ALABAMA POWER COMPANY

FARLEY NUCLEAR PLANT UNIT NO. ONE

LICENSE NO. NPF-2

AND

FARLEY NUCLEAR PLANT UNIT NO. TWO

LICENSE NO. NPF-8

SEMI-ANNUAL RADIOACTIVE EFFLUENT RELEASE REPORT

JULY 1, 1984 THROUGH DEC. 31, 1984

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INTRODUCTION

This Semi-annual radioactive release report, for the period July 1 through December 31, 1984, is submitted in accordance with Appendix A of License Nos. NPF-2 and NPF-8. Appendix A will hereinafter be referred to as the Standard Technical Specifications or STS.

A single submittal is made for both units which combines those sections that are common. Separate tables of releases and release totals are included where separate processing systems exist.

This report includes an annual summary of hourly meteorological data collected over the past year and an assessment of the radiation doses due to the radioactive liquid and gaseous effluents released from the Farley Nuclear Plant site over the same period. Additionally Section 12.d with associated dose contributions to sectors comprises an assessment of radiation doses to the likely most exposed member of the public from reactor releases and other nearby uranium fuel cycle sources (including doses from primary effluent pathways and direct radiation). All assessments of radiation doses are performed in accordance with the OFFSITE DOSE CALCULATION MANUAL (ODCM).

B. SUPPLEMENTAL INFORMATION FOR EFFLUENT AND WASTE DISPOSAL

1. Regulatory Limits

a. Fission and Activation Gases

The release rate limit at any time of noble gases to areas at or beyond the site boundary shall be such that

$$10^{6} \frac{pCi}{uCi} \sum_{i}^{14} K_{i} \left[\sum_{v}^{2} \left[\overline{(X/Q)}_{v} \; Q_{iv} \right] \right] < 500 \text{ mrem/yr}$$

and

$$10^{6} \frac{pCi}{uCi} \sum_{i}^{14} \left[(L_{i} + 1.1 M_{i}) \sum_{v}^{2} \left[\overline{(X/Q)}_{v} \; Q_{iv} \right] \right] < 3000 \text{ mrem/yr}$$

where the terms are defined in the ODCM.

b. Iodines and Particulates

The release rate limits in the grass-cow-milk pathway for the sampling period of all radioiodines and radioactive materials in particulate form and radionuclides other than noble gases released to the environs as part of the gaseous wastes from the site shall be such that

$$10^{6} \frac{pCi}{uCi} \sum_{i}^{18} \left[P_{i} \sum_{v}^{2} \left[\overline{(X/Q)}_{mv} \; Q_{iv} \right] \right] < 6.3 \text{ mrem/yr}$$

where the terms are defined in the ODCM.

c. Liquid Effluents

The concentration of radioactive materials released in liquid effluents to unrestricted areas from all reactors at the site shall not exceed at any time the values specified in 10 CFR Part 20, Appendix B, Table II, Column 2. The concentration of dissolved or entrained noble gases, released in liquid effluents to unrestricted areas from all reactors at the site, shall not exceed at any time 2 E-4 uCi/ml in water.

2. Maximum Permissible Concentrations

   a. Airborne - The maximum permissible concentration of radioactive materials in gaseous effluents is limited by the dose rate restrictions of 10CFR20. In this case, the maximum permissible concentrations are actually determined by the dose factors in the ODCM.

   b. Liquid - 10 CFR Part 20, Appendix B Table II, Column 2.*

   *NOTE: The MPC chosen is the most conservative value of either the soluble or insoluble MPC for each isotope.

3. Average Energy
   Not Applicable for Farley's STS.

4. Measurements and Approximations of Total Activity

   The following discussion details the methods used to measure and approximate total activity for the following:

   a. Fission and Activation Gases
   b. Iodines and Particulates
   c. Liquid Effluents

   Tables 5 and 6 give sampling frequencies and minimum detectable concentration requirements for the analysis of liquid and gaseous effluent streams, respectively.

   Values in the attached tables given as zero do not mean that the nuclides were not present. A zero indicates that the nuclide was not present at levels greater than the sensitivity requirements shown in Tables 5 and 6. For some nuclides, lower detection limits than required may be readily achievable; when a nuclide is measured below its stated limit, it is reported.

   Fission and Activation Gases

   The following noble gases are considered in evaluating gaseous airborne discharge:

   Kr-87 Xe-133
   Kr-88 Xe-135
   Xe-133m Xe-138

Periodic grab samples from plant effluent streams are analyzed by a computerized pulse height analyzer system utilizing high resolution germanium detectors. (See Table 6 for sampling and analytical requirements). Isotopic values thus obtained are used for release rate calculations as given in section 1a of this report. Only those nuclides that are detected are used in this computation. During the period between grab samples, the amount of radioactivity released is based on the effluent monitor readings. Monitors are assigned a calibration factor based upon the last isotopic analysis using the following relationship:

$CF_i = A_i / m$, where

CF_i = isotopic calibration factor for isotope i.

A_i = concentration of isotope in the grab sample, in uCi/ml.

m = net monitor reading associated with the effluent stream.

These calibration factors along with the hourly effluent monitor readings are inputs to the laboratory computer where the release rates for individual nuclides are calculated and stored.

To ensure isotopic distributions do not change significantly during major operational occurrences, the frequency of grab sampling is increased to satisfy the requirements of footnotes b & d of STS Table 4.11-2, "Radioactive Gaseous Waste Sampling and Analysis Program".

Iodines and Particulates

The radioiodines and radioactive materials in particulate forms to be considered are:

Mn-54
Fe-59
Co-58
Co-60
Zn-65
Sr-89
Sr-90
Mo-99

I-131
I-133
Cs-134
Cs-137
Ce-141
Ce-144
* H-3

Other nuclides with half-lives greater than 8 days which are identified and measured are also considered. The MDC's will vary and are not required to meet the MDC limits of those isotopes listed specifically.

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* Tritium is considered in the gaseous or water vapor form.

Continuous Releases: Continuous sampling is performed on the continuous release points (i.e. the Plant Vent Stack, Containment Purge and the Turbine Building Vent). Particulate material is collected by filtration. Periodically these filters are removed and analyzed on the pulse height analyzer to identify and quantify radioactive materials collected on the filters. Particulate filters are then analyzed for gross alpha and strontium as required. Gross alpha determinations are made using a 2 pi gas flow proportional counter. Sr-89 and 90 values are obtained by chemical separation and subsequent analysis using 2 pi gas flow proportional counters.

Batch Releases: The processing of batch type releases (from Containment Waste Gas Decay Tanks) is analogous to continuous releases, except that the release is not commenced until grab samples have been obtained and analyzed.

Liquid Effluents

The radionuclides listed below are considered when evaluating liquid effluents:

Mn-54
Fe-59
Co-58
Co-60
Zn-65
Sr-89
Sr-90

I-131
Cs-134
Cs-137
Ce-141
Ce-144
Mo-99
Fe-55
H-3

Batch Releases: Representative pre-release grab samples are obtained and analyzed per Table 5. Isotopic analyses are performed using the computerized pulse height analysis system previously described. Aliquots of each pre-release sample proportional to the waste volume released are composited in accordance with requirements in Table 5. Strontium and Iron determinations are made by performing a chemical separation and counting the isotope thus separated using a 2 pi gas flow proportional counter. Gross beta and gross alpha determinations are made using 2 pi gas flow proportional counters. Tritium concentrations are determined by using liquid scintillation techniques. Dissolved gases are determined employing grab sampling techniques and then counting on the pulse height analyzer.

Continuous releases: Continuous releases (from the Steam Generator Blowdown) are analogous to that of the batch releases except that they are analyzed on a weekly composite basis per Table 5.

UNIT # 1

1984

5. Batch Release

a. Liquid

	Quarter 3	Quarter 4
1. Number of batch releases:	99	139
2. Total time period for releases:	8559 min.	11254 min.
3. Maximum time period for a release:	138 min.	166 min.
4. Average time period for a release:	86 min.	81 min.
5. Minimum time period for a release:	54 min.	5 min.
6. Average stream flow during periods of release of effluent into a flowing stream:	*1.15E4 cfs	*1.15E4 cfs

b. Gaseous

	Quarter 3	Quarter 4
1. Number of releases:	1	0
2. Total time period for releases:	420 min.	0 min.
3. Maximum time period for a release:	420 min.	0 min.
4. Average time period for a release:	420 min.	0 min.
5. Minimum time period for a release:	420 min.	0 min.

6. Abnormal Releases

a. Liquid

1. Number of releases: None

2. Total activity released: N/A

b. Gaseous

1. Number of releases: None

2. Total activity released: N/A

* Annual Average River Flow Rate.

UNIT # 2

1984

5. Batch Release

a. Liquid	Quarter 3	Quarter 4
1. Number of batch releases:	50	86
2. Total time period for releases:	4257 min.	6535 min.
3. Maximum time period for a release:	170 min.	116 min.
4. Average time period for a release:	85 min.	76 min.
5. Minimum time period for a release:	20 min.	48 min.
6. Average stream flow during periods of release of effluent into a flowing stream:	*1.15E4 cfs	*1.15E4 cfs

b. Gaseous	Quarter 3	Quarter 4
1. Number of releases:	7	0
2. Total time period for releases:	3960 min.	0 min.
3. Maximum time period for a release:	720 min.	0 min.
4. Average time period for a release:	566 min.	0 min.
5. Minimum time period for a release:	420 min.	0 min.

6. Abnormal Releases

a. Liquid

1. Number of releases: None
2. Total activity released: N/A

b. Gaseous

1. Number of releases: None
2. Total activity released: N/A

* Annual Average River Flow Rate.

7. Estimate of Total Error

a. Liquid

1. The maximum error associated with volume and flow measurements, based upon plant calibration practice is estimated to be + or - 10%.

2. The average error associated with counting is estimated to be less than + or - 15%.

b. Gaseous

1. The maximum errors associated with monitor readings, sample flow, vent flow, sample collection, monitor calibration and laboratory procedure are collectively estimated to be:

Fission and Activation Gases	Iodines	Particulates	Tritium
75%	60%	50%	45%

2. The average error associated with counting is estimated to be:

Fission and Activation Gases	Iodines	Particulates	Tritium
6%	18%	19%	12%

c. Solid Radwaste

The error involved in determining the contents of solid radwaste shipments is estimated to be less than + or - 15%.

UNIT # 1

1984

8. Solid Waste

See Table 3

9. Radiological Impact On Man

a. Water Related Exposure Pathways

3rd Quarter	4th Quarter
Total Body = 1.6E-03 mrem	3.2E-03 mrem
Bone = 7.7E-04 mrem	1.4E-03 mrem
Liver = 2.3E-03 mrem	4.5E-03 mrem
Thyroid = 9.4E-04 mrem	1.9E-03 mrem
Kidney = 1.1E-03 mrem	2.3E-03 mrem
Lungs = 1.1E-03 mrem	3.8E-03 mrem
GI Tract = 3.1E-02 mrem	1.0E-02 mrem

b. Gaseous Related Exposure Pathways

3rd Quarter	4th Quarter
Total Body = 7.7E-02 mrem	3.5E-02 mrem
Skin = 1.6E-01 mrem	5.1E-02 mrem

c. Particulate and Iodine

3rd Quarter	4th Quarter
Organ Dose = 2.9E-02 mrem	3.2E-02 mrem

UNIT # 2

1984

8. Solid Waste

See Table 3

9. Radiological Impact On Man

a. Water Related Exposure Pathways

	3rd Quarter	4th Quarter
Total Body =	1.4e-01 mrem	2.3E-02 mrem
Bone =	1.2E-01 mrem	1.8E-02 mrem
Liver =	2.0E-01 mrem	3.2E-02 mrem
Thyroid =	1.1E-02 mrem	2.0E-03 mrem
Kidney =	6.6E-02 mrem	1.1E-02 mrem
Lungs =	2.5E-02 mrem	8.8E-03 mrem
GI Tract =	1.7E-01 mrem	9.5E-03 mrem

b. Gaseous Related Exposure Pathways

	3rd Quarter	4th Quarter
Total Body =	1.2E-01 mrem	1.5E-02 mrem
Skin =	2.7E-01 mrem	2.7E-02 mrem

c. Particulate and Iodine

	3rd Quarter	4th Quarter
Organ Dose =	2.0E-02 mrem	1.2E-02 mrem

10. Meteorological Data

See Table 4A, "Cumulative Joint Frequency Distribution".

Continuous Release Mode:
3rd Quarter, 1984 : 4A-CQ3
4th Quarter, 1984 : 4A-CQ4

Batch Release Mode (Units 1&2):
3rd Quarter, 1984 : 4A-1BQ3 & 4A-2BQ3
4th Quarter, 1984 : 4A-1BQ4 & 4A-2BQ4

11. Minimum Detectable Concentration (MDC)

Detectable limits for activity analyses are based upon the technical feasibility and on the potential significance in the environment of the quantities released. However, in practice, when an isotope's a posteriori MDC could not be met due to other nuclides being present in much greater concentrations, the a priori MDC as defined in the STS Table 4.11-1 a. is relied upon.

12. Annual Radiation Dose Assessment (1984)

a. Water Related Exposure Pathways

Total Body = 2.1E-01 mrem

Bone = 1.7E-01 mrem

Liver = 2.9E-01 mrem

Thyroid = 2.2E-02 mrem

Kidney = 1.0E-01 mrem

Lungs = 4.6E-02 mrem

GI Tract = 3.7E-01 mrem

b. Gaseous Related Exposure Pathways

Total Body = 3.7E-01 mrem

Skin = 7.2E-01 mrem

c. Particulate and Iodine

Organ = 1.6E-01 mrem

Note: The meteorological conditions concurrent with the time of release of radioactive materials in gaseous effluents (as determined by sampling frequency and measurement outlined in Tables 5 and 6) have been used for the gaseous pathway doses. The assessment of radiation doses has been performed in accordance with the OFFSITE DOSE CALCULATION MANUAL (ODCM).

d. Maximum Real Exposure

The maximum real exposure is an assessment of radiation doses to the likely most exposed member of the public from reactor releases and other nearby uranium fuel cycle sources including doses from all primary effluent pathways and direct radiation(liquid pathways are limited to the Chattahoochee River , for the previous 12 consecutive months in conformance with 40 CFR 190.

A tabulation of doses to sixteen 22.5 degree sectors around the plant calculated at the site boundary provides the quarterly and yearly dose for each sector. The dose or dose commitment to any member of the public due to releases of radioactivity and radiation from uranium fuel cycle sources are limited by STS to less than or equal to 25 mrem to the total body or an organ (except the thyroid which is limited to less than or equal to 75 mrem) over 4 consecutive quarters. This technical specification is provided to meet the dose limitations of 40 CFR 190.

