the major pre-operational test, operation, and maintenance procedures for the MDSS is shown on Table 6-1.

These procedures are submitted to each plant prior to processing. The Plant's Quality Assurance Department then oversees the performance of the processes according to the procedures.

6.9 Operator Training

Hittman Field Services personnel are trained in such areas as radiation safety, operational safety, engineered systems, Process Control Program and test solidifications, cask maintenance, transportation, and quality assurance. The administration, control, and documentation of this training is described in Hittman Document 0-011, "Training for Field Services Personnel." Following the training program, a written test is administered. A predetermined score on the test is required prior to the person joining a field service crew. A copy of the test is filed with the individual's training records.

TABLE 6-1

MAJOR PRE-OPERATIONAL TEST, OPERATION AND MAINTENANCE PROCEDURES FOR THE HITTMAN MDSS

Document Number	Title
STD-P-03-006	Inspection of Completed HNDC Liners
STD-P-03-019	Field Hydrotest of Hittman Liners
STD-P-03-020	RADLOK Inspection Procedure
STD-P-03-032	RADLOK Visual Examination Procedure
STD-P-05-023	Incontainer Solidification System Operational Inspection Procedure
STD-P-01-001	Hose Control Procedure
HNDC-TS-4000	Shop Test Procedure for Hydrostatic and Leak Tests for Tanks and Skids
HNDC-TS-5000	Process Control Panel Acceptance Testing
HNDC-TS-13000	Cement Feed System Instruction Manual
HNDC-TS-17000	Mixer Head Drive Assembly Mounting Procedure
HNDC-TS-18000	Field Assembly & Operating Procedure for the Power Distribution & Level Control Panel
HNDC-TS-19000	Field Assembly & Operating Procedure for the Electric Mixer Head Drive Assembly
HNDC-TS-25000	Dewatering Pump Skid (Standard) Procedure
STD-P-05-040	Assembly & Operating Procedure for the Hydraulic Drive Solidification System
STD-PCP-03-001	Powdered Resin Transfer & Dewatering Procedure Using Steel Containers
STD-PCP-03-002	Powdered Resin Transfer & Dewatering Procedure Using RADLOK High Integrity Containers
STD-P-03-010	Transfer & Dewatering Bead Resin in RADLOK-100s and -200s with Flexible Underdrain to Less than 1% Liquid
STD-P-04-002	Dewatering Ion Exchange Resin & Activated Charcoal Filter Media to 1/2% Drainable Liquid
STD-P-03-022	Decant Procedure
HNDC-TS-15000	Powdered Resin Transfer & Dewatering System
HNDC-TS-16000	In-Container Solidification Procedure
HNDC-TS-20000	Boric Acid Solidification Procedure

7.0 OPERATIONS EXPERIENCE

Westinghouse Hittman Nuclear Incorporated (Hittman) has been the leader in the development of equipment and technology for the solidification of low-level radioactive waste using cement and additives. The first mobile cement solidification system went into service in 1978 and since that time has consistently produced acceptable products using Portland Type I or Type II cement. In 1983 alone, over 1,000 large liners were solidified or dewatered and shipped for burial. Hittman currently has twelve mobile cement solidification systems in operation and has current contracts with, or has provided radwaste solidification services to the following utilities:

(a) Alabama Power Company
(b) Arkansas Power and Light Company
(c) Baltimore Gas and Electric Company
(d) Carolina Power and Light Company
(e) Consolidated Edison Company
(f) Commonwealth Edison Company
(g) Florida Power and Light Company
(h) Georgia Power Company
(i) Indiana and Michigan Electric Company
(j) Iowa Electric Light and Power Company
(k) Jersey Central Power and Light Company
(l) Long Island Lighting Company
(m) Louisiana Power and Light Company
(n) Maine Yankee Atomic Power Company
(o) Metropolitan Edison Company
(p) New York Power Authority
(q) Niagara Mohawk Power Corporation
(r) Northern States Power Company
(s) Pacific Gas and Electric Company
(t) Pennsylvania Power and Light Company
(u) Public Service Electric and Gas
(v) Rochester Gas & Electric Corporation

(w) Sacramento Municipal Utilities District
(x) Tennessee Valley Authority

In addition to the electric utilities listed above, mobile radwaste solidification services have been provided to the General Electric Company and other divisions within the Westinghouse Electric Corporation.

