NUS PROCESS SERVICES CORPORATION

TOPICAL REPORT

ON

RADWASTE SOLIDIFICATION SYSTEM

Document Number PS-53-0378
Revision: O

NUS PROCESS SERVICES
A Halliburton Company

1501 KEY ROAD, COLUMBIA, S.C. 29201
(803) 256-4355

NUS PROCESS SERVICES CORPORATION

TOPICAL REPORT

ON

RADWASTE SOLIDIFICATION SYSTEM

Document Number PS-53-0378
Revision: O

Prepared April 1983
By

NUS PROCESS SERVICES CORPORATION
1501 KEY ROAD
COLUMBIA, SOUTH CAROLINA 29201

NUS PROCESS SERVICES
A Halliburton Company

1501 KEY ROAD, COLUMBIA, S.C. 29201
(803) 256-4355

ABSTRACT

This topical report describes the design and operation of NUS Process Services Corporation's Radwaste Solidification System. Mobile equipment is provided to treat and solidify radioactive waste. It provides nuclear utilities with a convenient, economical and reliable method for solidifying radioactive liquid wastes including PWR and BWR concentrates, resins and filter media slurries.

The primary binding agent used in the Radwaste Solidification System is Portland Type I Cement. Additives are selected to allow precise chemical control of the solidification process and to optimize volumetric efficiencies. Properly formulated cement assures that the disposable container will contain essentially no free standing water, produces an end product with a high structural integrity and permits high processing rates.

All materials used in the solidification process are readily available through commercial sources and are not considered harmful to either personnel or the environment.

Chemical control of the entire waste processing sequence is assured by compliance with the Process Control Program (PCP). The PCP addresses both laboratory verification of process parameters and control of solidification in large disposable liners. The formulae for various waste types are developed under controlled laboratory conditions which are then scaled up in pilot plant studies. Actual solidification of radioactive waste is conducted under carefully controlled conditions and a conservative approach to the theoretical efficiency of the formula is used with actual radioactive waste.

All chemical reactions and physical operations, including waste pretreatment, slurry dewatering, pH adjustment and solidification, are conducted in a disposable liner. Following solidification, the liner becomes the final disposal container.

TABLE OF CONTENTS

TABLE OF CONTENTS

(Cont'd)

PROPRIETARY INFORMATION

The following sections of the NUS Process Services Corporation Topical Report on Radwaste Solidification System, Rev. 0 are considered proprietary to NUS Process Services Corporation and are not to be used for public information or distribution without direct written permission of the General Manager, NUSPSC.

Section	Title
Appendix A	Cement Research Program
Appendix B	Process Control Program
Appendix C	Piping and Instrument Diagram
Appendix D	Disposable Liner Information

1.0 INTRODUCTION

Recent changes in burial site licenses and increased concern over free-standing water during transportation and disposal of low-level radioactive liquid and slurry waste have increased nuclear utility concerns over the proper operation and the efficiency of radwaste disposal systems. This topical report describes a process by which waste generators may be assured that waste intended for shallow land disposal meets or exceeds all current regulations.

The NUS Process Services Corporation Radwaste Solidification Service provides equipment designed to process all types of wet radioactive wastes and a complete Process Control Program to ensure that chemical control of the waste is maintained at all times.

All equipment provided as part of the service package is designed and constructed to current regulatory guidelines. Special provisions, based on the previous operating experience of the design team, have been incorporated to ensure radiation exposure of the system technician is maintained as low as reasonably assurable. These provisions include multiple flush paths for radioactive components, remotely operated components, component placement in low radiation areas and zoning of subsystems into radioactive and non-radioactive areas.

The Process Control Program (PCP) was derived from laboratory testing conducted by NUS Process Services Corporation. The ultimate goal of this testing program was to produce an end product which was low in weight, high in strength and resulted in a packaging efficiency of at least 75 percent waste by volume. Parameters examined included pH, water content, pretreatment techniques, density adjustments and additives to accelerate or retard reactions. Careful chemical control of the cement hydration reaction allows the technician to control the rate of the exothermic releases taking place in the disposable liner.