Since the Farley Nuclear Plant is the only uranium fuel cycle source within a radius of 50 miles, the dose to any member of the public will be less than the dose in the highest sector. The tabulation below includes the highest organ dose or the whole body dose if greater for each quarter from liquid effluents. The tabulation also includes the quarterly and yearly doses from the highest sector for each of the following:

1. Gaseous iodine / particulate

2. Noble gases

3. Direct radiation

MAXIMUM* OFF-SITE DOSES AND DOSE COMMITMENTS TO MEMBERS OF THE PUBLIC

Source	Note:	Dose, Millirems 1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	Year**
Organ		G I	G I	LIV	LIV	G I
Liquid Effluents	(1)	8.6E-02	6.7E-02	2.0E-01	3.7E-02	3.7E-01
Airborne Effluents						
Sector		W	WSW	WSW	WSW	WSW
Iodines & Particulates	(2)	1.1E-02	6.2E-03	1.8E-02	1.1E-02	4.3E-02
Sector		S	WNW	W	WSW	S
Noble gases	(3)	5.2E-02	5.5E-03	3.3E-02	1.0E-02	6.5E-02
Sector		NE	SSW	E	E	E
Direct Radiation	(4)	2.6E 01	3.9E 01	2.7E 01	2.7E 01	8.2E 01

*"Maximum" means the largest fraction of the corresponding 10CFR50 Appendix I dose design objective.

**"Maximum" dose for the year may not equal the sum of the quarterly maximum doses because the doses may be to different organs or may occur at different places.

Note:

1. The liquid effluent total body and organ doses are determined primarily by the fish pathway. These are calculated using the bioaccumulation factors , dose conversion factors and assumptions of Regulatory guide 1.109 (March 1976).
2. Airborne effluent iodine and particulate doses are determined through the inhalation pathway using reported isotopic concentrations, atmospheric dispersion assumptions of Regulatory guide 1.111 (March 1976) and inhalation dose factors of Regulatory guide 1.109. Once calculated these doses are multiplied by a constant (238) to convert them to the grass/cow/milk pathway equivalents in accordance with the OFFSITE DOSE CALCULATION MANUAL (ODCM).
3. The noble gas doses are determined using the measured isotopic concentrations, the atmospheric dispersion assumptions of Regulatory guide 1.111 and submersion dose factors from Regulatory guide 1.109.
4. Direct radiation was assessed using thermal luminescent dosimetry. Two dosimeters containing three LiF TLD chips each were placed at selected locations within each of 16 sectors around the plant. These chips were collected and read quarterly and annually.

TABLE 1A-1Q3

GASEOUS EFFLUENTS--SUMMATION OF ALL RELEASES

Farley Unit 1 - 3rd Quarter, 1984

	UNITS	QTR 3	Est Error
A. Fission & activation gases:			
1. Total release	Ci	1.82E 03	4.40E 01
2. Average release rate	uCi/sec	2.30E 02	
3. % of Technical Specification	%	4.58E-03*	
	%	1.04E-02**	
B. Iodines			
1. Total iodine-131	Ci	1.43E-03	8.71E-05
2. Average release rate	uCi/sec	1.80E-04	
3. % of Technical Specification	%	5.48E-07***	
C. Particulates			
1. Particulates with T1/2>8 days	Ci	0.00E 00	0.00E 00
2. Average release rate	uCi/sec	0.00E 00	
3. % of Technical Specification	%	0.00E 00***	
4. Gross alpha radioactivity	Ci	0.00E 00	
D. Tritium			
1. Total release	Ci	2.82E 01	1.83E-01
2. Average release rate	uCi/sec	3.54E 00	
3. % of Technical Specification	%	3.28E-07***	

*: Whole body limit (<500 mrem/yr)
**: Extrem. limit (<3000 mrem/yr)
***: % of 6.3 mrem/yr for all 18 isotopes

TABLE 1A-1Q4

GASEOUS EFFLUENTS--SUMMATION OF ALL RELEASES

Farley Unit 1 - 4th Quarter, 1984

	UNITS	QTR 4	Est Error
A. Fission & activation gases:			
1. Total release	Ci	2.85E 02	1.63E 01
2. Average release rate	uCi/sec	3.58E 01	
3. % of Technical Specification	%	1.49E-03*	
	%	3.17E-03**	
B. Iodines			
1. Total iodine-131	Ci	2.01E-03	1.24E-04
2. Average release rate	uCi/sec	2.53E-04	
3. % of Technical Specification	%	7.71E-07***	
C. Particulates			
1. Particulates with T1/2>8 days	Ci	1.20E-04	1.47E-05
2. Average release rate	uCi/sec	1.51E-05	
3. % of Technical Specification	%	1.38E-05***	
4. Gross alpha radioactivity	Ci	0.00E 00	
D. Tritium			
1. Total release	Ci	3.92E 01	2.76E-01
2. Average release rate	uCi/sec	4.93E 00	
3. % of Technical Specification	%	4.56E-07***	

*: Whole body limit (<500 mrem/yr)
**: Extrem. limit (<3000 mrem/yr)
***: % of 6.3 mrem/yr for all 18 isotopes

TABLE 1A-2Q3

GASEOUS EFFLUENTS--SUMMATION OF ALL RELEASES

Farley Unit 2 - 3rd Quarter, 1984

	UNITS	QTR 3	Est Error
A. Fission & activation gases:			
1. Total release	Ci	3.27E 03	1.28E 02
2. Average release rate	uCi/sec	4.11E 02	
3. % of Technical Specification	%	7.10E-03*	
	%	1.49E-02**	
B. Iodines			
1. Total iodine-131	Ci	4.20E-04	3.58E-05
2. Average release rate	uCi/sec	5.28E-05	
3. % of Technical Specification	%	1.51E-07***	
C. Particulates			
1. Particulates with T1/2>8 days	Ci	6.08E-06	1.99E-06
2. Average release rate	uCi/sec	7.65E-07	
3. % of Technical Specification	%	3.85E-09***	
4. Gross alpha radioactivity	Ci	0.00E 00	
D. Tritium			
1. Total release	Ci	5.91E 01	3.21E-01
2. Average release rate	uCi/sec	7.44E 00	
3. % of Technical Specification	%	6.89E-07***	

*: Whole body limit (<500 mrem/yr)
**: Extrem. limit (<3000 mrem/yr)
***: % of 6.3 mrem/yr for all 18 isotopes

TABLE 1A-2Q4

GASEOUS EFFLUENTS--SUMMATION OF ALL RELEASES

Farley Unit 2 - 4th Quarter, 1984

	UNITS	QTR 4	Est Error
A. Fission & activation gases:			
1. Total release	Ci	1.69E 02	3.22E 01
2. Average release rate	uCi/sec	2.13E 01	
3. % of Technical Specification	%	6.92E-04*	
	%	1.45E-03**	
B. Iodines			
1. Total iodine-131	Ci	2.97E-05	5.76E-06
2. Average release rate	uCi/sec	3.74E-06	
3. % of Technical Specification	%	1.14E-08***	
C. Particulates			
1. Particulates with T1/2>8 days	Ci	9.24E-07	6.16E-07
2. Average release rate	uCi/sec	1.16E-07	
3. % of Technical Specification	%	5.19E-09***	
4. Gross alpha radioactivity	Ci	0.00E 00	
D. Tritium			
1. Total release	Ci	3.57E 01	3.34E-01
2. Average release rate	uCi/sec	4.49E 00	
3. % of Technical Specification	%	4.16E-07***	

*: Whole body limit (<500 mrem/yr)
**: Extrem. limit (<3000 mrem/yr)
***: % of 6.3 mrem/yr for all 18 isotopes

TABLE 1B-1Q3

GASEOUS EFFLUENTS--ELEVATED RELEASE

Farley Unit 1 - 3rd Quarter, 1984

Nuclides Released	Unit	CONTINUOUS Mode QTR# 3	BATCH Mode QTR# 3
1. Fission gases			
Kr-85	Ci	0.00E 00	7.27E-01
Xe-138	Ci	0.00E 00	0.00E 00
Kr-87	Ci	0.00E 00	0.00E 00
Kr-85M	Ci	0.00E 00	3.12E-02
Xe-135	Ci	2.84E 02	1.05E 00
Xe-133M	Ci	0.00E 00	6.20E-01
Kr-88	Ci	0.00E 00	0.00E 00
Xe-131M	Ci	0.00E 00	1.25E 00
Xe-133	Ci	1.49E 03	4.26E 01
Total for period	Ci	1.77E 03	4.63E 01
2. Iodines			
I-133	Ci	3.20E-05	0.00E 00
I-131	Ci	1.42E-03	0.00E 00
Total for period	Ci	1.45E-03	0.00E 00
3. Particulates			
* Mo-99	Ci	0.00E 00	0.00E 00
Co-60	Ci	0.00E 00	0.00E 00
Zn-65	Ci	0.00E 00	0.00E 00
Fe-59	Ci	0.00E 00	0.00E 00
Mn-54	Ci	0.00E 00	0.00E 00
Co-58	Ci	0.00E 00	0.00E 00
Cs-137	Ci	0.00E 00	0.00E 00
Cs-134	Ci	0.00E 00	0.00E 00
* I-133	Ci	1.75E-03	0.00E 00
I-131	Ci	0.00E 00	0.00E 00
Ce-141	Ci	0.00E 00	0.00E 00
Ce-144	Ci	0.00E 00	0.00E 00
Sr-89	Ci	0.00E 00	0.00E 00
Sr-90	Ci	0.00E 00	0.00E 00
Total for period	Ci	1.75E-03	0.00E 00

* Isotope with half-life less then 8 days

TABLE 18-1Q4

GASEOUS EFFLUENTS--ELEVATED RELEASE

Farley Unit 1 - 4th Quarter, 1984

Nuclides Released	Unit	CONTINUOUS Mode QTR# 4	BATCH Mode QTR# 4
1. Fission gases			
Ar-41	Ci	2.37E 00	0.00E 00
Kr-90	Ci	5.41E-06	0.00E 00
Xe-138	Ci	0.00E 00	0.00E 00
Kr-87	Ci	0.00E 00	0.00E 00
Xe-135	Ci	1.28E 02	0.00E 00
Xe-133M	Ci	0.00E 00	0.00E 00
Kr-88	Ci	8.76E-01	0.00E 00
Xe-133	Ci	1.49E 02	0.00E 00
Total for period	Ci	2.80E 02	0.00E 00
2. Iodines			
I-133	Ci	4.59E-04	0.00E 00
I-131	Ci	1.98E-03	0.00E 00
Total for period	Ci	2.44E-03	0.00E 00
3. Particulates			
* Mo-99	Ci	0.00E 00	0.00E 00
Co-60	Ci	3.20E-05	0.00E 00
Zn-65	Ci	0.00E 00	0.00E 00
Fe-59	Ci	0.00E 00	0.00E 00
Mn-54	Ci	1.21E-05	0.00E 00
Co-58	Ci	5.68E-05	0.00E 00
Zr-95	Ci	1.64E-05	0.00E 00
Cs-137	Ci	0.00E 00	0.00E 00
Cs-134	Ci	0.00E 00	0.00E 00
* I-133	Ci	1.01E-03	0.00E 00
I-131	Ci	0.00E 00	0.00E 00
Ce-141	Ci	0.00E 00	0.00E 00
Ce-144	Ci	0.00E 00	0.00E 00
Sr-89	Ci	0.00E 00	0.00E 00
Sr-90	Ci	0.00E 00	0.00E 00
Total for period	Ci	1.12E-03	0.00E 00

* Isotope with half-life less then 8 days

TABLE 1B-2Q3

GASEOUS EFFLUENTS--ELEVATED RELEASE

Farley Unit 2 - 3rd Quarter, 1984

Nuclides Released	Unit	CONTINUOUS Mode QTR# 3	BATCH Mode QTR# 3
1. Fission gases			
Ar-41	Ci	4.49E 01	0.00E 00
Kr-90	Ci	6.76E-09	0.00E 00
Kr-85	Ci	0.00E 00	1.31E 00
Xe-138	Ci	0.00E 00	0.00E 00
Kr-87	Ci	0.00E 00	0.00E 00
Kr-85M	Ci	0.00E 00	3.78E-03
Xe-135	Ci	1.06E 02	2.91E-02
Xe-133M	Ci	0.00E 00	4.69E-01
Kr-88	Ci	0.00E 00	0.00E 00
Xe-131M	Ci	0.00E 00	3.05E-01
Xe-133	Ci	3.06E 03	4.25E 01
Total for period	Ci	3.21E 03	4.46E 01
2. Iodines			
I-133	Ci	1.60E-05	6.07E-08
I-131	Ci	4.17E-04	1.84E-06
Total for period	Ci	4.33E-04	1.90E-06
3. Particulates			
* Mo-99	Ci	0.00E 00	0.00E 00
Co-60	Ci	0.00E 00	1.86E-10
Zn-65	Ci	0.00E 00	0.00E 00
Fe-59	Ci	0.00E 00	0.00E 00
Mn-54	Ci	0.00E 00	0.00E 00
Co-58	Ci	0.00E 00	0.00E 00
Cs-137	Ci	5.40E-07	0.00E 00
Cs-134	Ci	0.00E 00	0.00E 00
* I-133	Ci	0.00E 00	6.07E-08
I-131	Ci	0.00E 00	1.84E-06
Ce-141	Ci	3.62E-06	0.00E 00
Ce-144	Ci	0.00E 00	0.00E 00
Sr-89	Ci	0.00E 00	0.00E 00
Sr-90	Ci	0.00E 00	0.00E 00
Total for period	Ci	4.16E-06	1.90E-06

* Isotope with half-life less then 8 days

TABLE 1B-2Q4

GASEOUS EFFLUENTS--ELEVATED RELEASE

Farley Unit 2 - 4th Quarter, 1984

Nuclides Released	Unit	CONTINUOUS Mode QTR# 4	BATCH Mode QTR# 4
1. Fission gases			
Ar-41	Ci	9.87E 00	0.00E 00
Kr-85	Ci	3.56E 01	0.00E 00
Xe-138	Ci	0.00E 00	0.00E 00
Kr-87	Ci	0.00E 00	0.00E 00
Kr-85M	Ci	1.54E-01	0.00E 00
Xe-135	Ci	1.19E 01	0.00E 00
Xe-133M	Ci	0.00E 00	0.00E 00
Kr-88	Ci	2.12E-01	0.00E 00
Xe-133	Ci	1.09E 02	0.00E 00
Total for period	Ci	1.67E 02	0.00E 00
2. Iodines			
I-133	Ci	2.94E-07	0.00E 00
I-131	Ci	2.81E-05	0.00E 00
Total for period	Ci	2.84E-05	0.00E 00
3. Particulates			
* Mo-99	Ci	0.00E 00	0.00E 00
Co-60	Ci	0.00E 00	0.00E 00
Zn-65	Ci	0.00E 00	0.00E 00
Fe-59	Ci	0.00E 00	0.00E 00
Mn-54	Ci	0.00E 00	0.00E 00
Co-58	Ci	0.00E 00	0.00E 00
Cs-137	Ci	8.85E-07	0.00E 00
Cs-134	Ci	0.00E 00	0.00E 00
* I-133	Ci	0.00E 00	0.00E 00
I-131	Ci	0.00E 00	0.00E 00
Ce-141	Ci	0.00E 00	0.00E 00
Ce-144	Ci	0.00E 00	0.00E 00
Sr-89	Ci	0.00E 00	0.00E 00
Sr-90	Ci	0.00E 00	0.00E 00
Total for period	Ci	8.85E-07	0.00E 00