Hittman has also developed cement solidification systems for permanent installation within nuclear power plants. Seven of these systems have been delivered and are in various stages of installation, startup, or operation. The plants are:

(a) Arizona Public Service Company
Palo Verde, Units 1,2, and 3

(b) Houston Lighting and Power Company
South Texas, Units 1 and 2

(c) Phillipine National Power Corporation
PNPP Unit 1

(d) Korea Electric Company
KO-RI, Unit 2

The systems at these plants were designed and built in accordance with an NRC approved Topical Report submitted by Hittman.

Hittman has undertaken a program to qualify cement solidified waste forms to meet the requirements of 10CFR61 for shallow land burial. This involves the selection of mixing ratios that will immobilize the various wastes generated at nuclear power plants. The selected waste forms are subjected to extensive testing to demonstrate that they are capable of meeting the requirements of the Nuclear Regulatory Commission. The tests include: radiation; biodegradation; leachability; thermal cycling; immersion; and compression. The results have been compiled in a topical report which has been accepted by the NRC.

8.0 ACCIDENT ANALYSES

The Westinghouse-Hittman Mobile Incontainer Dewatering and Solidification System, (MDSS), is designed, fabricated and operated in accordance with applicable sections of appropriate regulations, codes and standards. However, accidents can occur that could potentially result in a release of radioactive materials to the surrounding area. This section analyzes those accidents, the features incorporated into the system to mitigate the consequences of those accidents, and the potential effects of the accidents. Specifically, the accidents which are addressed in this report are:

(a) Fire,
(b) Rupture of a liner,
(c) Rupture of transfer hose,
(d) Rupture of a receiver tank, and
(e) Equipment failure.

8.1 Fire

The only combustible materials in the MDSS are the electrical components in the indicator panels, and the polyethylene RADLOK high integrity containers. The panels are in the immediate vicinity of the operator and any fire in them would be readily detected. In accordance with plant emergency procedures, the Hittman operator would immediately notify station personnel and perform the initial fire-fighting with backup provided by the in-plant fire brigade. Although the high integrity RADLOK containers could burn, such an accident would result in the loss of its contents, which would extinguish the fire. Loss of RADLOK contents is discussed in subsequent text.

8.2 Rupture of a Liner

The possibility of a release of radioactive material exists during waste transfer operations and while the waste is stored in the liner prior to solidification. The two accident cases involving the rupture of a liner would be (1) the complete failure of the largest possible liner in an unshielded configuration containing relatively low-level wastes, and (2) the complete failure of a smaller liner containing high-activity waste confined within a process shield.

8.2.1 Case I - Waste with contact radiation readings of 200 mR/hr on contact and less may be solidified in a liner without a process shield. The largest liner presently in use could contain a maximum of 169 cubic feet of waste. The principal radionuclides present would be Co-58, Co-60, Cs-134, Cs-137, I-131, Sr-90, and Mn-54. Typical concentrations that could be present in the liner are shown in Table 8-1.

If this liner were to rupture along one-quarter of the bottom weld, the waste would be released at a rate given by the following equation:

$$R = A \cdot (2gh)^{1/2}$$

Where: A = the area of the rupture
g = gravitational constant, (32 ft/sec/sec)
h = height of waste in container, (ft)
R = release rate, (cu.ft./sec)

Evaluating the expression for a 73.5-inch diameter liner, 3/16-inch weld area, and a 66-inch height gives a leak rate of 1.42 cu.ft./sec. With a total waste volume of 169 cu/ft, it would take about 2 minutes to empty the liner. Using this release rate, a conservative χ/Q at the site boundary (1.0E-05 sec/m^3), and a partition factor of 1.0E+05 (1.0E+04 for radioiodine), the maximum instantaneous concentration of each nuclide can be calculated. The results of these calculations are provided in Table 8-2. As can be seen from these calculations, failure of the liner will not result in off-site concentrations above those specified in 10CFR20, Appendix B. These calculations are very conservative because:

(a) They are based on a very conservative χ/Q, (which is the average value reported by several sites in their respective FSAR's)

(b) The leak rate is conservatively high.