The purpose of this Topical Report is to provide sufficient information to the Nuclear Regulatory Commission and other regulatory bodies to allow a review of this service for use at nuclear generating facilities.

2.0 PROCESS DESCRIPTION

2.1 Operating Sequence

The Radwaste Solidification System (RSS) is a portable waste processing package which utilizes a disposable container (liner) as a batch tank for waste pretreatment, solidification, transportation and disposal.

Radioactive liquid or slurry wastes are pumped from the utility, to the disposable liner. Once in the liner, the waste can be pretreated, dewatered or both, as necessary to adjust waste parameters to the optimum point for solidification. After pretreatment, cement is pneumatically conveyed to the liner, blended with the waste and then allowed to cure.

While curing, the waste temperature is closely monitored to confirm that the hydration of cement with the waste is taking place. This temperature profile is used to determine the exact time that cement cure is sufficiently complete to allow shipment of the processed waste.

Prior to actually conducting solidification in the liner, a series of lab-scale tests are conducted to ensure that the proper pretreatment formula and cement requirements have been established. This testing is then scaled up to the volume of the container being used. Exact volumes of waste, additive and cement are established before solidification begins.

3.0 EQUIPMENT DESCRIPTION

3.1 General

The Radwaste Solidification System is composed of skid mounted components and a bulk cement trailer. These components are completely portable and are normally delivered to the utility site in two shipments, one for the bulk trailer and one for other system components and an initial supply of disposable liners. Setup of the equipment is normally accomplished in one day.

The process equipment is designed to eliminate problems normally encountered in temporary cement equipment. The equipment offers the following advantages:

- Bulk storage of all dry powders outside of the plant.
- Cement transfer via a split-air stream to eliminate cement carry over to utility ventilation.
- Compact equipment packages.
- Interchangeable components for reliability.

3.2 Bulk Cement Trailer

This trailer is a combination storage container and cement transfer mechanism.

Two blowers are mounted in the nose of the trailer. One provides air to fluff the cement before it leaves the trailer while the other provides the air needed to transfer the cement from the trailer to the cement batch tank at the fillhead. After the transfer air has deposited the dry cement in the batch tank, it is returned to a high efficiency bag filter located inside the trailer. The transfer air is filtered to remove residual cement dust and is then released to atmosphere.

3.3 Fillhead Assembly

The fillhead is the heart of the NUS Radwaste Solidification System. When the fillhead is attached to a disposable liner, the liner becomes a disposable process tank. The fillhead/liner arrangement allows for chemical conditioning of the waste prior to solidification, removal of excess water from slurries and fine control of the dry cement used in solidification.

The fillhead assembly includes a cement batching chamber to control the addition of cement to the liner. The batch chamber is independently suspended on a load cell to permit the precise cement weight to be determined. The fillhead also prevents the non-radioactive air used to transfer the cement to the fillhead from coming in contact with the contaminated liner environment. Only that air displaced by cement addition is removed from the liner and routed to the plants off-gas system.

Other components on the fillhead assembly include a hydraulic drive motor, closed circuit TV camera, connections for liner level and temperature probes and piping connections for all chemicals and the cement used in the solidification process.

3.4 Main Control Panel

The Solidification System's Main Control Panel provides the system operator with remote control of all system components and remote indication of all important process parameters. A list of these components and indications follows:

Panel-Controlled Components/Services	Panel Indications
. Hydraulic Power Package	. Radiation Level at Fillhead
. Bulk Storage Trailer	. Radiation Level at Process Piping Skid
. Service Air	. Liner Level (5)
. Service Water	. Liner Temperature
. Off-Gas Blower	. Cement Batch Weight
. Dewatering Pump	. Cement Total Weight
. Chemical Pumps (2)	. Liner Temperature Profile
. Waste Flow Shut	. Closed Circuit TV Monitor
	. Mixer RPM
	. Filter Performance
	. Waste Flow Rate
	. Waste Total Flow
	. Chemical Addition Volumes

3.5 Process Piping Skid

The Process Piping Skid is the interface between the plant's radwaste system and the NUS Radwaste Solidification System. Subassemblies on the skid include a waste line equipped with an emergency shut-off valve to stop waste flow and a combination flow rate/totalizer which reads out at the Main Control Panel. The skid is also equipped with a dewatering pump for removing excess slurry water from disposable liners. The Process Piping Skid is the connection point for the service air and service water required to support RSS operation. Stacked solenoid valve assemblies distribute air and water to other system components as required.