* Isotope with half-life less then 8 days

TABLE 1C-1Q3

GASEOUS EFFLUENTS--GROUND RELEASE

Farley Unit 1 - 3rd Quarter, 1984

Nuclides Released	Unit	CONTINUOUS Mode QTR# 3	BATCH Mode QTR# 3
1. Fission gases			
Xe-138	Ci	0.00E 00	0.00E 00
Kr-87	Ci	0.00E 00	0.00E 00
Xe-135	Ci	1.29E 00	0.00E 00
Xe-133M	Ci	0.00E 00	0.00E 00
Kr-88	Ci	0.00E 00	0.00E 00
Xe-133	Ci	5.21E 00	0.00E 00
Total for period	Ci	6.50E 00	0.00E 00
2. Iodines			
I-133	Ci	2.37E-07	0.00E 00
I-131	Ci	8.89E-06	0.00E 00
Total for period	Ci	9.12E-06	0.00E 00
3. Particulates			
* Mo-99	Ci	0.00E 00	0.00E 00
Co-60	Ci	0.00E 00	0.00E 00
Zn-65	Ci	0.00E 00	0.00E 00
Fe-59	Ci	0.00E 00	0.00E 00
Mn-54	Ci	0.00E 00	0.00E 00
Co-58	Ci	0.00E 00	0.00E 00
Cs-137	Ci	0.00E 00	0.00E 00
Cs-134	Ci	0.00E 00	0.00E 00
* I-133	Ci	1.30E-05	0.00E 00
I-131	Ci	0.00E 00	0.00E 00
Ce-141	Ci	0.00E 00	0.00E 00
Ce-144	Ci	0.00E 00	0.00E 00
Sr-89	Ci	0.00E 00	0.00E 00
Sr-90	Ci	0.00E 00	0.00E 00
Total for period	Ci	1.30E-05	0.00E 00

* Isotope with half-life less then 8 days

TABLE 1C-1Q4

GASEOUS EFFLUENTS--GROUND RELEASE

Farley Unit 1 - 4th Quarter, 1984

Nuclides Released	Unit	CONTINUOUS Mode QTR# 4	BATCH Mode QTR# 4
1. Fission gases			
Ar-41	Ci	1.25E-02	0.00E 00
Kr-90	Ci	1.12E-07	0.00E 00
Xe-138	Ci	0.00E 00	0.00E 00
Kr-87	Ci	0.00E 00	0.00E 00
Xe-135	Ci	2.11E 00	0.00E 00
Xe-133M	Ci	0.00E 00	0.00E 00
Kr-88	Ci	7.63E-03	0.00E 00
Xe-133	Ci	2.44E 00	0.00E 00
Total for period	Ci	4.57E 00	0.00E 00
2. Iodines			
I-133	Ci	4.26E-06	0.00E 00
I-131	Ci	2.97E-05	0.00E 00
Total for period	Ci	3.40E-05	0.00E 00
3. Particulates			
* Mo-99	Ci	0.00E 00	0.00E 00
Co-60	Ci	8.06E-07	0.00E 00
Zn-65	Ci	0.00E 00	0.00E 00
Fe-59	Ci	0.00E 00	0.00E 00
Mn-54	Ci	3.04E-07	0.00E 00
Co-58	Ci	1.43E-06	0.00E 00
Zr-95	Ci	4.12E-07	0.00E 00
Cs-137	Ci	0.00E 00	0.00E 00
Cs-134	Ci	0.00E 00	0.00E 00
* I-133	Ci	6.54E-06	0.00E 00
I-131	Ci	0.00E 00	0.00E 00
Ce-141	Ci	0.00E 00	0.00E 00
Ce-144	Ci	0.00E 00	0.00E 00
Sr-89	Ci	0.00E 00	0.00E 00
Sr-90	Ci	0.00E 00	0.00E 00
Total for period	Ci	9.50E-06	0.00E 00

* Isotope with half-life less then 8 days

TABLE 1C-2Q3

GASEOUS EFFLUENTS--GROUND RELEASE

Farley Unit 2 - 3rd Quarter, 1984

Nuclides Released	Unit	CONTINUOUS Mode QTR# 3	BATCH Mode QTR# 3
1. Fission gases			
Ar-41	Ci	1.55E-01	0.00E 00
Kr-90	Ci	2.30E-11	0.00E 00
Kr-85	Ci	0.00E 00	1.75E-02
Xe-138	Ci	0.00E 00	0.00E 00
Kr-87	Ci	9.31E-05	0.00E 00
Xe-135	Ci	3.88E-01	2.97E-05
Xe-133M	Ci	0.00E 00	9.81E-03
Kr-88	Ci	3.94E-04	0.00E 00
Xe-131M	Ci	0.00E 00	2.85E-03
Xe-133	Ci	1.42E 01	9.42E-01
Total for period	Ci	1.48E 01	9.72E-01
2. Iodines			
I-133	Ci	2.51E-09	0.00E 00
I-131	Ci	7.29E-07	6.04E-10
Total for period	Ci	7.32E-07	6.04E-10
3. Particulates			
* Mo-99	Ci	0.00E 00	0.00E 00
Co-60	Ci	0.00E 00	0.00E 00
Zn-65	Ci	0.00E 00	0.00E 00
Fe-59	Ci	0.00E 00	0.00E 00
Mn-54	Ci	0.00E 00	0.00E 00
Co-58	Ci	0.00E 00	0.00E 00
Cs-137	Ci	3.04E-09	0.00E 00
Cs-134	Ci	0.00E 00	0.00E 00
* I-133	Ci	0.00E 00	0.00E 00
I-131	Ci	0.00E 00	5.98E-10
Cr-51	Ci	2.73E-08	0.00E 00
Ce-141	Ci	5.09E-08	0.00E 00
Ce-144	Ci	0.00E 00	0.00E 00
Sr-89	Ci	0.00E 00	0.00E 00
Sr-90	Ci	0.00E 00	0.00E 00
Total for period	Ci	8.12E-08	5.98E-10

* Isotope with half-life less then 8 days

TABLE 1C-2Q4

GASEOUS EFFLUENTS--GROUND RELEASE

Farley Unit 2 - 4th Quarter, 1984

Nuclides Released	Unit	CONTINUOUS Mode QTR# 4	BATCH Mode QTR# 4
1. Fission gases			
Ar-41	Ci	1.28E-01	0.00E 00
Kr-85	Ci	6.12E-01	0.00E 00
Xe-138	Ci	0.00E 00	0.00E 00
Kr-87	Ci	0.00E 00	0.00E 00
Kr-85M	Ci	1.57E-03	0.00E 00
Xe-135	Ci	2.14E-01	0.00E 00
Xe-133M	Ci	0.00E 00	0.00E 00
Kr-88	Ci	2.16E-03	0.00E 00
Xe-133	Ci	1.44E 00	0.00E 00
Total for period	Ci	2.39E 00	0.00E 00
2. Iodines			
I-133	Ci	5.75E-09	0.00E 00
I-131	Ci	1.58E-06	0.00E 00
Total for period	Ci	1.59E-06	0.00E 00
3. Particulates			
* Mo-99	Ci	0.00E 00	0.00E 00
Co-60	Ci	0.00E 00	0.00E 00
Zn-65	Ci	0.00E 00	0.00E 00
Fe-59	Ci	0.00E 00	0.00E 00
Mn-54	Ci	0.00E 00	0.00E 00
Co-58	Ci	0.00E 00	0.00E 00
Cs-137	Ci	3.34E-08	0.00E 00
Cs-134	Ci	0.00E 00	0.00E 00
* I-133	Ci	0.00E 00	0.00E 00
I-131	Ci	0.00E 00	0.00E 00
Ce-141	Ci	5.98E-09	0.00E 00
Ce-144	Ci	0.00E 00	0.00E 00
Sr-89	Ci	0.00E 00	0.00E 00
Sr-90	Ci	0.00E 00	0.00E 00
Total for period	Ci	3.94E-08	0.00E 00

* Isotope with half-life less then 8 days

TABLE 2A-1

LIQUID EFFLUENT--SUMMATION OF ALL RELEASES
Farley Unit 1 - 2nd Half, 1984

		UNIT	Qtr 3	Qtr 4
A. Fission and Activation Products				
1. Total release	Note (4)	Ci	1.27E-02	1.13E-02
2. Average diluted concentration During Period	Note (1)	uCi/ml	1.14E-08	8.66E-09
3. Percent of applicable limit During Period	Note (1)	%	9.96E-02	6.43E-02
B. Tritium				
1. Total release	Note (4)	Ci	1.31E 02	1.46E 02
2. Average diluted concentration During Period	Note (1)	uCi/ml	1.21E-04	1.13E-04
3. Percent of applicable limit During Period	Note (1)	%	4.03E 00	3.74E 00
C. Dissolved and Entrained Gases				
1. Total release	Note (4)	Ci	1.36E-02	1.00E-02
2. Average diluted concentration During Period	Note (1)	uCi/ml	1.25E-08	7.70E-09
3. Percent of applicable limit During Period	Note (1)	%	3.13E-02	1.93E-02
D. Gross Alpha Radioactivity				
1. Total release	Note (4)	Ci	6.39E-05	0.00E 00
E. Volume of Waste Water	Note (2)			
1. WMT		liters	1.39E 06	1.74E 06
2. SGBD and Turbine Bldg Sumps		liters	6.54E 07	7.17E 07
3. Liquid Radioactive Effluent TOTAL	Note(3)	liters	1.39E 06	1.74E 06
F. Volume of Dilution Water During Quarter		liters	1.63E 10	2.60E 10

NOTE:

(1) During period of discharge

(2) Prior to dilution

(3) Steam Generator Blowdown and Turbine Building Sump releases are excluded from Total Liquid Radioactive Effluent in accordance with 10 CFR 20, Appendix B, Note 5.

(4) Steam Generator Blowdown and Turbine Building Sump release curie amounts and doses were measured and are included in these totals and in table 2B-1C in accordance with TABLE 4.11-1, Footnote E of Joseph M. Farley Nuclear Plant Unit Number 1 Technical Specifications (Appendix A of License No. NPF-2).

TABLE 2A-2

LIQUID EFFLUENT--SUMMATION OF ALL RELEASES
Farley Unit 2 - 2nd Half, 1984

		UNIT	Qtr 3	Qtr 4
A. Fission and Activation Products				
1. Total release	Note (4)	Ci	4.48E-02	1.10E-02
2. Average diluted concentration During Period	Note (1)	uCi/ml	1.55E-08	4.91E-09
3. Percent of applicable limit During Period	Note (1)	%	1.64E-01	8.43E-02
B. Tritium				
1. Total release	Note (4)	Ci	1.22E 02	1.34E 02
2. Average diluted concentration During Period	Note (1)	uCi/ml	1.50E-04	1.63E-04
3. Percent of applicable limit During Period	Note (1)	%	4.98E 00	5.45E 00
C. Dissolved and Entrained Gases				
1. Total release	Note (4)	Ci	5.03E-03	1.11E-02
2. Average diluted concentration During Period	Note (1)	uCi/ml	8.44E-09	1.38E-08
3. Percent of applicable limit During Period	Note (1)	%	2.11E-02	3.45E-02
D. Gross Alpha Radioactivity				
1. Total release	Note (4)	Ci	5.45E-05	0.00E 00
E. Volume of Waste Water	Note (2)			
1. WMT		liters	6.97E 05	1.15E 06
2. SGBD and Turbine Bldg Sumps		liters	7.36E 07	7.22E 07
3. Liquid Radioactive Effluent TOTAL	Note(3)	liters	6.97E 05	1.15E 06
F. Volume of Dilution Water During Quarter		liters	2.01E 10	1.83E 10

NOTE:

(1) During period of discharge
(2) Prior to dilution
(3) Steam Generator Blowdown and Turbine Building Sump releases are excluded from Total Liquid Radioactive Effluent in accordance with 10 CFR 20, Appendix B, Note 5.
(4) Steam Generator Blowdown and Turbine Building Sump release curie amounts and doses were measured and are included in these totals and in table 2B-2C in accordance with TABLE 4.11-1, Footnote E of Joseph M. Farley Nuclear Plant Unit Number 2 Technical Specifications (Appendix A of License No. NPF-8).

TABLE 2B-1B

LIQUID EFFLUENTS--BATCH
Farley Unit 1 - 2nd Half, 1984

Nuclides Released	Unit	Qtr 3	Qtr 4
Sr-89	Ci	0.00E 00	0.00E 00
Sr-90	Ci	0.00E 00	0.00E 00
Fe-55	Ci	2.84E-03	7.29E-03
Co-57	Ci	0.00E 00	0.00E 00
Ce-144	Ci	4.52E-04	1.48E-05
Tc-99M	Ci	1.56E-05	2.08E-05
Ce-141	Ci	2.46E-06	0.00E 00
Cr-51	Ci	0.00E 00	7.08E-06
I-131	Ci	1.79E-04	6.15E-05
Ru-103	Ci	0.00E 00	1.01E-06
I-133	Ci	8.18E-05	1.87E-04
Ba-140	Ci	2.13E-05	0.00E 00
As-76	Ci	0.00E 00	0.00E 00
Cs-134	Ci	6.77E-06	1.00E-05
Ru-106	Ci	4.73E-04	0.00E 00
Cs-137	Ci	5.53E-05	2.47E-05
Mo-99	Ci	0.00E 00	6.25E-06
Zr-95	Ci	5.61E-06	1.78E-06
Nb-95	Ci	7.41E-04	1.78E-04
I-132	Ci	0.00E 00	6.08E-06
Co-58	Ci	6.48E-04	1.51E-04
Cs-136	Ci	1.24E-04	6.86E-06
Mn-54	Ci	5.68E-05	1.01E-05
Ag-110M	Ci	3.03E-03	8.83E-04
Sr-91	Ci	0.00E 00	8.63E-06
Zn-65	Ci	0.00E 00	4.09E-06
I-135	Ci	0.00E 00	6.05E-05
Fe-59	Ci	0.00E 00	0.00E 00
Co-60	Ci	2.70E-03	2.00E-03
Na-24	Ci	6.67E-06	1.32E-07
La-140	Ci	8.40E-05	3.35E-06
Cu-64	Ci	9.91E-05	2.90E-04
Sb-124	Ci	8.17E-04	7.28E-06
TOTALS	Ci	1.24E-02	1.12E-02
Xe-133	Ci	1.34E-02	9.70E-03
Xe-135	Ci	1.68E-04	0.00E 00
TOTALS	Ci	1.36E-02	9.70E-03
H-3	Ci	1.31E 02	1.45E 02