(c) The partition factor between the liquid and vapor phase is conservatively high

(d) They do not take credit for any installed gaseous waste treatment systems, such as HEPA or charcoal filters.

(e) They do not take credit for dilution in the plant ventilation system prior to release to the atmosphere.

The off-site doses which would result to an individual exposed to the maximum calculated concentrations are summarized in Table 8-3. The maximum exposed individual is an adult breathing air at the concentrations given in Table 8-2 for a two-hour period. The resultant 50-year committed dose would be 0.002 mrem to the lungs and 0.00002 mrem whole body. As can be seen, the accumulated dose over 50-years is insignificant. The dose that an individual would receive from gamma shine is much less than the inhalation dose.

8.2.2 Case II - High-activity waste solidification is generally conducted within a process shield, providing ample containment against spills. Therefore, a liner bottom weld rupture would not result in an instantaneous release since the rate of release of the material from the container is much slower than the potential rate of release analyzed for a transfer hose rupture. That method of release would also result in more activity becoming airborne than with a simple liner rupture. Therefore, the analysis of a transfer hose rupture provides an upper estimate of the environmental impact from a liner rupture.

8.3 Rupture of Transfer Hose

During the processing of high-activity wastes, the worst case accident is the failure of the waste transfer hose between the plant connection and the liner fill head. The total curies released depends upon the specific activity of the waste, the transfer pump flow rate, and the response time of the operator. The flow rate depends upon the capacity of the transfer pump, but 50 gpm is typical. The response time of the operator depends upon how quickly the operator observes the break and takes action to stop the flow. Should the break occur between the plant connection and the Hittman isolation valve, the Hittman operator must instruct the plant operator to stop the transfer pump. Once actuated, the waste isolation valve would close in 3-4 seconds; however, depending on the location in the plant and the communications established with the plant operator, it could take two-to-three minutes to secure the flow. If the break were to occur downstream of the Hittman isolation valve, flow would be terminated more quickly.

Considering the nominal flow rate and typical operator response time, rupture of the transfer hose could result in a spill of about 150 gallons of liquid or wet waste.

Table 8-4 shows the maximum possible radionuclide concentrations that can be transferred to an HN-200 cask for dewatering without exceeding the transportation limits of 200 mR/hr on contact with the cask or 10 mR/hr at two meters distant.

Using a spill rate of 50 gpm (0.111 cu.ft./sec), the concentrations at the site boundary and the maximum 50-year committed dose can be calculated. Since the method of release would result in more of the material becoming airborne, lower partition factors are used. Otherwise, the same assumptions used in Section 8.2.1 apply and the results of the calculations are conservative for the same reasons. The results of these calculations are summarized in Tables 8-5 and 8-6.

All of the nuclides of concern are below the 10CFR20, Appendix B, limits with the exception of I-131, which is a factor of 20 higher. If, however, allowance is taken for dilution with the air inside the building (conservatively 100 to 1) the resultant concentration is well below the limit for uncontrolled release during normal operations. The concentration is still conservative since a lower partition factor has been used, and no allowance has been made for in-plant air treatment, such as charcoal, zeolite, and HEPA filters.

The offsite doses which would result to an individual exposed to the maximum calculated concentrations are summarized in Table 8-6. The maximum exposed individual is an adult breathing air at the concentrations given in Table 8-5 for a two-hour period. The resultant 50-year committed dose would be 0.088 mrem to the whole body. The teenager, however, would receive a higher dose to the lung (0.149 mrem). An infant would receive the highest dose to the thyroid (0.65 mrem). It can be seen that the resultant doses are insignificant, even using very conservative assumptions. The off-site dose due to gamma shine would be even lower than the inhalation dose.