3.6 Hydraulic Power Package

A skid-mounted hydraulic system provides power to the mixer drive motor mounted on the fillhead. It allows remote control of both mixer speed and mixer direction. The hydraulic power package, when operated within normal limits, provides in excess of 25 horsepower to the disposable liner mixer which is sufficient mixing power to handle liners up to 300 cubic feet in size.

3.7 Off-Gas Blower

A high-efficiency blower system is connected to the fillhead/liner assembly to ensure that the disposable liner remains under negative pressure throughout the processing period. The blower is equipped with five separate filter stages including a HEPA filter as the last stage. The discharge from the offgas blower can be released directly to atmosphere or, if desired, can be routed to the plant's off-gas system.

3.8 Chemical Addition Pumps

Two stroke-type positive displacement pumps are provided with the Radwaste Solidification System. The pumps give NUS the ability to add small quantities of liquid chemicals to aid in optimizing the final solidification formula. Both pumps fit into standard 55-gallon chemical drums and are controlled from the Main Control Panel.

4.0 SYSTEM OPERATION

This section describes the processing steps necessary to support the operation of the Radwaste Solidification System. The Process Control Program is the controlling document for operating the system and addresses both lab-scale testing and full-scale system operation. This section also defines the characteristics of expected waste streams, the effect of various parameters on the solidification process and estimates both processing times and resultant personnel exposure.

4.1 Process Control Program (PCP)

The purpose of the PCP is to provide reasonable assurance of the complete solidification of low-level radioactive liquid and slurry wastes and to provide reasonable assurance of the absence of free water in the processed waste. The PCP is applicable to all solidification operations conducted at nuclear generating stations and shall be followed at all times.

4.1.1 General Description

The PCP is designed to ensure that chemical control of the waste is maintained at all times and that an acceptable end product results from all system operations.

Since solidification is conducted on a batch basis, testing requirements are established to correlate lab samples to a particular waste batch. A batch may be either the contents of one disposable liner or the contents of one isolated waste hold-up tank capable of recirculation or agitation of the tank contents. The larger of these two volumes is used to reduce the sampling frequency and the attendant personnel exposure.

Three types of lab tests, bracket, confirmation and data sample, may be conducted in accordance with the PCP. A bracket sample is taken on the first three batches of a specific waste type and is processed using a minimum of three separate waste-to-cement ratios. Once a repeatable formula is developed, the actual testing frequency drops to one sample per every ten batches. A confirmation sample is run on the tenth batch and every tenth batch thereafter to verify the formula is producing an acceptable end product.

A data sample is drawn for every batch of waste processed but a test solidification is not conducted on the data sample. The waste is evaluated to determine its physical characteristics and to determine the isotopic content for shipment papers. The physical characteristics of the waste are compared with the parameters identified during bracket sample testing to ensure the current waste is physically similar to the baseline waste.

From the results obtained during PCP testing, a linear extrapolation is made to scale-up the additives and cement needed to process waste in a disposable liner. The waste characteristics are considered constant and large scale testing confirms that the physical volume makeup of the waste does not change the solidification mechanism chemically. Some affects due to changes in heat dissipation rate are expected due to container geometry which is compensated for by curing the test container at controlled temperatures.

4.2 Expected Waste Characteristics

Typical waste streams encountered at PWR and BWR power plants are described below. These values are expected values only and will vary from site to site. Separate testing under the PCP is required to determine the waste characteristics and develop the correct cement formula.