TABLE 2B-2B

LIQUID EFFLUENTS--BATCH
Farley Unit 2 - 2nd Half, 1984

Nuclides Released	Unit	Qtr 3	Qtr 4
Sr-89	Ci	0.00E 00	0.00E 00
Sr-90	Ci	0.00E 00	0.00E 00
Fe-55	Ci	7.46E-04	2.59E-03
Co-57	Ci	0.00E 00	0.00E 00
Ce-144	Ci	2.64E-04	3.73E-05
Tc-99M	Ci	0.00E 00	2.00E-05
Ce-141	Ci	0.00E 00	2.02E-06
Np-239	Ci	0.00E 00	1.06E-05
Cr-51	Ci	0.00E 00	5.49E-05
I-131	Ci	3.64E-06	1.17E-04
Ru-103	Ci	0.00E 00	1.03E-06
I-133	Ci	3.32E-07	1.77E-04
Ba-140	Ci	0.00E 00	1.93E-05
As-76	Ci	0.00E 00	0.00E 00
Cs-134	Ci	2.19E-05	6.42E-05
Ru-106	Ci	2.71E-04	0.00E 00
Cs-137	Ci	5.85E-04	1.44E-04
Mo-99	Ci	0.00E 00	0.00E 00
Zr-95	Ci	0.00E 00	1.32E-05
Nb-95	Ci	5.26E-04	4.27E-05
I-132	Ci	0.00E 00	0.00E 00
Co-58	Ci	6.29E-04	3.41E-04
Cs-136	Ci	1.10E-04	5.05E-07
Mn-54	Ci	9.63E-05	3.23E-05
Ag-110M	Ci	2.04E-03	1.21E-04
Zn-65	Ci	0.00E 00	0.00E 00
I-135	Ci	0.00E 00	1.97E-05
Fe-59	Ci	2.51E-06	0.00E 00
Co-60	Ci	1.69E-03	2.45E-04
Na-24	Ci	2.64E-06	0.00E 00
La-140	Ci	2.26E-05	8.81E-06
Sb-124	Ci	4.58E-04	0.00E 00
TOTALS	Ci	7.47E-03	4.06E-03
Xe-133	Ci	4.84E-03	1.10E-02
Xe-135	Ci	1.79E-04	8.35E-05
TOTALS	Ci	5.02E-03	1.11E-02
H-3	Ci	8.61E 01	1.30E 02

TABLE 2B-1C

LIQUID EFFLUENTS--CONTINUOUS
Farley Unit 1 - 2nd Half, 1984

Nuclides Released	Unit	Qtr 3	Qtr 4
Sr-89	Ci	0.00E 00	0.00E 00
Sr-90	Ci	0.00E 00	0.00E 00
Ce-144	Ci	0.00E 00	0.00E 00
Ce-141	Ci	0.00E 00	0.00E 00
Np-239	Ci	3.55E-05	0.00E 00
Cs-134	Ci	0.00E 00	0.00E 00
Cs-137	Ci	0.00E 00	6.82E-05
Mo-99	Ci	0.00E 00	0.00E 00
Co-58	Ci	0.00E 00	0.00E 00
Mn-54	Ci	0.00E 00	0.00E 00
Ag-110M	Ci	1.36E-04	0.00E 00
Sr-91	Ci	2.18E-05	0.00E 00
Zn-65	Ci	0.00E 00	0.00E 00
Fe-59	Ci	0.00E 00	0.00E 00
Co-60	Ci	7.65E-05	0.00E 00
Zr-95	Ci	0.00E 00	0.00E 00
TOTALS	Ci	2.70E-04	6.82E-05
Xe-133	Ci	0.00E 00	0.00E 00
Xe-135	Ci	0.00E 00	0.00E 00
Kr-87	Ci	0.00E 00	0.00E 00
Kr-88	Ci	0.00E 00	0.00E 00
TOTALS	Ci	0.00E 00	0.00E 00
H-3	Ci	3.80E-02	1.16E 00

NOTE:

Although Steam Generator Blowdown and Turbine Building Sump releases were excluded from total liquid radioactive effluent volume in accordance with 10 CFR 20, Appendix B, Note 5, curie amounts and doses from these releases were measured and are reported here in accordance with Table 4.11-1, Footnote E of Joseph M. Farley Nuclear Plant Unit Number 1 Technical Specification (Appendix A of License No. NPF-2).

TABLE 2B-2C

LIQUID EFFLUENTS--CONTINUOUS
Farley Unit 2 - 2nd Half, 1984

Nuclides Released	Unit	Qtr 3	Qtr 4
Sr-89	Ci	0.00E 00	0.00E 00
Sr-90	Ci	0.00E 00	0.00E 00
Ce-144	Ci	0.00E 00	0.00E 00
Ce-141	Ci	0.00E 00	0.00E 00
Cs-134	Ci	5.10E-03	5.54E-04
Cs-137	Ci	6.91E-03	9.93E-04
Mo-99	Ci	7.36E-04	0.00E 00
Zr-95	Ci	0.00E 00	0.00E 00
Nb-95	Ci	3.17E-03	8.75E-05
Co-58	Ci	8.09E-03	4.86E-03
Mn-54	Ci	4.99E-04	1.21E-04
Zn-65	Ci	0.00E 00	0.00E 00
I-135	Ci	1.08E-03	0.00E 00
Fe-59	Ci	0.00E 00	0.00E 00
Co-60	Ci	4.74E-04	2.09E-04
I-131	Ci	4.21E-03	0.00E 00
I-133	Ci	4.15E-03	0.00E 00
Na-24	Ci	2.87E-03	0.00E 00
Fe-55	Ci	0.00E 00	0.00E 00
Ag-110M	Ci	0.00E 00	1.34E-04
TOTALS	Ci	3.73E-02	6.96E-03
Xe-133	Ci	1.41E-05	0.00E 00
Xe-135	Ci	0.00E 00	0.00E 00
Kr-87	Ci	0.00E 00	0.00E 00
Kr-88	Ci	0.00E 00	0.00E 00
TOTALS	Ci	1.41E-05	0.00E 00
H-3	Ci	3.59E 01	3.59E 00

NOTE:

Although Steam Generator Blowdown and Turbine Building Sump releases were excluded from total liquid radioactive effluent volume in accordance with 10 CFR 20, Appendix B, Note 5, curie amounts and doses from these releases were measured and are reported here in accordance with Table 4.11-1, Footnote E of Joseph M. Farley Nuclear Plant Unit Number 2 Technical Specification (Appendix A of License No. NPF-8).

TABLE 3

EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1984)

SOLID WASTE AND IRRADIATED FUEL SHIPMENTS

SOLID WASTE SHIPPED OFFSITE FOR BURIAL OR DISPOSAL
(Not irradiated fuel)

1. Type of Waste	UNITS	PERIOD July 1- Dec.31
a. Spent resins, filter sludges,	m^3	1.393E 01
evaporator bottoms, etc.	Ci	1.537E 02
b. Dry compressible waste,	m^3	2.399E 02
contaminated equipment, etc.	Ci	1.887E 01
c. Irradiated components,	m^3	None
control rods, etc.	Ci	None
d. Other (described)	m^3	None
	Ci	None

2. Estimate of major nuclide composition

	ISOTOPES	%	ISOTOPES	%
a.	H-3	3.10		
	Co-58	22.35		
	Co-60	50.64		
	Ni-63	9.90		
	Nb-95	0.47		
	Ce-144	0.16		
	Mn-54	13.31		
	Cs-137	0.07		
b.	H-3	42.19	Zr-95	0.73
	Cr-51	1.03	Cs-134	5.12
	Mn-54	0.55	Cs-137	11.90
	Co-58	1.17	Sr-90	0.45
	Co-60	26.64	Pu-241	0.66
	Ni-63	3.82	Ce-144	3.95
	Nb-95	1.79		

TABLE 3 (con't)

EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1984)

SOLID WASTE AND IRRADIATED FUEL SHIPMENTS

3. Solid Waste Disposition

a. Number of Shipments	15
b. Mode of Transportation	Chem-Nuclear Transport (11) Hittman Transport (4)
c. Destination	Chem-Nuclear Systems, Inc. Barnwell, South Carolina

4. Type of Containers

a. (1a)	170 cu.ft. steel liners (dewatered resin & charcoal media) 55 cu.ft. High Integrity Containers (Spent filters)
b. (1b)	55 gallon steel drum 112 cu.ft. wooden boxes

5. Solidification Agents

a. (1a)	No solidifications during this period. All items (spent resin and charcoal) that are categorized for item 1a were shipped dewatered.
b. (1b)	N/A

B. IRRADIATED FUEL SHIPMENTS (Disposition)

1. Number of Shipments	None
2. Mode of Transportation	N/A
3. Destination	N/A

Table 4A-CQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: A
ELEVATION:45.7m

Wind Direction	Wind Speed (mph) at 45.7m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	3	2	2	0	0	0	7
NNE	4	10	1	0	0	0	15
NE	6	3	5	1	0	0	15
ENE	3	19	24	7	0	0	53
E	5	26	25	2	0	0	58
ESE	8	20	17	0	0	0	45
SE	5	16	14	0	0	0	35
SSE	3	11	10	0	0	0	24
S	1	5	2	0	0	0	8
SSW	1	6	1	1	0	0	9
SW	1	7	15	1	0	0	24
WSW	7	16	8	0	0	0	31
W	0	7	4	0	0	0	11
WNW	1	11	2	0	0	0	14
NW	4	7	10	0	0	0	21
NNW	4	0	0	0	0	0	4
VARIABLE	0	0	0	0	0	0	0
Total	56	166	140	12	0	0	374

Periods of calm(hours): 0
Hours of missing data: 0

Table 4A-CQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: A
ELEVATION:10.0m

Wind Direction	Wind Speed (mph) at 10.0m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	6	5	0	0	0	0	11
NNE	8	7	0	0	0	0	15
NE	8	10	18	0	0	0	36
ENE	4	36	22	0	0	0	62
E	7	35	6	0	0	0	48
ESE	15	26	7	0	0	0	48
SE	4	21	5	0	0	0	30
SSE	1	5	1	0	0	0	7
S	3	6	0	0	0	0	9
SSW	2	6	6	0	0	0	14
SW	7	19	8	0	0	0	34
WSW	5	8	2	0	0	0	15
W	5	8	0	0	0	0	13
WNW	3	11	6	0	0	0	20
NW	2	4	3	0	0	0	9
NNW	1	2	0	0	0	0	3
VARIABLE	0	0	0	0	0	0	0
Total	81	209	84	0	0	0	374

Periods of calm(hours): 0
Hours of missing data: 0

Table 4A-CQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: B
ELEVATION:45.7m

Wind Direction	Wind Speed (mph) at 45.7m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	2	7	5	0	0	0	14
NNE	2	7	5	0	0	0	14
NE	3	1	0	0	0	0	4
ENE	1	4	4	1	0	0	10
E	7	7	4	1	0	0	19
ESE	3	3	6	0	0	0	12
SE	1	2	2	0	0	0	5
SSE	3	3	2	0	0	0	8
S	1	1	0	0	0	0	2
SSW	2	1	1	0	0	0	4
SW	1	1	2	0	0	0	4
WSW	0	11	2	0	0	0	13
W	2	8	2	0	0	1	13
WNW	4	13	3	0	0	0	20
NW	1	17	8	1	0	0	27
NNW	2	6	3	0	0	0	11
VARIABLE	0	0	0	0	0	0	0
Total	35	92	49	3	0	1	180

Periods of calm(hours): 0
Hours of missing data: 0

Table 4A-CQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: B
ELEVATION:10.0m

Wind Direction	Wind Speed (mph) at 10.0m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	5	12	0	0	0	0	17
NNE	1	0	0	0	0	0	1
NE	3	1	2	0	0	0	6
ENE	8	7	3	0	0	0	18
E	5	8	3	0	0	0	16
ESE	2	4	0	0	0	0	6
SE	4	2	2	0	0	0	8
SSE	2	3	0	0	0	0	5
S	1	1	0	0	0	0	2
SSW	1	1	0	0	0	0	2
SW	2	10	1	0	0	0	13
WSW	4	10	0	0	0	1	15
W	4	8	1	0	0	0	13
WNW	3	21	3	0	0	0	27
NW	4	14	1	0	0	0	19
NNW	4	8	0	0	0	0	12
VARIABLE	0	0	0	0	0	0	0
Total	53	110	16	0	0	1	180

Periods of calm(hours): 0
Hours of missing data: 0

Table 4A-CQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: C
ELEVATION:45.7m

Wind Direction	Wind Speed (mph) at 45.7m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	4	8	3	0	0	0	15
NNE	3	4	2	0	0	0	9
NE	3	1	0	0	0	0	4
ENE	2	3	2	1	0	0	8
E	1	6	2	0	0	0	9
ESE	0	3	5	0	0	0	8
SE	1	4	4	2	0	0	11
SSE	4	2	4	0	0	0	10
S	1	1	0	0	0	0	2
SSW	0	2	1	0	0	0	3
SW	1	6	4	1	0	0	12
WSW	0	17	1	0	0	0	18
W	5	4	2	0	0	0	11
WNW	0	6	0	0	0	0	6
NW	4	18	3	0	0	0	25
NNW	3	6	1	0	0	0	10
VARIABLE	0	0	0	0	0	0	0
Total	32	91	34	4	0	0	161

Periods of calm(hours): 0
Hours of missing data: 0

Table 4A-CQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: C
ELEVATION:10.0m

Wind Direction	Wind Speed (mph) at 10.0m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	7	6	0	0	0	0	13
NNE	3	3	0	0	0	0	6
NE	4	1	2	0	0	0	7
ENE	2	5	1	0	0	0	8
E	4	3	0	0	0	0	7
ESE	2	8	2	0	0	0	12
SE	3	4	3	0	0	0	10
SSE	2	2	0	0	0	0	4
S	0	1	0	0	0	0	1
SSW	2	3	1	1	0	0	7
SW	1	10	4	0	0	0	15
WSW	8	11	2	0	0	0	21
W	3	1	0	0	0	0	4
WNW	6	15	0	0	0	0	21
NW	6	8	0	0	0	0	14
NNW	2	9	0	0	0	0	11
VARIABLE	0	0	0	0	0	0	0
Total	55	90	15	1	0	0	161

Periods of calm(hours): 0
Hours of missing data: 0

Table 4A-CQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: D
ELEVATION:45.7m

Wind Direction	Wind Speed (mph) at 45.7m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	7	8	1	0	0	0	16
NNE	2	9	6	0	0	0	17
NE	6	2	4	0	0	0	12
ENE	4	6	18	2	0	0	30
E	1	10	9	2	0	0	22
ESE	6	6	1	1	0	0	14
SE	8	8	6	0	0	0	22
SSE	2	4	2	0	0	0	8
S	5	2	2	0	0	0	9
SSW	3	0	2	0	0	0	5
SW	4	9	5	3	0	0	21
WSW	7	11	4	0	0	0	22
W	2	12	5	1	0	0	20
WNW	4	6	0	0	0	0	10
NW	7	15	3	0	0	0	25
NNW	10	5	4	1	0	0	20
VARIABLE	0	0	0	0	0	0	0
Total	78	113	72	10	0	0	273

Periods of calm(hours): 0
Hours of missing data: 0

Table 4A-CQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: D
ELEVATION: 10.0m

Wind Direction	Wind Speed (mph) at 10.0m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	10	9	0	0	0	0	19
NNE	9	2	0	0	0	0	11
NE	9	7	10	0	0	0	26
ENE	9	9	10	0	0	0	28
E	5	9	0	1	0	0	15
ESE	11	12	0	0	0	0	23
SE	3	6	0	0	0	0	9
SSE	3	1	0	0	0	0	4
S	4	2	1	0	0	0	7
SSW	4	2	2	0	0	0	8
SW	10	13	4	0	0	0	27
WSW	6	10	0	1	0	0	17
W	7	11	0	0	0	0	18
WNW	8	8	0	0	0	0	16
NW	15	10	4	0	0	0	29
NNW	9	6	1	0	0	0	16
VARIABLE	0	0	0	0	0	0	0
Total	122	117	32	2	0	0	273