8.4 Rupture of the Vacuum Receiver Tank

During the HIC dewatering process, the Vacuum Receiver Tank is used to collect the water being removed from within the liner. The tank is operated under a vacuum and contains a maximum of 33.3 gallons of water. Assuming a break along one-fourth of the quarter-inch weld between the cylindrical wall and the bottom plate, the maximum release rate can be calculated using the same method as in Section 8.2.1. Evaluating the expression for R, release rate, for a 14-inch diameter tank, 1/4-inch weld area and a 50-inch height yields a leak rate of 0.31 cu.ft./second. With a total waste volume of 33.3 gallons, it would take about 14 seconds to empty the tank.

A second possible release pathway is through a rupture of the discharge pipe. In that case, the cross-sectional area is that of a one-inch schedule 40 pipe, or 0.864 in^2. That is less than the area previously calculated and would result in a slower release rate.

Based upon field experience with this equipment, the water removed from the liner during dewatering operations contains very little carryover of radioactivity (less than 1%). If the carryover was one-percent of the radioactivity in the dewatered waste, however, concentrations in the Vacuum Receiver Tank could approach the levels given in Table 8.7. These values are based on the concentrations listed in Table 8-4 for an HN-200 liner and cask.

Using the release rate previously calculated (0.31 cu.ft./sec), the nuclide concentrations presented in Table 8-7, a conservative X/Q (1.0E-05 sec/m^3), and a partition factor of 1.0E+5 (1.0E+04 for radio iodine), the maximum instantaneous concentration of each nuclide at the site boundary can be calculated. The results of these calculations are presented in Table 8-8. Again it can be seen that the resultant airborne radioactivity is well below 10CFR20, Appendix B, limits. The 50-year committed dose to the maximum exposed individual would be 0.0003 mrem to an adult breathing air contaminated with the maximum calculated concentrations for two hours. This dose is insignificant compared to background radiation. The dose calculations are summarized in Table 8-9.

8.5 Equipment Malfunction or Failure

The Hittman MDSS is designed to automatically notify the operator of an abnormal operating condition, or to revert to a fail-safe condition as the result of any equipment failure. Possible failures which may occur, as well as their consequences, are presented in the following text.

8.5.1 Dewatering Pump

Failure of the dewatering pump would result in the inability to remove water from the liner. The water level in the liner would rise until it reached the high level alarm, at which time the alarm would sound. The waste inlet value would close automatically or the operator would terminate the waste transfer manually, depending upon site specifications.

Failure of the dewatering pump could also result in water being drawn into the suction of the vacuum pump. This would result in a loss of vacuum in the vacuum receiver tank allowing the water level to rise in the liner causing the high level alarm to sound. The waste transfer would terminate either automatically or manually, as before.

8.5.2 Waste Isolation Valve

The waste isolation valve is opened with air pressure and closed by a spring. This valve closes in response to an electrical signal or loss of control air pressure. The waste isolation valve is provided with a manual override to enable opening the valve if it should fail closed. Manual override allows completion of the flush cycle. If the valve does not shut after the correct waste volume has been transferred, the waste flow can be stopped by the station operator. Waste in the line between the transfer pump and the container would be flushed to the plant's contaminated drain system.

8.5.3 Loss of Air

Any loss of control air will shut down the entire system. If the Hittman three-way isolation valve is being used, it will fail in the "divert" or shut position, thereby either returning the waste being transferred back to the plant or terminating the transfer. A loss of air would also result in a loss of the dewatering pump, with consequences as described in Section 8.5.1.

8.5.4 Loss of Electrical Power

A general loss of electrical power would be evidenced on the system level control panel by failure of the power "ON" light. The waste transfer operation would be terminated automatically until power is restored. Loss of power to any of the control panels would result in a loss of instrumentation, as described in Section 8.5.5. If the system three-way valve is being used, it will fail in the "divert" or shut position, thereby either returning the waste being transferred back to the plant or terminating the transfer. If the three-way valve is not being used, the waste inlet valve would fail in the shut position. In the event of a total loss of power, the in-plant waste transfer pump would also stop, terminating the transfer.