4.2.1 Bead Resins:

- Mesh size - 20-50 mesh
- Density - 50 lbs/ft^3
- Mositure Content - 30-50% by weight
- Void Volume - 30-45 percent

4.2.2 Filter Sludge:

- Solids concentration - 3-50 wt percent
- Particle Size - 100x20 micron
- Density - 20 lb/ft^3
- Void Volume - varies

4.2.3	Boric Acid:	Concentration - 6-12 percent pH - 1.5-4 Temperature - 160°-200°F
4.2.4	Sodium Sulfate:	Concentration - 12-25 percent pH - 8-11 Temperature - 110°-140°F
4.2.5	Other:	As encountered. Includes tank sludges, chemical drains, laundry and decon wash wastes. Characterized prior to processing.

4.3 Waste Effects on Cement

Many of the constituents found in typical power plant wastes can influence the hydration of cement. Therefore, the chemical makeup of the waste must be identified and controlled to ensure solidification occurs in a controlled, repeatable manner. Some of the effects of waste on cement and critical parameters for solidification are discussed below.

4.3.1 Resin Wastes

The effect of bead ion exchange wastes in cement must be considered for two characteristics. The first is the residual ion exchange capacity of the material. Undepleted resins may remove divalent or trivalent ions from the cement-water slurry and limit the hydration reaction. Pretreatment of resin with lime to a pH of 9-11 depletes unused exchange capacity and stablizes the resin at a uniform size.

The second consideration in solidifying ion exchange resins is the resin water content. Water is present in bead resin both in the interstitial void spaces and in the bead structure itself. The proper cement formula must account for all water in the waste to ensure adequate solidification.

4.3.2 pH

Cement reactions are retarded or inhibited by acidic pH's and accelereated by basic pH's. All waste pretreatment includes pH adjustment with lime to produce a basic pH.

4.3.3 Boric Acid

Boric acid in small amounts is a well known inhibitor of cement reactions and in the high concentrations usually encountered at PWR's may completely inhibit cement hydration. Pretreatment of boric acid to convert it into an insoluble salt is necessary to prevent cement retardation. Lime, when used for this purpose precipitates the boron and adjusts the pH.

4.3.4 Sodium Sulfate

Sodium sulfate is a known accelerator of cement reactions. Conversion of sodium sulfate to an insoluble salt is usually required to prevent flash setting and extremely rapid heat release.

4.3.5 Waste-to-Cement Ratios

Careful control of the amount of cement to be added to the waste is required to ensure that sufficient cement is available to tie up all water in the waste. It is also necessary to minimize the amount of cement so that high density waste forms are not produced which would limit waste loading in the liner. Selection of the proper waste-to-cement ratio is accomplished during bracket sample testing and results in a low density, low heat, high strength cement matrix.

4.3.6 Oil

Small quantities of oil are easily tolerated in the cement matrix but oil in excess of one percent is unacceptable at burial sites. Oil in excess of one percent would require mechanical removal prior to solidification.

4.4 Processing Times and Exposures

The accumulated radiation exposure to field technicians is minimal and will not exceed 5 Rem per year for year round processing.

Exposure resulting from solidification operations is normally 50 mR per liner solidified. This number is based on a normal operating sequence. Based on the average of one liner per week, technician exposure should not exceed 2.5 Rem during any calendar year.

Activity	Time	Exposure
Disposable Liner Inspection	45 min	0 mRem
Fillhead Installation	30 min	5 mRem*
Waste Transfer	30 min	0 mRem
Chemical Treatment	180 min	0 mRem
Cement Addition	60 min	0 mRem
Fillhead Removal	15 min	5 mRem
Liner Closing	< 1 min	15 mRem
	6 hours	25 mRem
Process Control Program Testing	5 hours	25 mRem

* From background radiation levels.

These numbers will vary depending on the number of samples processed, amount of shielding used and specific activity of the waste.

The RSS equipment is designed to limit personnel exposure both during system operation and while performing routine maintenance. Wherever possible, components requiring servicing are removed from potentially radioactive areas and located in low-radiation areas. The majority of the processing operation is controlled by remotely operated mechanical systems. The technician is not required to be in the immediate vicinity of the disposable liner except during fillhead removal and liner closure.