Periods of calm(hours): 0
Hours of missing data: 0

Table 4A-CQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: E
ELEVATION:45.7m

Wind Direction	Wind Speed (mph) at 45.7m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	5	23	4	0	0	1	33
NNE	6	15	19	0	0	0	40
NE	5	15	13	0	0	0	33
ENE	11	30	28	0	0	0	69
E	12	31	16	0	0	0	59
ESE	14	15	28	1	0	0	58
SE	5	28	11	0	0	0	44
SSE	10	17	11	0	0	0	38
S	13	7	6	0	0	0	26
SSW	10	9	8	1	0	0	28
SW	9	32	60	7	0	0	108
WSW	6	29	26	0	0	1	62
W	7	30	5	0	0	0	42
WNW	5	7	15	0	0	1	28
NW	11	8	11	0	0	0	30
NNW	1	10	13	1	0	0	25
VARIABLE	0	0	0	0	0	0	0
Total	130	306	274	10	0	3	723

Periods of calm(hours): 0
Hours of missing data: 0

Table 4A-CQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: E
ELEVATION:10.0m

Wind Direction	Wind Speed (mph) at 10.0m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	34	13	0	0	0	0	47
NNE	43	12	0	0	0	0	55
NE	20	27	4	0	0	0	51
ENE	27	23	3	0	0	0	53
E	27	37	0	0	0	0	64
ESE	23	18	0	0	0	0	41
SE	19	16	1	0	0	0	36
SSE	15	5	0	0	0	0	20
S	14	7	1	0	0	0	22
SSW	7	12	10	0	0	0	29
SW	48	49	19	0	1	0	117
WSW	32	11	1	0	0	0	44
W	33	4	0	1	0	0	38
WNW	15	8	0	0	0	0	23
NW	19	18	2	0	0	0	39
NNW	31	12	0	0	0	1	44
VARIABLE	0	0	0	0	0	0	0
Total	407	272	41	1	1	1	723

Periods of calm(hours): 0
Hours of missing data: 0

Table 4A-CQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: F
ELEVATION:45.7m

Wind Direction	Wind Speed (mph) at 45.7m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	7	8	2	0	0	0	17
NNE	3	9	9	0	0	0	21
NE	3	6	7	0	0	1	17
ENE	1	9	17	0	0	0	27
E	4	5	15	0	0	0	24
ESE	4	8	11	0	0	0	23
SE	6	4	2	0	0	0	12
SSE	5	5	3	0	0	0	13
S	4	0	1	0	0	0	5
SSW	3	2	0	0	0	0	5
SW	4	13	11	2	0	0	30
WSW	3	20	10	0	0	0	33
W	6	16	8	0	0	0	30
WNW	4	16	9	0	0	0	29
NW	4	13	10	0	0	0	27
NNW	6	4	2	0	0	0	12
VARIABLE	0	0	0	0	0	0	0
Total	67	138	117	2	0	1	325

Periods of calm(hours): 0
Hours of missing data: 0

Table 4A-DQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: F
ELEVATION:10.0m

Wind Direction	Wind Speed (mph) at 10.0m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	36	2	0	0	0	0	38
NNE	19	3	0	0	1	0	23
NE	22	3	0	0	0	0	25
ENE	7	12	0	0	0	0	19
E	8	4	0	0	0	0	12
ESE	8	3	0	0	0	0	11
SE	7	4	0	0	0	0	11
SSE	0	1	0	0	0	0	1
S	4	0	0	0	0	0	4
SSW	3	2	0	0	0	0	5
SW	13	9	3	0	0	0	25
WSW	24	4	0	0	0	0	28
W	23	7	0	0	0	0	30
WNW	24	7	0	0	0	0	31
NW	28	6	0	0	0	0	34
NNW	26	2	0	0	0	0	28
VARIABLE	0	0	0	0	0	0	0
Total	252	69	3	0	1	0	325

Periods of calm(hours): 0
Hours of missing data: 0

Table 4A-CQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: G
ELEVATION:45.7m

Wind Direction	Wind Speed (mph) at 45.7m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	3	3	5	0	0	0	11
NNE	3	2	1	0	0	0	6
NE	0	5	0	0	0	0	5
ENE	0	10	2	0	0	0	12
E	0	4	14	0	0	0	18
ESE	0	5	6	0	0	0	11
SE	0	1	1	0	0	0	2
SSE	3	5	2	0	0	0	10
S	2	0	0	0	0	0	2
SSW	1	1	0	0	0	0	2
SW	3	2	0	0	0	0	5
WSW	1	5	2	0	0	0	8
W	3	9	3	0	0	0	15
WNW	2	13	7	0	0	0	22
NW	6	15	7	0	0	0	28
NNW	6	7	2	0	0	0	15
VARIABLE	0	0	0	0	0	0	0
Total	33	87	52	0	0	0	172

Periods of calm(hours): 0
Hours of missing data: 0

Table 4A-CQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: G
ELEVATION:10.0m

	Wind Speed (mph) at 10.0m level						
Wind Direction	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	24	1	0	0	0	0	25
NNE	18	2	0	0	0	0	20
NE	10	2	0	0	0	0	12
ENE	1	0	0	0	0	0	1
E	7	1	0	0	0	0	8
ESE	1	0	0	0	0	0	1
SE	2	1	0	0	0	0	3
SSE	0	0	0	0	0	0	0
S	1	0	0	0	0	0	1
SSW	0	1	0	0	0	0	1
SW	1	0	0	0	0	0	1
WSW	7	1	0	0	0	0	8
W	17	4	0	0	0	0	21
WNW	14	4	0	0	0	0	18
NW	14	4	0	0	0	0	18
NNW	33	1	0	0	0	0	34
VARIABLE	0	0	0	0	0	0	0
Total	150	22	0	0	0	0	172

Periods of calm(hours): 0
Hours of missing data: 0

Table 4A-CQ4

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - 4th Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 10 -1-84 > 12-31-84
STABILITY CLASS: A
ELEVATION:45.7m

Wind Direction	Wind Speed (mph) at 45.7m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	1	6	3	0	0	0	10
NNE	3	1	0	0	0	0	4
NE	4	4	2	4	0	0	14
ENE	2	9	13	1	0	0	25
E	3	14	14	0	0	0	31
ESE	3	14	4	1	0	0	22
SE	1	10	7	0	0	0	18
SSE	2	9	10	1	0	0	22
S	2	2	2	2	0	0	8
SSW	0	2	2	0	0	0	4
SW	1	1	4	0	0	0	6
WSW	1	1	1	0	0	0	3
W	2	0	5	1	0	0	8
WNW	1	1	1	0	0	0	3
NW	0	2	0	0	0	0	2
NNW	0	1	2	0	0	0	3
VARIABLE	0	0	0	0	0	0	0
Total	26	77	70	10	0	0	183

Periods of calm(hours): 0
Hours of missing data: 0

Table 4A-CQ4

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - 4th Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 10 -1-84 > 12-31-84
STABILITY CLASS: A
ELEVATION:10.0m

Wind Direction	Wind Speed (mph) at 10.0m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	1	3	0	0	0	0	4
NNE	6	0	4	0	0	0	10
NE	3	9	4	0	0	0	16
ENE	3	18	8	1	0	0	30
E	7	15	8	0	0	0	30
ESE	7	14	2	0	0	0	23
SE	5	17	3	0	0	0	25
SSE	1	2	4	1	0	0	8
S	3	1	1	0	0	0	5
SSW	2	1	0	0	0	0	3
SW	1	3	3	0	0	0	7
WSW	2	1	3	0	0	0	6
W	0	1	2	0	0	0	3
WNW	1	1	0	0	0	0	2
NW	0	3	0	0	0	0	3
NNW	1	3	4	0	0	0	8
VARIABLE	0	0	0	0	0	0	0
Total	43	92	46	2	0	0	183

Periods of calm(hours): 0
Hours of missing data: 0

Table 4A-CQ4

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - 4th Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 10 -1-84 > 12-31-84
STABILITY CLASS: B
ELEVATION:45.7m

Wind Direction	Wind Speed (mph) at 45.7m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	1	3	7	2	0	0	13
NNE	1	5	5	0	0	0	11
NE	1	5	4	2	0	0	12
ENE	3	9	7	0	0	0	19
E	2	14	6	0	0	0	22
ESE	2	11	4	1	0	0	18
SE	1	10	9	1	0	0	21
SSE	0	3	9	5	0	0	17
S	0	1	0	2	0	0	3
SSW	0	0	0	1	2	0	3
SW	0	2	3	0	0	0	5
WSW	1	4	3	0	0	0	8
W	2	0	3	0	0	0	5
WNW	0	5	0	0	0	0	5
NW	0	0	1	0	0	0	1
NNW	1	2	8	0	1	0	12
VARIABLE	0	0	0	0	0	0	0
Total	15	74	69	14	3	0	175

Periods of calm(hours): 0
Hours of missing data: 0

Table 4A-CQ4

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - 4th Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 10 -1-84 > 12-31-84
STABILITY CLASS: B
ELEVATION:10.0m

Wind Direction	Wind Speed (mph) at 10.0m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	4	7	0	0	0	0	11
NNE	2	3	3	0	0	0	8
NE	3	7	3	0	0	0	13
ENE	4	19	4	0	0	0	27
E	5	11	2	0	0	0	18
ESE	5	12	4	0	0	0	21
SE	1	11	10	1	0	0	23
SSE	0	0	2	2	0	0	4
S	0	1	0	1	1	0	3
SSW	2	1	2	1	0	0	6
SW	1	3	2	0	0	0	6
WSW	0	5	0	0	0	0	5
W	1	2	1	0	0	0	4
WNW	0	3	0	0	0	0	3
NW	1	2	6	1	0	0	10
NNW	0	7	6	0	0	0	13
VARIABLE	0	0	0	0	0	0	0
Total	29	94	45	6	1	0	175

Periods of calm(hours): 0
Hours of missing data: 0

Table 4A-CQ4

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - 4th Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 10 -1-84 > 12-31-84
STABILITY CLASS: C
ELEVATION:45.7m

Wind Direction	Wind Speed (mph) at 45.7m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	1	7	6	0	0	0	14
NNE	3	10	7	0	0	0	20
NE	1	5	3	2	0	0	11
ENE	2	6	0	2	0	0	10
E	4	9	2	0	0	0	15
ESE	2	4	3	0	0	0	9
SE	0	4	5	1	1	0	11
SSE	1	2	3	3	0	0	9
S	1	2	1	1	0	0	5
SSW	0	0	1	2	0	0	3
SW	0	0	3	5	0	0	8
WSW	2	4	1	0	0	0	7
W	2	1	2	0	0	0	5
WNW	0	2	0	0	0	0	2
NW	0	0	4	0	2	0	6
NNW	0	2	3	1	0	0	6
VARIABLE	0	0	0	0	0	0	0
Total	19	58	44	17	3	0	141

Periods of calm(hours): 0
Hours of missing data: 0

Table 4A-CQ4

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - 4th Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 10 -1-84 > 12-31-84
STABILITY CLASS: C
ELEVATION:10.0m

Wind Direction	Wind Speed (mph) at 10.0m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	3	12	0	0	0	0	15
NNE	8	5	2	0	0	0	15
NE	3	8	2	0	0	0	13
ENE	2	11	0	0	0	0	13
E	5	4	0	0	0	0	9
ESE	4	5	0	0	0	0	9
SE	0	7	5	2	0	0	14
SSE	0	2	1	0	0	0	3
S	3	0	0	2	0	0	5
SSW	0	0	1	4	0	0	5
SW	0	4	2	0	0	0	6
WSW	2	3	0	0	0	0	5
W	3	2	0	0	0	0	5
WNW	0	2	0	0	0	0	2
NW	0	4	2	3	0	0	9
NNW	3	8	2	0	0	0	13
VARIABLE	0	0	0	0	0	0	0
Total	36	77	17	11	0	0	141

Periods of calm(hours): 0
Hours of missing data: 0

Table 4A-CQ4

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - 4th Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 10 -1-84 > 12-31-84
STABILITY CLASS: D
ELEVATION:45.7m

Wind Direction	Wind Speed (mph) at 45.7m level						
	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	5	2	15	0	0	0	22
NNE	5	8	12	0	0	1	26
NE	4	7	19	5	0	0	35
ENE	2	5	10	3	0	0	20
E	1	10	1	1	0	0	13
ESE	3	14	4	0	0	0	21
SE	3	4	3	0	0	0	10
SSE	1	0	10	3	0	0	14
S	6	5	1	4	0	0	16
SSW	0	0	0	3	1	0	4
SW	1	3	15	8	0	0	27
WSW	1	3	7	0	0	0	11
W	2	11	5	0	0	0	18
WNW	4	5	2	0	0	0	11
NW	2	2	5	1	0	0	10
NNW	1	4	9	1	0	0	15
VARIABLE	0	0	0	0	0	0	0
Total	41	83	118	29	1	1	273

Periods of calm(hours): 0
Hours of missing data: 0

Table 4A-CQ4

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - 4th Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 10 -1-84 > 12-31-84
STABILITY CLASS: D
ELEVATION:10.0m

	Wind Speed (mph) at 10.0m level					
Wind Direction	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	8	11	0	0	0	1	20
NNE	10	16	5	1	0	0	32
NE	6	21	6	0	0	0	33
ENE	6	7	4	1	0	0	18
E	5	10	0	0	0	0	15
ESE	4	8	1	0	0	0	13
SE	1	7	6	1	0	0	15
SSE	2	3	5	0	0	0	10
S	5	0	1	0	0	0	6
SSW	2	5	7	6	0	0	20
SW	1	6	9	0	0	0	16
WSW	1	13	0	0	0	0	14
W	4	7	1	0	0	0	12
WNW	4	7	1	0	0	0	12
NW	2	8	5	2	0	0	17
NNW	4	14	2	0	0	0	20
VARIABLE	0	0	0	0	0	0	0
Total	65	143	53	11	0	1	273

Periods of calm(hours): 0
Hours of missing data: 0

Table 4A-CQ4

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - 4th Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 10 -1-84 > 12-31-84
STABILITY CLASS: E
ELEVATION:45.7m

Wind Direction	Wind Speed (mph) at 45.7m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	3	11	21	0	0	0	35
NNE	2	15	36	1	0	1	55
NE	5	20	22	2	0	0	49
ENE	6	23	20	5	0	0	54
E	7	37	31	2	0	1	78
ESE	5	19	17	1	0	0	42
SE	6	11	19	0	0	1	37
SSE	6	9	23	13	1	0	52
S	7	3	11	4	2	0	27
SSW	2	8	9	10	0	0	29
SW	1	8	24	20	1	0	54
WSW	1	11	18	0	0	0	30
W	5	12	8	1	0	1	27
WNW	6	8	2	0	0	0	16
NW	5	6	20	9	2	0	42
NNW	3	10	20	7	0	0	40
VARIABLE	0	0	0	0	0	0	0
Total	70	211	301	75	6	4	667

Periods of calm(hours): 0
Hours of missing data: 0

Table 4A-CQ4

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - 4th Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 10 -1-84 > 12-31-84
STABILITY CLASS: E
ELEVATION:10.0m