8.5.5 Container Level Instrumentation

Should any or all of the container level instruments fail to function, the possibility exists that the liner being filled would overflow. The overflow is directed to the overflow drum with its own independent alarm system or into the plant drain system. Upon reaching the high-level alarm setpoint in the container, the alarm will sound and the waste inlet valve will close, stopping the waste transfer.

8.5.6 Mixer Head Drive Assembly Failure

Failure of the mixer head drive assembly is not considered a problem, except after cement addition has started. The hydraulic motor and drive system has proven reliable in the past and a failure of this equipment is considered improbable. If the mixer fails early in the cement addition stage, repair of the failed part is all that is required. If the failure occurs after a significant amount of cement has been added, the lower portion of the cement/waste matrix will solidify while the less dense waste would remain liquid, requiring transfer to another liner.

8.6 Conclusions

Use of the Hittman Mobile Incontainer Dewatering and Solidification System does not result in increased off-site doses during normal operations. The concentrations of radionuclides in the air as a result of the worst case accidents analyzed are, even under the conservative assumptions used, only a small fraction of the maximum permissible concentrations allowed for normal operations as specified in 10CFR20, Appendix B. The resultant annual dose commitment to the maximum exposed individual is much less than that allowed by 10CFR100.11 (for upset conditions) and 10CFR50, Appendix I, (for normal operations). The derived airborne concentrations are less than those specified in 10CFR20, Appendix B, for uncontrolled release during normal operations. Therefore, the use of this equipment does not constitute a threat to the health and safety of the general public.

Table 8-1

Maximum Radionuclide Concentration for Unsolidified Waste in a Steel Liner (no cask)

	Maximum Concentration [a] (μCi/ml)	Percent [b] Abundance	Maximum Concentration in Liner (μCi/ml)
Co-58	0.20	25	5.0E-02
Co-60	0.05	30	1.5E-02
Cs-134	0.08	13	1.0E-02
Cs-137	0.18	22	3.9E-02
I-131	0.33	2	6.6E-03
Mn-54	0.20	6	1.2E-02
Sr-90	1.6E-03 [c]	2	3.2E-05

(a) Based on 200 mR/hr contact. (Data from Hittman Report No. I-834, Jan., 1983, "Shielding Capabilities of Hittman Nuclear and Development Corporation Radwaste Shipping Casks").

(b) From EPRI NP-3370, Identification of Radwaste Sources and Reduction Techniques, 12, January 1984.

(c) From IF/NESP-027; $\frac{\text{SR-90}}{\text{Cs-137}}$ = 8.7E-03. This ratio is used to provide a concentration for Sr-90 (which was not reported in the EPRI document related to the value for Cs-137, which was reported.

Table 8-2

Concentrations of Nuclides at Site Boundary
Rupture of Unshielded Liner

Nuclide	Maximum Liner Concentration µCi/ml(a)	µCi/ft^3	Liner Release Rate µCi/Sec(b)	Partition Factor(c)	Airborne Release Rate µCi/Sec(d)	Airborne Concentration at Boundary µCi/ml(e)	Max. Allowable µCi/ml(f)
Co-58	5.0E-02	1.41E+03	1.99E+03	10^5	1.99E-02	2.0E-13	2.0E-09
Co-60	1.5E-02	4.24E+02	5.95E+02	10^5	5.95E-03	6.0E-14	3.0E-10
Cs-134	1.0E-02	2.82E+02	3.96E+02	10^5	3.96E-03	4.0E-14	4.0E-10
Cs-137	3.9E-02	1.10E+03	1.54E+03	10^5	1.54E-02	1.5E-13	5.0E-10
I-131	6.6E-03	1.86E+02	2.62E+02	10^4	2.62E-02	2.6E-13	1.0E-10
Mn-54	1.2E-02	3.39E+02	4.76E+02	10^5	4.76E-03	4.8E-14	1.0E-09
Sr-90	3.2E-05	9.04E-01	1.27E+00	10^5	1.27E-05	1.3E-16	3.0E-11