4.5 Packaging Efficiency Ratios

No discussion of radwaste solidification is complete without considering both the amount of waste incorporated into the final waste form and the product density. Both are vital to the overall disposal efficiency. While the actual waste ratio will depend on plant chemical characteristics, expected ratios are as follows:

Waste Type	Percent Volume of Waste	Product Density
Boric Acid Concentrates	72%	95 lb/ft^3
Na_2SO_4 Concentrates	80%	95 lb/ft^3
Bead Resin	85%	84 lb/ft^3
Filter Sludge	85%	82 lb/ft^3

NUS Process Services is committed to an ongoing research and development program aimed to increasing the overall packaging efficiency for all types of radwastes. Improvements, once tested and approved, will be reflected in the Process Control Program and incorporated into RSS operating procedures.

5.0 UTILITY INTERFACE REQUIREMENTS

5.1 The Radwaste Solidification System requires connections to the utility's electrical, service air, service water and off-gas ventilation systems. Crane and/or forklift services are also required. A complete list of connections is provided below.

Connection	Description
Electrical Power	440VAC, 30, 60 Hz @ 100 Amps
Service Water	10 gpm @ 80 $\pm$ 20 psig (non-contaminated water) Size: 1 inch connection
Service Air	25 CFM @ 125 $\pm$ 10 psig dry air Size: 1 inch connection
Ventilation Discharge	100 CFM @ 5 inches water gage to monitored exhaust Size: 1 1/2 inch connection
Waste Supply	40 GPM Size: 1 1/2 inch ANSI 150 lb flange
Dewater Return	30 GPM Size: 1 1/2 inch ANSI 150 lb flange
Forklift	4000 lb - nominal
Crane	10 ton liner handling 15 ton shield handling

A typical RSS layout arrangement is illustrated in Figure 1. Additional details on system connections is provided in Appendix C.

6.0 QUALITY ASSURANCE PROGRAM

The design, fabrication, testing and operation of the NUSPSC Radwaste Solidification System is accomplished under strict quality assurance requirements which conform, to the extent practicable, with the guidelines provided in the U.S. Nuclear Regulatory Commission's Regulatory Guide 1.143.

The activities listed below fall under the perview of NUSPSC's Quality Assurance Program.

6.1 Design Control

Design control of NUSPSC equipment includes the preparation, control and maintenance of design specifications, analyses, calculations and drawings. Design criteria are always documented, verified and retained. Verification of the design is conducted by a person who is qualified in the subject and is done without recourse to the originator.

6.2 Procurement Control

Procurement control is applicable to all materials, equipment, supplies and services purchased by NUSPSC. Prior to placement of a purchase order, the vendor will be evaluated to verify his capability for supplying materials of the quality specified.

6.3 Document Control

Documents that prescribe or affect the quality of NUSPSC work shall be controlled, properly identified, filed and retained traceable for the period specified by the document governing such work.

6.4 Control of Purchased Material

Controls are applied to ensure that purchased material, equipment and services conform to the procurement documents. These controls include supplier surveys and approval, source surveillance when appropriate, receipt inspection and materials, parts and components identification.

6.5 Handling, Storage, and Shipping

Controls are applied to ensure that materials, parts and components are handled, stored, shipped, cleaned and preserved to prevent damage, loss or deterioration.

6.6 Non Conformances

Materials, parts, components and services which do not conform to the applicable codes, specifications or other documented requirements are controlled to prevent their inadvertent use or installation. These controls include the identification, documentation, segregation, disposition and notification to affected services of all nonconforming items.

7.0 SAFETY ANALYSIS

7.1 General

The Radwaste Solidification System is designed to meet all current industry standards including regulatory requirements, ASME, ANSI, NEC, and NFPA codes and standards. Recognizing that no system will ever be free from faults, the Radwaste Solidification System was designed to minimize the potential personnel and property hazards in the event of a system malfunction or operator error. The primary accidents analyzed were fire, release of radioactive material in the process area (spills), release of radioactive material from an intact liner (overflows) and system failure during processing.