Wind Direction	Wind Speed (mph) at 10.0m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	41	8	0	0	0	0	49
NNE	37	25	1	0	0	0	63
NE	30	31	8	0	0	0	69
ENE	19	27	10	0	0	0	56
E	9	25	4	0	0	2	40
ESE	12	33	1	2	0	0	48
SE	8	18	14	2	0	0	42
SSE	3	6	5	2	0	0	16
S	6	8	7	0	0	0	21
SSW	4	8	14	3	0	0	29
SW	2	30	14	0	0	0	46
WSW	14	17	1	0	0	1	33
W	9	2	0	0	0	0	11
WNW	10	13	2	1	0	0	26
NW	13	28	20	1	0	0	62
NNW	24	23	8	0	1	0	56
VARIABLE	0	0	0	0	0	0	0
Total	241	302	109	11	1	3	667

Periods of calm(hours): 0
Hours of missing data: 0

Table 4A-CQ4

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - 4th Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 10 -1-84 > 12-31-84
STABILITY CLASS: F
ELEVATION:45.7m

Wind Direction	Wind Speed (mph) at 45.7m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	0	6	12	0	0	0	18
NNE	2	5	9	2	0	0	18
NE	1	14	11	0	0	1	27
ENE	1	25	19	4	0	0	49
E	4	14	13	0	0	1	32
ESE	2	15	19	0	0	0	36
SE	2	9	3	0	0	0	14
SSE	2	4	11	4	0	0	21
S	3	2	2	1	0	0	8
SSW	1	1	2	1	0	0	5
SW	2	6	16	8	0	1	33
WSW	0	6	11	0	0	0	17
W	2	5	5	0	0	0	12
WNW	0	3	3	0	0	0	6
NW	4	6	4	0	0	0	14
NNW	0	2	18	0	0	0	20
VARIABLE	0	0	0	0	0	0	0
Total	26	123	158	20	0	3	330

Periods of calm(hours): 0
Hours of missing data: 0

Table 4A-CQ4

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - 4th Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 10 -1-84 > 12-31-84
STABILITY CLASS: F
ELEVATION:10.0m

Wind Direction	Wind Speed (mph) at 10.0m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	48	0	0	0	0	0	48
NNE	30	3	0	1	0	0	34
NE	26	2	0	0	0	0	28
ENE	19	6	0	4	0	0	29
E	14	4	0	0	0	0	18
ESE	5	7	0	0	0	0	12
SE	3	9	5	0	0	0	17
SSE	1	2	0	0	0	0	3
S	1	1	1	0	0	0	3
SSW	5	3	2	0	0	1	11
SW	8	16	6	0	0	0	30
WSW	6	4	0	0	0	0	10
W	14	0	0	0	0	0	14
WNW	4	2	0	0	0	0	6
NW	9	11	5	0	0	0	25
NNW	35	4	2	1	0	0	42
VARIABLE	0	0	0	0	0	0	0
Total	228	74	21	6	0	1	330

Periods of calm(hours): 0
Hours of missing data: 0

Table 4A-CQ4

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - 4th Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 10 -1-84 > 12-31-84
STABILITY CLASS: G
ELEVATION:45.7m

Wind Direction	Wind Speed (mph) at 45.7m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	6	11	12	0	0	0	29
NNE	5	11	18	2	0	0	36
NE	7	7	14	0	0	0	28
ENE	9	19	27	1	0	0	56
E	6	16	30	0	0	0	52
ESE	4	16	26	1	0	0	47
SE	3	9	6	0	0	0	18
SSE	7	6	21	1	0	0	35
S	4	5	2	1	0	0	12
SSW	3	3	0	0	0	0	6
SW	8	6	8	0	0	0	22
WSW	5	12	8	1	0	0	26
W	2	8	3	0	0	0	13
WNW	4	7	3	0	0	0	14
NW	3	11	4	0	0	0	18
NNW	4	10	11	2	0	0	27
VARIABLE	0	0	0	0	0	0	0
Total	80	157	193	9	0	0	439

Periods of calm(hours): 0
Hours of missing data: 0

Table 4A-CQ4

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - 4th Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 10 -1-84 > 12-31-84
STABILITY CLASS: G
ELEVATION:10.0m

Wind Direction	Wind Speed (mph) at 10.0m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	90	3	0	0	0	0	93
NNE	43	5	0	0	0	0	48
NE	19	0	0	0	0	0	19
ENE	23	3	0	1	0	0	27
E	14	5	2	0	0	0	21
ESE	12	8	0	0	0	0	20
SE	8	5	0	0	0	0	13
SSE	3	0	0	0	0	0	3
S	2	0	0	0	0	0	2
SSW	2	0	0	0	0	0	2
SW	7	1	2	0	0	0	10
WSW	7	1	0	0	0	0	8
W	5	1	0	0	0	0	6
WNW	9	4	0	0	0	0	13
NW	31	6	1	0	0	0	38
NNW	110	6	0	0	0	0	116
VARIABLE	0	0	0	0	0	0	0
Total	385	48	5	1	0	0	439

Periods of calm(hours): 0
Hours of missing data: 0

TABLE 4A-1BW3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Unit 1 - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: BATCH
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: A
ELEVATION:45.7m

Wind Direction	Wind Speed (mph) at 45.7m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	0	0	0	0	0	0	0
NNE	0	0	0	0	0	0	0
NE	0	0	0	0	0	0	0
ENE	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0
ESE	0	0	0	0	0	0	0
SE	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0
VARIABLE	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0

Periods of calm(hours): 0
Hours of missing data: 0

TABLE 4A-1BW3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Unit 1 - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: BATCH
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: A
ELEVATION:10.0m

Wind Direction	Wind Speed (mph) at 10.0m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	0	0	0	0	0	0	0
NNE	0	0	0	0	0	0	0
NE	0	0	0	0	0	0	0
ENE	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0
ESE	0	0	0	0	0	0	0
SE	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0
VARIABLE	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0

Periods of calm(hours): 0
Hours of missing data: 0

TABLE 4A-1BQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Unit 1 - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: BATCH
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: B
ELEVATION:45.7m

Wind Direction	Wind Speed (mph) at 45.7m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	0	0	0	0	0	0	0
NNE	0	0	0	0	0	0	0
NE	0	0	0	0	0	0	0
ENE	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0
ESE	0	0	0	0	0	0	0
SE	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0
VARIABLE	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0

Periods of calm(hours): 0
Hours of missing data: 0

TABLE 4A-1BW3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Unit 1 - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: BATCH
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: B
ELEVATION:10.0m

Wind Direction	Wind Speed (mph) at 10.0m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	0	0	0	0	0	0	0
NNE	0	0	0	0	0	0	0
NE	0	0	0	0	0	0	0
ENE	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0
ESE	0	0	0	0	0	0	0
SE	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0
VARIABLE	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0

Periods of calm(hours): 0
Hours of missing data: 0

TABLE 4A-1BQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Unit 1 - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: BATCH
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: C
ELEVATION:45.7m

	Wind Speed (mph) at 45.7m level					
Wind Direction	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	0	0	0	0	0	0	0
NNE	0	0	0	0	0	0	0
NE	0	0	0	0	0	0	0
ENE	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0
ESE	0	0	0	0	0	0	0
SE	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0
VARIABLE	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0

Periods of calm(hours): 0
Hours of missing data: 0

TABLE 4A-1BW3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Unit 1 - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: BATCH
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: C
ELEVATION:10.0m

Wind Direction	Wind Speed (mph) at 10.0m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	0	0	0	0	0	0	0
NNE	0	0	0	0	0	0	0
NE	0	0	0	0	0	0	0
ENE	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0
ESE	0	0	0	0	0	0	0
SE	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0
VARIABLE	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0

Periods of calm(hours): 0
Hours of missing data: 0

TABLE 4A-1BQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Unit 1 - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: BATCH
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: D
ELEVATION:45.7m

Wind Direction	Wind Speed (mph) at 45.7m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	0	0	0	0	0	0	0
NNE	0	0	0	0	0	0	0
NE	0	0	0	0	0	0	0
ENE	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0
ESE	0	0	0	0	0	0	0
SE	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0
VARIABLE	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0

Periods of calm(hours): 0
Hours of missing data: 0

TABLE 4A-1BQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Unit 1 - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: BATCH
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: D
ELEVATION:10.0m

Wind Direction	Wind Speed (mph) at 10.0m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	0	0	0	0	0	0	0
NNE	0	0	0	0	0	0	0
NE	0	0	0	0	0	0	0
ENE	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0
ESE	0	0	0	0	0	0	0
SE	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0
VARIABLE	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0

Periods of calm(hours): 0
Hours of missing data: 0

TABLE 4A-1BQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Unit 1 - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: BATCH
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: E
ELEVATION:45.7m

Wind	Wind Speed (mph) at 45.7m level						
Direction	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	0	0	0	0	0	0	0
NNE	0	0	0	0	0	0	0
NE	0	0	0	0	0	0	0
ENE	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0
ESE	0	0	0	0	0	0	0
SE	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0
S	1	0	0	0	0	0	1
SSW	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0
WSW	0	2	0	0	0	0	2
W	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0
VARIABLE	0	0	0	0	0	0	0
Total	1	2	0	0	0	0	3

Periods of calm(hours): 0
Hours of missing data: 0

TABLE 4A-1BQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Unit 1 - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: BATCH
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: E
ELEVATION:10.0m

Wind Direction	Wind Speed (mph) at 10.0m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	0	0	0	0	0	0	0
NNE	0	0	0	0	0	0	0
NE	0	0	0	0	0	0	0
ENE	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0
ESE	0	0	0	0	0	0	0
SE	1	0	0	0	0	0	1
SSE	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0
WSW	2	0	0	0	0	0	2
W	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0
VARIABLE	0	0	0	0	0	0	0
Total	3	0	0	0	0	0	3

Periods of calm(hours): 0
Hours of missing data: 0

TABLE 4A-1BQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Unit 1 - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: BATCH
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: F
ELEVATION:45.7m

	Wind Speed (mph) at 45.7m level					
Wind Direction	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	0	0	0	0	0	0	0
NNE	0	0	0	0	0	0	0
NE	0	0	0	0	0	0	0
ENE	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0
ESE	0	0	0	0	0	0	0
SE	0	0	0	0	0	0	0
SSE	1	1	1	0	0	0	3
S	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0
SW	1	0	0	0	0	0	1
WSW	0	1	0	0	0	0	1
W	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0
VARIABLE	0	0	0	0	0	0	0
Total	2	2	1	0	0	0	5

Periods of calm(hours): 0
Hours of missing data: 0

TABLE 4A-1BQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Unit 1 - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: BATCH
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: F
ELEVATION:10.0m

Wind Direction	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
	Wind Speed (mph) at 10.0m level						
N	0	0	0	0	0	0	0
NNE	1	0	0	0	0	0	1
NE	0	0	0	0	0	0	0
ENE	1	0	0	0	0	0	1
E	0	0	0	0	0	0	0
ESE	1	0	0	0	0	0	1
SE	0	1	0	0	0	0	1
SSE	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0
WSW	1	0	0	0	0	0	1
W	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0
VARIABLE	0	0	0	0	0	0	0
Total	4	1	0	0	0	0	5

Periods of calm(hours): 0
Hours of missing data: 0

TABLE 4A-18Q3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Unit 1 - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: BATCH
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: G
ELEVATION:45.7m

Wind Direction	Wind Speed (mph) at 45.7m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	0	0	0	0	0	0	0
NNE	0	0	0	0	0	0	0
NE	0	0	0	0	0	0	0
ENE	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0
ESE	0	0	0	0	0	0	0
SE	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0
VARIABLE	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0

Periods of calm(hours): 0
Hours of missing data: 0

TABLE 4A-1BQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Unit 1 - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: BATCH
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: G
ELEVATION:10.0m

Wind Direction	Wind Speed (mph) at 10.0m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	0	0	0	0	0	0	0
NNE	0	0	0	0	0	0	0
NE	0	0	0	0	0	0	0
ENE	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0
ESE	0	0	0	0	0	0	0
SE	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0
VARIABLE	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0

Periods of calm(hours): 0
Hours of missing data: 0

TABLE 4A-1BQ4

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Unit 1 - 4th Quarter, 1984

No batch releases were made during 4th Quarter 1984 therefore Cumulative Joint Frequency Distribution tables are not applicable.

TABLE 4A-2BQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Unit 2 - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: BATCH
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: A
ELEVATION:45.7m

Wind Direction	Wind Speed (mph) at 45.7m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	0	0	1	0	0	0	1
NNE	0	1	0	0	0	0	1
NE	0	0	0	0	0	0	0
ENE	0	0	2	2	0	0	4
E	0	6	7	0	0	0	13
ESE	0	0	0	0	0	0	0
SE	0	0	1	0	0	0	1
SSE	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0
VARIABLE	0	0	0	0	0	0	0
Total	0	7	11	2	0	0	20

Periods of calm(hours): 0
Hours of missing data: 0

TABLE 4A-2BQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Unit 2 - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: BATCH
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: A
ELEVATION:10.0m

Wind Direction	Wind Speed (mph) at 10.0m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	0	0	0	0	0	0	0
NNE	0	0	0	0	0	0	0
NE	0	1	1	0	0	0	2
ENE	0	4	5	0	0	0	9
E	0	6	1	0	0	0	7
ESE	0	0	1	0	0	0	1
SE	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0
NNW	0	1	0	0	0	0	1
VARIABLE	0	0	0	0	0	0	0
Total	0	12	8	0	0	0	20

Periods of calm(hours): 0
Hours of missing data: 0

TABLE 4A-2BQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Unit 2 - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: BATCH
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: B
ELEVATION:45.7m

	Wind Speed (mph) at 45.7m level					
Wind Direction	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	0	1	3	0	0	0	4
NNE	1	1	0	0	0	0	2
NE	0	0	0	0	0	0	0
ENE	0	1	0	0	0	0	1
E	0	0	1	0	0	0	1
ESE	0	0	1	0	0	0	1
SE	0	0	1	0	0	0	1
SSE	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0
VARIABLE	0	0	0	0	0	0	0
Total	1	3	6	0	0	0	10

Periods of calm(hours): 0
Hours of missing data: 0

TABLE 4A-28Q3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Unit 2 - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: BATCH
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: B
ELEVATION:10.0m

Wind Direction	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
	Wind Speed (mph) at 10.0m level						
N	1	2	0	0	0	0	3
NNE	0	0	0	0	0	0	0
NE	1	0	0	0	0	0	1
ENE	0	1	0	0	0	0	1
E	0	1	0	0	0	0	1
ESE	0	1	0	0	0	0	1
SE	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0
NNW	0	3	0	0	0	0	3
VARIABLE	0	0	0	0	0	0	0
Total	2	8	0	0	0	0	10

Periods of calm(hours): 0
Hours of missing data: 0

TABLE 4A-2BQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Unit 2 - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: BATCH
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: C
ELEVATION:45.7m

Wind Direction	Wind Speed (mph) at 45.7m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	0	0	1	0	0	0	1
NNE	0	1	0	0	0	0	1
NE	0	1	0	0	0	0	1
ENE	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0
ESE	0	0	0	0	0	0	0
SE	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0
VARIABLE	0	0	0	0	0	0	0
Total	0	2	1	0	0	0	3