(a)From Table 8-1
(b)Release rate = 1.4 cu.ft./sec. from the liner
(c)WASH-1258, V2, USAEC, 1973
(d)From the spill
(e)χ/Q = 1.0E-05 sec/m^3 = 1.0E-11 sec/ml
(f)10CFR20, Appendix B, for continuous release during normal operations

Table 8-3

50-year Dose Commitment at Site Boundary from Rupture of an Unshielded Liner

Individual	Dose (mrem)						
	Bone	Liver	Body	Thyroid	Kidney	Lung	GI
Adult(a)	2.1E-05	3.2E-05	2.3E-05	7.1E-04	1.4E-05	1.6E-03	1.0E-05
Teen(b)	3.3E-05	4.3E-05	1.8E-05	8.7E-04	1.4E-05	6.1E-04	3.7E-04
Child(c)	4.3E-05	4.1E-05	8.9E-06	9.7E-04	1.7E-05	1.7E-04	3.5E-06
Infant(d)	2.6E-05	3.1E-05	3.8E-06	8.9E-04	1.1E-05	1.1E-04	1.2E-06

(a) USNRC Reg. Guide 1.109, Table E-7
(b) Op.cit., Table E-8
(c) Op.cit., Table E-9
(d) Op.cit., Table E10

Table 8-4

Maximum Radionuclide Concentrations for Unsolidified Waste in the HN-200 Liner with Cask

Nuclide	Maximum Concentration µCi/ml (a)	Percent Abundance (b)	Maximum Concentration in Liner µCi/ml
Co-58	22	25	5.5
Co-60	48	30	14.4
Mn-54	260	6	15.6
I-131	3000	2	60
Cs-134	500	13	65
Cs-137	600	22	132
SR-90/Y-90	5.2 (c)	2	1.2

(a) based on 200 mR/hr contact radiation level (data from Hittman Report No. I-834, Jan., 1983, "Shielding Capabilitie of Hittman Nuclear and Development Corporation Radwaste Shipping Casks")

(b) EPRI NP-3370

(c) from IF/NESP-027; $\frac{SR\text{-}90}{Cs\text{-}137}$= 8.7E-03. This ratio is used to provide a concentration for Sr-90 (which was not reported in the EPRI document related to the value for Cs-137, which was reported)

Table 8-5

Concentrations of Radionuclides at Site Boundary
Rupture of Waste Transfer Hose

Nuclide	Maximum Liner Concentration µCi/ml(a)	µCi/ft^3	Hose Release Rate µCi/Sec(b)	Partition Factor(c)	Airborne Release Rate µCi/Sec(d)	Airborne Concentration at Boundary µCi/ml(e)	Max. Allowable µCi/ml(f)
Co-58	5.50E+00	1.55E+05	1.72E+04	10^4	1.72E+00	1.7E-11	2.0E-09
Co-60	1.44E+00	4.07E+05	4.52E+04	10^4	4.52E+00	4.5E-11	3.0E-10
Mn-54	1.56E+01	4.41E+05	4.90E+04	10^4	4.90E+00	4.9E-11	1.0E-09
Sr/Y-90	1.20E+00	3.39E+04	3.76E+03	10^4	3.76E-01	3.8E-12	3.0E-11
I-131	6.00E+01	1.69E+06	1.88E+05	10^3	1.88E+02	1.9E-09	1.0E-10
Cs-134	6.50E+01	1.84E+06	2.04E+05	10^4	2.04E+01	2.0E-10	4.0E-10
Cs-137	1.32E+02	3.73E+06	4.14E+05	10^4	4.14E+01	4.1E-10	5.0E-10

(a)From Table 8-4
(b)Spill rate = 0.111 cu.ft./sec. from the hose
(c)WASH-1258, V2, USAEC, 1973
(d)From the spill
(e)χ/Q = 1.0E-05 sec/m^3 = 1.0E-11 sec/ml
(f)10CFR20, App. B, for continuous release during normal operations