7.2 Fire

There are only two potential types of fire for the Radwaste Solidification System - an electrical fire and hydraulic oil fire.

7.2.1 The potential for an electrical fire is minimized by conformance to NEC and NFPA codes in the system design and conservative sizing of all components. All components are equipped with protective breakers or fuses and the entire system may be deactivated using an Emergency Stop from the Main Control Panel. In the event of an electrical fire, the system would be deenergized and would fail to a safe condition.

7.2.2 For optimum system performance, the hydraulic oil must be operated between 140 and 160°F. This is 100°F minimum below the hydraulic oil flash point. In designing the hydraulic power package, the oil reservoir was sized to adequately maintain system temperature through ambient losses. In addition, a fan cooled heat exchange is installed in the hydraulic oil return path to ensure system temperature is maintained in the operating band.

7.3 Spills

The uncontrolled release of radioactive material in the processing area from component failure is commonly referred to as a spill. The credible situations that are considered are component failure between the utility and the Radwaste Solidification System, between the Radwaste Solidification System and the disposable liner, and rupture of the disposable liner.

7.3.1 The Radwaste Solidification System is connected to the utility radwaste system through a flexible hose. A rupture of this hose could result in a spill in the processing area. The radwaste technician is able to determine a loss of flow to the Radwaste Solidification System from the flow/totalizer display and liner level instruments installed in the main control panel.

During waste transfer, the technician and the utility operator are in continuous communication. Should a loss of flow to the Radwaste Solidification System be indicated it would be immediately reported to the utility operator and corrective action by the utility would be initiated.

7.3.2 A hose rupture or failure between the process piping skid and the liner would not be as easy to detect but monitors are available which indicate this event. The system technician monitors both liner level and waste flowrate during the liner filling operations. A mismatch between flow and liner level would key the technician that a system fault was occurring and the waste feed to the liner would be stopped.

The nominal waste feed rate is 40 gallons per minute to the system which corresponds to a liner level change of 2 inches per minute. The longest credible time a complete liner rupture could go undetected is two minutes resulting in a spill of approximately 80 gallons of radioactive liquids before the system is isolated.

7.3.3 The worst case accident which could occur during solidification is the complete rupture of a liner which is filled with unsolidified radioactive waste and cement. In this event, 1500 gallons of radioactive material could be released in the processing area. The primary concern in this event is release of airborne radioactivity.

Whether the system is operated within an existing building or on an outside pad, the potential release of radioactive airborne material in excess of plant design limits is negligible. Indoor operation would allow processing of particulate and gaseous contamination through the utility's off-gas system. Outdoor operation, where monitored ventilation is not possible, is included in the utility's licensing package before the decision is made to operate out-of-doors.

7.3.4 Minor spills from component leakage and partial hose failures were considered during system design. The connections between components are made over integral drip trays and are bagged during normal operation. All components including hoses and piping are hydrostatically tested following assembly and installation and are periodically pressure tested during normal operation.

~.4 Overflows

The uncontrolled release of radioactive material from the disposable liner, excluding gross failure of the liner, is considered an overflow. An overflow condition could be an actual overflow while filling the liner, overflow from cement addition or the release of airborne radioactive material during waste processing.

7.4.1 Overfilling of the disposable liner during waste transfer is prevented primarily by operating procedures and indications. The waste is added to the liner before the solidification agent is introduced. The normal radioactive waste level will be sixty to eighty percent of the available liner freeboard. During the filling phase of the solidification process, the technician monitors both the continuous liner level readout and the totalizer readout. By procedure, the technician calculates the target waste level and coordinates the waste transfer with the utility operator.

In the event that waste flow continues above the calculated waste level, a mechanical float switch at the top of the liner will activate and shut the Remote Waste Isolation Valve stopping waste flow to the liner. There are also two manually operated isolation valves downstream of the remote waste isolation valve should it be necessary to manually secure waste flow.