Periods of calm(hours): 0
Hours of missing data: 0

TABLE 4A-28Q3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Unit 2 - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: BATCH
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: C
ELEVATION:10.0m

Wind Direction	Wind Speed (mph) at 10.0m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	1	0	0	0	0	0	1
NNE	0	1	0	0	0	0	1
NE	0	0	0	0	0	0	0
ENE	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0
ESE	0	0	0	0	0	0	0
SE	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0
NNW	0	1	0	0	0	0	1
VARIABLE	0	0	0	0	0	0	0
Total	1	2	0	0	0	0	3

Periods of calm(hours): 0
Hours of missing data: 0

TABLE 4A-2BQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Unit 2 - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: BATCH
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: D
ELEVATION:45.7m

Wind Direction	Wind Speed (mph) at 45.7m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	0	0	0	0	0	0	0
NNE	0	2	1	0	0	0	3
NE	0	0	0	0	0	0	0
ENE	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0
ESE	0	0	0	0	0	0	0
SE	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0
VARIABLE	0	0	0	0	0	0	0
Total	0	2	1	0	0	0	3

Periods of calm(hours): 0
Hours of missing data: 0

TABLE 4A-2BQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Unit 2 - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: BATCH
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: D
ELEVATION:10.0m

Wind Direction	Wind Speed (mph) at 10.0m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	1	1	0	0	0	0	2
NNE	1	0	0	0	0	0	1
NE	0	0	0	0	0	0	0
ENE	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0
ESE	0	0	0	0	0	0	0
SE	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0
VARIABLE	0	0	0	0	0	0	0
Total	2	1	0	0	0	0	3

Periods of calm(hours): 0
Hours of missing data: 0

TABLE 4A-2BQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Unit 2 - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: BATCH
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: E
ELEVATION:45.7m

	Wind Speed (mph) at 45.7m level						
Wind Direction	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	0	3	1	0	0	0	4
NNE	0	5	2	0	0	0	7
NE	0	1	0	0	0	0	1
ENE	0	1	2	0	0	0	3
E	0	0	0	0	0	0	0
ESE	0	0	4	1	0	0	5
SE	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0
VARIABLE	0	0	0	0	0	0	0
Total	0	10	9	1	0	0	20

Periods of calm(hours): 0
Hours of missing data: 0

TABLE 4A-2BQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Unit 2 - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: BATCH
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: E
ELEVATION:10.0m

Wind Direction	Wind Speed (mph) at 10.0m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	4	0	0	0	0	0	4
NNE	1	0	0	0	0	0	1
NE	1	1	0	0	0	0	2
ENE	0	0	0	0	0	0	0
E	1	1	0	0	0	0	2
ESE	0	3	0	0	0	0	3
SE	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0
NW	1	0	0	0	0	0	1
NNW	5	2	0	0	0	0	7
VARIABLE	0	0	0	0	0	0	0
Total	13	7	0	0	0	0	20

Periods of calm(hours): 0
Hours of missing data: 0

TABLE 4A-2BQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Unit 2 - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: BATCH
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: F
ELEVATION:45.7m

Wind Direction	Wind Speed (mph) at 45.7m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	0	1	1	0	0	0	2
NNE	0	1	2	0	0	0	3
NE	0	0	0	0	0	0	0
ENE	0	0	1	0	0	0	1
E	0	0	2	0	0	0	2
ESE	0	0	2	0	0	0	2
SE	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0
VARIABLE	0	0	0	0	0	0	0
Total	0	2	8	0	0	0	10

Periods of calm(hours): 0
Hours of missing data: 0

TABLE 4A-2BQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Unit 2 - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: BATCH
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: F
ELEVATION:10.0m

Wind Direction	Wind Speed (mph) at 10.0m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	1	0	0	0	0	0	1
NNE	1	0	0	0	0	0	1
NE	0	0	0	0	0	0	0
ENE	0	3	0	0	0	0	3
E	1	0	0	0	0	0	1
ESE	0	0	0	0	0	0	0
SE	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0
NW	2	0	0	0	0	0	2
NNW	2	0	0	0	0	0	2
VARIABLE	0	0	0	0	0	0	0
Total	7	3	0	0	0	0	10

Periods of calm(hours): 0
Hours of missing data: 0

TABLE 4A-2BQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Unit 2 - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: BATCH
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: G
ELEVATION:45.7m

Wind	Wind Speed (mph) at 45.7m level						
Direction	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	0	0	0	0	0	0	0
NNE	0	0	0	0	0	0	0
NE	0	0	0	0	0	0	0
ENE	0	1	1	0	0	0	2
E	0	1	3	0	0	0	4
ESE	0	1	0	0	0	0	1
SE	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0
VARIABLE	0	0	0	0	0	0	0
Total	0	3	4	0	0	0	7

Periods of calm(hours): 0
Hours of missing data: 0

TABLE 4A-2BQ3

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Unit 2 - 3rd Quarter, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: BATCH
PERIOD OF RECORD: 7 -1-84 > 9-30-84
STABILITY CLASS: G
ELEVATION:10.0m

Wind Direction	Wind Speed (mph) at 10.0m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	4	0	0	0	0	0	4
NNE	2	0	0	0	0	0	2
NE	1	0	0	0	0	0	1
ENE	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0
ESE	0	0	0	0	0	0	0
SE	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0
VARIABLE	0	0	0	0	0	0	0
Total	7	0	0	0	0	0	7

Periods of calm(hours): 0
Hours of missing data: 0

TABLE 4A-2BQ4

CUMULATIVE JOINT FREQUENCY DISTRIBUTION

Farley Unit 2 - 4th Quarter, 1984

No batch releases were made during 4th Quarter 1984 therefore Cumulative Joint Frequency Distribution tables are not applicable.

TABLE 4B

CLASSIFICATION OF ATMOSPHERIC STABILITY

Stability Classification	Pasquill Categories	$\sigma\theta$[a] (degrees)	Temperature change with height (°F/20m)
Extremely unstable	A	25.0	<-0.69
Moderately unstable	B	20.0	-0.69 to -0.61
Slightly unstable	C	15.0	-0.61 to -0.53
Neutral	D	10.0	-0.53 to -0.18
Slightly stable	E	5.0	-0.18 to 0.53
Moderately stable	F	2.5	0.53 to 1.40
Extremely stable	G	1.7	>1.40

[a] Standard deviations of horizontal wind direction fluctuation over a period of 15 minutes to 1 hour. The values shown are averages for each stability classification.

TABLE 5

RADIAOACTIVE LIQUID WASTE SAMPLING AND ANALYSIS PROGRAM
FARLEY NUCLEAR PLANT - UNIT 1 & 2

Liquid Release Type	Sampling Frequency	Mimimum Analysis Frequency	Type of Activity Analysis	Minimum Detectable Concentration (MDC)(uCi/ml)[a,g]
A. Batch Waste Release Tanks[c]	Each Batch[P]	Each Batch[P]	Principal Gamma Emmiters[e]	5E-07
			I-131	1E-06
	One Batch/M	M	Dissolved & Entrained Gases (Gamma Emitters)	1E-05
	Each Batch[P]	M[b] Composite	H-3	1E-05
			Gross Alpha	1E-07
	Each Batch[P]	Q[b] Composite	Sr-89, Sr-90	5E-08
			Fe-55	1E-06
B. Continuous Releases[d,f]	Grab Sample[D]	Q[b] Composite	Principal Gamma Emitters[e]	5E-07
			I-131	1E-06
1. Steam Generator Blowdown	Grab Sample[M]	M	Dissolved & Entrained Gases (Gamma Emitters)	1E-05
	Grab Sample[D]	M[b] Composite	H-3	1E-05
			Gross Alpha	1E-07
	Grab Sample[D]	Q[b] Composite	Sr-89, Sr-90	5E-08
			Fe-55	1E-06
2. Turbine Building Sump	Grab Sample[P]	W[b] Composite	Principle Gamma Emmiters[e]	5E-07
			H-3	1E-05

TABLE 5 (Continued)

TABLE NOTATION

a. The MDC is the smallest concentration of radioactive material in a sample that will be detected with 95% probability with 5% probability of falsely concluding that a blank observation represents a "real" signal.

For a particular measurement system (which may include radiochemical separation):

$$MDC = 4.66 s_b / E * V * 2.22X10^6 * Y * \exp(-\lambda\Delta t)$$

where:

MDC is the "a priori" lower limit of detection as defined above (as microcurie per unit mass or volume),

s_b is the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (as counts per minute),

E is the counting efficiency (as counts per transformation),

V is the sample size (in units mass or volume),

$2.22x10^6$ is the number of transformations per minute per microcurie,

Y is the fractional radiochemical yield (when applicable),

λ is the radioactive decay constant for the particular radionuclide, and

Δt is the elapsed time between midpoint of sample collection and time of counting (for plant effluents, not environmental samples).

The value of s_b used in the calculation of the MDC for a detection system shall be based on the actual observed variance of the background counting rate or of the counting rate of the blank samples (as appropriate) rather than on an unverified theoretically predicted variance. Typical values of E, V, Y, and Δt shall be used in the calculation.

TABLE 5 (Continued)

TABLE NOTATION

b. A composite sample is one in which the quantity of liquid sampled is proportional to the quantity of liquid waste discharged and in which the method of sampling employed results in a specimen which is representative of the liquids released.

c. A batch release is the discharge of liquid wastes of a discrete volume. Prior to sampling for analyses, each batch shall be isolated, and then thoroughly mixed, by a method described in the ODCM, to assure representative sampling.

d. A continuous release is the discharge of liquid wastes of a nondiscrete volume; e.g., from a volume of system that has an input flow during the effluent release.

e. The principal gamma emitters for which the MDC specification applies exclusively are the following radionuclides: Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, Cs-134, Cs-137, Ce-141, and Ce-144. This list does not mean that only these nuclides are to be detected and reported. Other peaks which are measurable and identifiable, together with the above nuclides, shall also be identified and reported.

f. Sampling will be performed only if the effluent will be discharged to the environment.

g. Deviation from the MDC requirements of Table 4.11-1 shall be reported per Specification 6.9.1.8 in lieu of any other report.

TABLE 6

RADIOACTIVE GASEOUS WASTE SAMPLING AND ANALYSIS PROGRAM
FARLEY NUCLEAR PLANT - UNITS 1 & 2

Gaseous Release Type	Sampling Frequency	Minimum Analysis Frequency	Type of Activity Analysis	Minimum Detectable Concentration (MDC)(uCi/ml)[a,h]
A. Waste Gas Storage Tank	Each Tank Grab Sample P[b]	Each Tank P	Principle Gamma Emitters[g,h]	1E-04
B. Containment Purge	Each Purge Grab Sample P[b]	Each Purge Grab Sample P[b]	Principle Gamma Emitters[g,j]	1E-04
			H-3	1E-06
C. Condenser Steam Jet Air Ejector Plant Vent Stack	M-[b,c,e] Grab Sample	M[b]	Principle Gamma Emitters[g,j]	1E-04
			H-3	1E-06
D. Plant Vent Stack Containment Purge	Continuous[f] Charcoal	Charcoal Sample W[d]	I-131	1E-12
			I-133	1E-10
	Continuous[f]	Particulate Sample W[d]	Principle Gamma Emitters[g] (I-131, Others)	1E-11
	Continuous[f]	W[i] Composite Particulate Sample	Gross Alpha	1E-11
	Continuous[f]	Q[i] Composite Particulate Sample	Sr-89, Sr-90	1E-11
	Continuous[f]	Noble Gas Monitor	Noble Gases Gross Beta & Gamma	1E-06

TABLE 6 (Continued)

TABLE NOTATION

a. The MDC is the smallest concentration of radioactive material in a sample that will be detected with 95% probability with 5% probability of falsely concluding that a blank observation represents a "real" signal.

For a particular measurement system (which may include radiochemical separation):

$$MDC = 4.66\, s_b \;/\; E * V * 2.22X10^6 * Y * \exp(-\lambda\Delta t)$$

where:

MDC is the "a priori" lower limit of detection as defined above (as microcurie per unit mass or volume),

s_b is the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (as counts per minute),

E is the counting efficiency (as counts per transformation),

V is the sample size (in units mass or volume),

$2.22x10^6$ is the number of transformations per minute per microcurie,

Y is the fractional radiochemical yield (when applicable),

λ is the radioactive decay constant for the particular radionuclide, and

Δt is the elapsed time between midpoint of sample collection and time of counting (for plant effluents, not environmental samples).

The value of s_b used in the calculation of the MDC for a detection system shall be based on the actual observed variance of the background counting rate or of the counting rate of the blank samples (as appropriate) rather than on an unverified theoretically predicted variance. Typical values of E, V, Y, and Δt shall be used in the calculation.

TABLE 6 (Continued)

TABLE NOTATION

b. Analyses shall also be performed following shutdown from > or = 15% RATED THERMAL POWER, startup to > or = 15% RATED THERMAL POWER or a THERMAL POWER change exceeding 15% of the RATED THERMAL POWER within a one hour period.

c. Tritium grab samples shall be taken from the plant vent stack at least once per 24 hours when the refueling canal is flooded.

d. Samples shall be changed at least once per 7 days and analyses shall be completed within 48 hours after changing (or after removal from sampler). Sampling shall also be performed at least once per 24 hours for at least 2 days following each shutdown from > or = 15% RATED THERMAL POWER, startup to > or = 15% RATED THERMAL POWER or THERMAL POWER change exceeding 15% of RATED THERMAL POWER in one hour and analyses shall be completed within 48 hours of changing. When samples collected for 24 hours are analyzed, the corresponding MDC may be increased by a factor of 10.

e. Tritium grab samples shall be taken at least once per 7 days from the ventilation exhaust from the spent fuel pool area, whenever spent fuel is in the spent fuel pool.

f. The ratio of the sample flow rate to the sampled stream flow rate shall be known for the time period covered by each dose or dose rate calculation made in accordance with Specifications 3.11.2.1, 3.11.2.2 and 3.11.2.3.

g. The principle gamma emitters for which the MDC specification applies exclusively are the following radionuclides: Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, Cs-134, Cs-137, Ce-141 and Ce-144 for particulate emmissions. This list does not mean that only these nuclides are to be detected and reported. Other which are measureable and identifiable, together with the above nuclides, shall also be identified and reported.

h. Deviations from MDC requirements of Table 4.11-2 shall be reported per Specification 6.9.1.8 in lieu of any other report.

i. A composite particulate sample is one in which the quantity of air sampled is proportional to the quantity of air discharged. Either a specimen which is representative of the air discharged may be accumulated and analyzed or the individual samples may be analyzed and weighted in proportion to their respective volume discharged.

j. The principal gamma emitters for which the MDC specification applies exclusively are the following radionuclides: Kr-87, Kr-88, Xe-133, Xe-133m, Xe-135, and Xe-138 for gaseous emissions. This does not mean that only these nuclides are to be detected and reported. Other peaks which are measurable and identifiable together with the above nuclides, shall also be identified and reported.

TABLE 7

LIQUID DISCHARGES NOT MEETING SPECIFIED DETECTION LIMITS
Farley Units 1 & 2 - 2nd half, 1984

Batch #	N/A*
Date	N/A
Count Time in Seconds	N/A
Volume Discharged in Gallons	N/A
Dilution Water in Gallons	N/A
Total Isotopic Acitvity (uCi/ml)	N/A
Isotope of Interest	N/A
MDC Measured	N/A
% of Total Isotopic Activity	N/A
% of Total Dose	N/A

* No liquid discharges made that did not meet specified detection limits.