Table 8-6

50-year Dose Commitment from Rupture of a Transfer Hose

Individual	Dose (mrem) Bone	Liver	Body	Thyroid(e)	Kidney	Lung	GI
Adult(a)	1.59E-1	1.13E-1	8.78E-2	5.19 (5.19E-2)	6.07E-2	1.01E-1	9.2E-3
Teen(b)	1.95E-1	8.32E-2	7.19E-2	6.37 (6.37E-2)	8.23E-2	1.49E-1	9.0E-3
Child(c)	2.10E-1	1.32E-1	3.27E-2	2.69 (2.69E-2)	5.46E-2	1.23E-1	2.99E-3
Infant(d)	1.22E-1	1.10E-1	1.88E-2	6.48 (6.48E-2)	4.77E-2	8.13E-2	1.3E-3

(a) USNRC Reg. Guide 1.109, Table E-7

(b) Op.cit., Table E-8

(c) Op.cit., Table E-9

(d) Op.cit., Table E-10

(e) Values in parentheses for 100 to 1 in-plant dilution

Table 8-7

Maximum Radionuclide Concentrations for Water in the Vacuum Receiver Tank

Nuclide	Maximum in Liner μCi/ml(a)	Percent Carryover	Concentration in Tank μCi/ml
Mn-54	15.6	1.0	1.5E-01
Co-58	5.5	1.0	5.5E-02
Co-60	14.4	1.0	1.4E-01
Sr/Y-90	1.2	1.0	1.2E-02
I-131	60	1.0	6.0E-01
Cs-134	65	1.0	6.5E-01
Cs-137	132	1.0	1.3E-00

(a) from Table 8-4

Table 8-8

Concentrations of Radionuclides at Site Boundary
Rupture of Vacuum Receiver Tank

Nuclide	Maximum Liner Concentration µCi/ml(a)	Maximum Liner Concentration µCi/ft^3	Tank Release Rate µCi/Sec(b)	Partition Factor(c)	Airborne Release Rate µCi/Sec(d)	Airborne Concentration at Boundary µCi/ml(e)	Max. Allowable µCi/ml(f)
Mn-54	1.56E-01	4.42E+03	3.16E+02	10^5	3.16E-03	3.16E-14	1.0E-09
Co-58	5.50E-02	1.56E+03	1.11E+02	10^5	1.11E-03	1.11E-14	2.0E-09
Co-60	1.44E-01	4.08E+03	2.90E+02	10^5	2.90E-03	2.90E-14	3.0E-10
Sr/Y-90	1.20E-02	3.40E+02	2.43E-01	10^5	2.43E-04	2.43E-15	3.0E-11
I-131	6.00E-01	1.70E+04	1.21E+03	10^4	1.21E-01	1.21E-12	1.0E-10
Cs-134	6.50E-01	1.84E+04	1.31E+03	10^5	1.31E-02	1.31E-13	4.0E-10
Cs-137	1.32E-00	3.74E+04	2.67E+03	10^5	2.67E-02	2.67E-13	5.0E-10

(a)Based on 1% carryover from liner
(b)Leak rate of 0.31 cu.ft./sec. from the tank
(c)WASH-1258, V2, USAEC, 1973
(d)From the spill
(e)χ/Q = 1.0E-05 sec/m^3 = 1.0E-11 sec/ml
(f)10CFR20, Appendix B, for continuous release during normal operations

Table 8-9

50-year Dose Committment from Rupture of the Vacuum Receiver Tank

Individual	Dose (mrem)						
	Bone	Liver	Body	Thyroid	Kidney	Lung	GI
Adult(a)	4.7E-04	3.3E-04	2.6E-04	1.6E-03	1.2E-04	3.3E-04	2.2E-05
Teen(b)	5.8E-04	4.4E-04	2.0E-04	2.0E-03	1.6E-04	4.8E-04	2.1E-05
Child(c)	6.5E-04	4.1E-04	9.5E-05	2.2E-03	1.5E-04	3.9E-04	8.2E-06
Infant(d)	3.4E-04	1.2E-04	3.5E-05	2.0E-03	8.7E-05	2.6E-04	2.9E-06

(a)USNRC Reg. Guide 1.109, Table E-7

(b)Op.cit., Table E-8

(c)Op.cit., Table E-9

(d)Op.cit., Table E-10