7.4.2 Once the radioactive waste has been transferred to the liner, cement addition is iniated. Cement addition is made on a batch basis of 325 pounds per cycle to the liner. Each cement addition results in a level increase of 1/2 to 1 inch, depending upon the admixtures blended with the cement. The transfer of cement to the liner is manually controlled by the system technician who has both liner level and visual indication of the liner contents to gage the volume in the liner. Again, the mechanical float swich at the top of the liner provides a safety backup to prevent overfilling of the container.

7.4.3 When considering radioactive releases, it is also necessary to consider gaseous releases from the disposable liner. During waste processing, all system components are interlocked with the off-gas blower to ensure that a negative pressure is maintained in the liner. The off-gas blower is designed to maintain 5 inches water gage vacuum in the disposable liner with a 1 1/2 inch hole in the fillhead open to atmosphere.

7.5 Component Failure

7.5.1 Remote Waste Isolation Valve

The remote waste isolation valve is a fail-shut valve which is designed to fail on loss of air pressure or loss of electrical power. Should the remote waste isolation valve fail to shut during processing, an independent backup is located downstream to isolate waste flow.

The actual control of waste flow to the Radwaste Solidification System is controlled by the utility radwaste operator. Under normal conditions, the remote waste isolation valve is never used to start or stop waste flow to the system. Should this valve fail to close, the waste isolation valve is shut and waste processing would continue. Repairs would be completed following waste solidification.

7.5.2 The control system for the Radwaste Solidification System provides redundant indications for waste quantities. A totalizer circuit is installed to determine the actual volume of waste transferred to the liner. Cement addition is on a batch basis and the amount of cement transferred is determined by a load cell arrangement. Using absolute specific gravity values, it is possible to convert cement weight directly to volume increase.

It should be noted that once cement addition starts, liner level becomes non-linear due to the gradual change in specific gravity of the liner contents. The cement addition rate allows sufficient time for the technician to calculate liner level following each cement addition. The technician is able to monitor liner contents on the closed circuit television monitor. In addition, the mechanical float switch provides a final backup to prevent overfilling the container.

Should liner level indication be lost, the level indication may be repaired without the risk of excessive exposure. The actual level transmitter for level indication is located on the Process Piping Skid, not at the liner.

7.5.3 Mixer

The probability of a hydraulic system failure is extremely low. The primary failure mode of this system would be from loss of hydraulic fluid. Repairs to the hydraulic motor are not possible while the fillhead is in place on the liner.

Actual operating experience with the hydraulic drive system has demonstrated the system is usable for thousands of hours with no maintenance outside of filter replacement.

7.5.4 Cement Transfer System

The worst case failure mode for loss of cement feed capability occurs when some cement has been added to the liner but not enough to assure complete solidification. Should a failure occur which is repairable in a short time, cement addition may continue as long as it is possible to agitate the contents of the liner. If the cement in the liner sets before repairs are complete, the material at the bottom of the liner will set and it would be necessary to decant the unsolidified material to another disposable liner.

8.0 REFERENCES

8.1 U.S. Nuclear Regulatory Commission Regulatory Guides

8.1.1 1.143, "Design Guidance for Radioactive Waste Management Systems, Structures and Components Installed in Light-Water-Cooled Nuclear Power Plants."

8.1.2 8.8, "Information Relevant to Ensuring That Occupational Radiation Exposures At Nuclear Power Stations Will Be As Low As Is Reasonably Achievable."

8.1.3 8.10, "Operating Philosophy For Maintaining Occupational Radiation Exposures As Low As Is Reasonably Achievable."

8.2 NUREGS

8.2.1 0800, "Standard Review Plan"

8.2.2 0133, "Preparation of Radiological Effluent Technical Specifications For Nuclear Power Plants"

8.3 Code of Federal Regulations

8.3.1 10 CFR 20, "Standards for Protection Against Radiation"

8.3.2 10 CFR 50, "Quality Assurance Criteria"

8.3.3 49 CFR 100-199, "Transportation"

8.3.4 10 CFR 71, "Packaging of Radioactive Material for Transport"