Table 8-CA

CUMLATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - Annual, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 1 -1-84 > 12-31-84
STABILITY CLASS: A
ELEVATION:45.7m

Wind Direction	Wind Speed (mph) at 45.7m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	11	28	21	13	0	0	73
NNE	15	34	22	5	0	6	82
NE	17	58	31	7	0	0	113
ENE	14	60	45	8	0	1	128
E	15	67	51	5	0	0	138
ESE	20	73	37	1	1	0	132
SE	18	72	46	0	0	0	136
SSE	24	58	55	6	3	6	152
S	20	37	36	9	1	1	104
SSW	10	25	23	7	0	2	67
SW	8	26	35	25	9	8	111
WSW	29	35	24	2	1	3	94
W	22	46	25	5	5	4	107
WNW	28	56	16	10	0	2	112
NW	12	39	20	2	0	2	75
NNW	7	40	13	5	0	0	65
VARIABLE	7	177	13	6	0	0	203
Total	270	754	500	110	20	35	1689

Periods of calm(hours): 0
Hours of missing data: 0

Table 8-CA

CUMLATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - Annual, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 1 -1-84 > 12-31-84
STABILITY CLASS: A
ELEVATION:10.0m

Wind Direction	Wind Speed (mph) at 10.0m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	19	32	12	0	0	0	63
NNE	30	34	7	0	0	6	77
NE	31	48	32	0	0	0	111
ENE	21	84	35	1	0	1	142
E	36	80	21	0	0	0	137
ESE	37	71	16	0	1	1	126
SE	38	94	31	0	0	1	164
SSE	29	54	35	2	3	6	129
S	19	20	15	2	0	0	56
SSW	12	34	21	10	0	5	82
SW	29	44	41	10	2	1	127
WSW	34	31	10	2	0	3	80
W	44	96	17	1	4	4	166
WNW	26	52	13	3	1	2	97
NW	10	28	14	1	0	0	53
NNW	12	43	14	3	0	0	72
VARIABLE	7	178	24	1	0	0	210
Total	427	845	334	35	11	30	1682

Periods of calm(hours): 0
Hours of missing data: 0

Table 8-CA

CUMLATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - Annual, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 1 -1-84 > 12-31-84
STABILITY CLASS: B
ELEVATION:45.7m

Wind Direction	Wind Speed (mph) at 45.7m level						
	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	3	12	14	3	0	0	32
NNE	4	12	12	0	0	0	28
NE	4	26	5	2	0	0	37
ENE	5	16	14	1	0	0	36
E	9	25	12	1	0	0	47
ESE	5	15	12	1	0	0	33
SE	4	34	18	4	0	0	60
SSE	3	9	14	6	1	1	34
S	2	9	6	3	0	0	20
SSW	2	9	12	10	5	1	39
SW	2	8	7	4	2	0	23
WSW	2	19	10	4	0	0	35
W	4	25	18	10	5	1	63
WNW	4	23	6	0	0	0	33
NW	1	19	11	1	0	0	32
NNW	3	57	19	0	1	0	80
VARIABLE	0	164	36	11	2	0	213
Total	57	318	190	50	14	3	632

Periods of calm(hours): 0
Hours of missing data: 0

Table 8-CA

CUMLATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - Annual, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 1 -1-84 > 12-31-84
STABILITY CLASS: B
ELEVATION:10.0m

Wind Direction	Wind Speed (mph) at 10.0m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	11	22	1	0	0	0	34
NNE	5	4	3	0	0	0	12
NE	6	11	5	0	0	0	22
ENE	12	35	7	0	0	0	54
E	11	19	7	0	0	0	37
ESE	8	22	6	0	0	0	36
SE	7	25	21	3	0	0	56
SSE	5	10	5	2	1	1	24
S	1	5	2	1	1	0	10
SSW	3	24	11	5	1	2	46
SW	8	19	11	2	0	0	40
WSW	4	21	2	0	0	1	28
W	7	52	16	11	1	0	87
WNW	5	28	6	0	0	0	39
NW	5	20	9	1	0	0	35
NNW	4	37	6	0	0	0	47
VARIABLE	0	205	28	5	0	0	238
Total	102	354	118	25	4	4	607

Periods of calm(hours): 0
Hours of missing data: 0

Table 8-CA

CUMLATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - Annual, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 1 -1-84 > 12-31-84
STABILITY CLASS: C
ELEVATION:45.7m

	Wind Speed (mph) at 45.7m level					
Wind Direction	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	6	19	14	1	0	0	40
NNE	8	16	9	0	0	0	33
NE	4	23	3	2	0	0	32
ENE	4	14	2	3	0	0	23
E	6	18	6	1	0	0	31
ESE	3	15	8	0	0	0	26
SE	1	10	16	5	1	0	33
SSE	6	11	12	5	0	0	34
S	4	8	5	3	0	0	20
SSW	2	9	3	6	3	0	23
SW	2	9	11	10	3	0	35
WSW	3	24	8	0	0	0	35
W	9	13	11	14	6	0	53
WNW	2	8	1	0	0	0	11
NW	5	23	11	0	2	0	41
NNW	6	35	5	1	0	0	47
VARIABLE	1	62	11	2	0	0	76
Total	71	255	125	51	15	0	517

Periods of calm(hours): 0
Hours of missing data: 0

Table 8-CA

CUMLATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - Annual, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 1 -1-84 > 12-31-84
STABILITY CLASS: C
ELEVATION:10.0m

Wind Direction	Wind Speed (mph) at 10.0m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	14	20	1	0	0	0	35
NNE	14	8	2	0	0	0	24
NE	9	12	4	1	0	0	26
ENE	5	18	2	0	0	0	25
E	12	8	0	0	0	0	20
ESE	10	18	2	0	0	0	30
SE	7	18	18	2	0	0	45
SSE	7	7	5	0	0	0	19
S	5	2	1	2	0	0	10
SSW	3	13	5	9	1	0	31
SW	2	24	9	4	1	0	40
WSW	11	21	2	0	0	0	34
W	12	32	15	4	0	0	63
WNW	8	23	1	0	0	0	32
NW	8	13	2	3	0	0	26
NNW	8	35	3	0	0	0	46
VARIABLE	1	73	9	4	0	0	87
Total	135	272	72	25	2	0	506

Periods of calm(hours): 0
Hours of missing data: 0

Table 8-CA

CUMLATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - Annual, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 1 -1-84 > 12-31-84
STABILITY CLASS: D
ELEVATION:45.7m

Wind Direction	Wind Speed (mph) at 45.7m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	14	14	17	2	0	0	47
NNE	9	23	22	0	0	1	55
NE	12	36	26	5	0	0	79
ENE	9	16	29	5	0	1	60
E	3	26	13	4	0	0	46
ESE	10	24	10	1	0	0	45
SE	14	25	16	3	1	1	60
SSE	9	16	22	8	0	1	56
S	16	23	9	7	0	0	55
SSW	6	15	13	9	3	4	50
SW	8	25	37	19	0	0	89
WSW	11	29	25	1	0	0	66
W	17	46	27	18	7	1	116
WNW	13	28	6	1	0	0	48
NW	13	32	8	2	0	0	55
NNW	13	38	14	2	0	0	67
VARIABLE	6	112	12	4	3	0	137
Total	177	416	294	87	11	9	994

Periods of calm(hours): 0
Hours of missing data: 0

Table 8-CA

CUMLATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - Annual, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 1 -1-84 > 12-31-84
STABILITY CLASS: D
ELEVATION:10.0m

Wind Direction	Wind Speed (mph) at 10.0m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	24	26	1	0	0	1	52
NNE	23	21	5	1	0	0	50
NE	18	31	17	0	0	0	66
ENE	23	19	14	2	0	0	58
E	16	23	1	1	0	0	41
ESE	23	26	3	0	0	0	52
SE	18	27	22	1	1	0	69
SSE	16	15	10	0	0	1	42
S	16	13	4	1	0	0	34
SSW	11	22	20	12	5	0	70
SW	20	49	19	1	0	0	89
WSW	20	38	2	2	0	0	62
W	35	53	13	13	0	0	114
WNW	26	25	2	0	0	0	53
NW	25	27	9	2	0	0	63
NNW	13	42	3	0	0	0	58
VARIABLE	6	129	11	12	0	0	158
Total	327	457	145	36	6	2	973

Periods of calm(hours): 0
Hours of missing data: 0

Table 8-CA

CUMLATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - Annual, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 1 -1-84 > 12-31-84
STABILITY CLASS: E
ELEVATION:45.7m

	Wind Speed (mph) at 45.7m level					
Wind Direction	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	11	48	33	0	0	1	93
NNE	10	35	60	1	2	1	109
NE	12	60	37	2	0	0	111
ENE	21	64	50	6	0	0	141
E	21	72	53	2	1	1	150
ESE	24	51	48	4	1	0	128
SE	16	63	41	1	1	1	123
SSE	20	41	45	14	1	0	121
S	21	19	25	4	2	0	71
SSW	16	36	46	17	2	0	117
SW	17	52	112	33	3	0	217
WSW	11	63	57	0	0	1	132
W	24	107	24	2	2	1	160
WNW	12	34	20	0	0	1	67
NW	18	31	35	9	2	0	95
NNW	8	63	39	8	1	0	119
VARIABLE	0	159	20	3	2	0	184
Total	262	839	725	103	18	7	1954

Periods of calm(hours): 0
Hours of missing data: 0

Table 8-CA

CUMLATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - Annual, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 1 -1-84 > 12-31-84
STABILITY CLASS: E
ELEVATION:10.0m

Wind Direction	Wind Speed (mph) at 10.0m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	85	23	0	0	0	0	108
NNE	89	37	1	0	2	0	129
NE	61	60	12	0	0	0	133
ENE	58	63	13	2	0	0	136
E	47	65	6	0	1	2	121
ESE	41	61	2	2	1	0	107
SE	36	63	22	2	1	0	124
SSE	20	23	8	3	0	0	54
S	28	18	10	0	0	0	56
SSW	17	62	36	4	1	0	120
SW	71	109	44	0	1	0	225
WSW	63	40	2	0	0	1	106
W	74	85	2	3	0	0	164
WNW	43	32	4	1	0	0	80
NW	45	53	22	1	0	0	121
NNW	70	59	8	0	2	1	140
VARIABLE	0	200	11	3	0	0	214
Total	848	853	192	18	9	4	1924

Periods of calm(hours): 0
Hours of missing data: 0

Table 8-CA

CUMLATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - Annual, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 1 -1-84 > 12-31-84
STABILITY CLASS: F
ELEVATION:45.7m

Wind Direction	Wind Speed (mph) at 45.7m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	9	22	17	0	0	0	48
NNE	6	21	21	2	0	0	50
NE	5	40	24	0	0	2	71
ENE	5	45	37	5	0	0	92
E	10	22	30	0	0	1	63
ESE	10	27	30	0	0	0	67
SE	10	28	8	0	0	0	46
SSE	13	12	15	6	0	1	47
S	11	3	5	2	0	0	21
SSW	4	37	13	1	0	0	55
SW	9	23	35	11	0	1	79
WSW	3	32	25	0	0	0	60
W	14	58	26	0	0	0	98
WNW	6	24	13	0	0	1	44
NW	15	26	21	1	0	0	63
NNW	11	46	23	0	0	0	80
VARIABLE	1	71	5	0	0	0	77
Total	141	466	343	28	0	6	984

Periods of calm(hours): 0
Hours of missing data: 0

Table 8-CA

CUMLATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - Annual, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 1 -1-84 > 12-31-84
STABILITY CLASS: F
ELEVATION:10.0m

Wind Direction	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
	Wind Speed (mph) at 10.0m level						
N	95	6	0	0	0	0	101
NNE	65	10	0	2	1	0	78
NE	52	6	1	0	0	0	59
ENE	27	25	0	4	0	0	56
E	25	9	0	0	0	0	34
ESE	17	12	0	0	0	0	29
SE	13	24	6	0	0	0	43
SSE	6	4	1	1	0	1	13
S	8	3	4	0	0	0	15
SSW	10	37	2	0	0	1	50
SW	27	34	11	0	0	0	72
WSW	36	11	0	0	0	0	47
W	50	46	1	1	0	0	98
WNW	36	17	0	0	0	0	53
NW	46	21	5	0	0	0	72
NNW	78	27	2	1	0	0	108
VARIABLE	2	130	1	0	0	0	133
Total	591	292	33	9	1	2	928

Periods of calm(hours): 0
Hours of missing data: 0

Table 8-CA

CUMLATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - Annual, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 1 -1-84 > 12-31-84
STABILITY CLASS: G
ELEVATION:45.7m

Wind Direction	Wind Speed (mph) at 45.7m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	18	23	22	1	0	0	64
NNE	16	14	22	2	0	0	54
NE	9	44	14	0	0	0	67
ENE	16	45	34	1	0	0	96
E	7	23	48	0	0	0	78
ESE	8	32	35	1	0	0	76
SE	8	34	10	0	0	0	52
SSE	12	17	24	3	0	0	56
S	10	8	2	1	0	0	21
SSW	7	25	2	0	0	0	34
SW	13	10	11	2	0	0	36
WSW	8	22	11	1	0	0	42
W	9	55	10	0	0	0	74
WNW	14	27	14	0	0	0	55
NW	15	37	18	0	0	0	70
NNW	22	79	19	2	0	0	122
VARIABLE	6	114	7	0	0	0	127
Total	192	495	296	14	0	0	997

Periods of calm(hours): 0
Hours of missing data: 0

Table 8-CA

CUMLATIVE JOINT FREQUENCY DISTRIBUTION

Farley Nuclear Plant - Annual, 1984

HOURS AT EACH WIND SPEED AND DIRECTION

RELEASE MODE: CONTINUOUS
PERIOD OF RECORD: 1 -1-84 > 12-31-84
STABILITY CLASS: G
ELEVATION: 10.0m

Wind Direction	Wind Speed (mph) at 10.0m level 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	164	8	0	0	0	0	172
NNE	75	8	0	0	0	0	83
NE	33	2	0	0	0	0	35
ENE	32	7	0	1	0	0	40
E	25	8	2	0	0	0	35
ESE	17	12	1	0	0	0	30
SE	12	7	2	0	0	0	21
SSE	7	3	0	1	0	0	11
S	5	1	0	0	0	0	6
SSW	3	23	1	0	0	0	27
SW	10	5	4	0	0	0	19
WSW	24	8	1	0	0	0	33
W	29	52	1	0	0	0	82
WNW	36	19	0	0	0	0	55
NW	54	16	1	0	0	0	71
NNW	172	45	0	0	0	0	217
VARIABLE	15	172	0	0	0	0	187
Total	698	224	13	2	0	0	937

Periods of calm(hours): 0
Hours of missing data: 0

13. Process Control Program

Changes to the Process Control Program (PCP) during the second semi-annual period of 1984 are submitted per STS section 6.13.2. Documentation that the changes were reviewed and found acceptable by the Plant Operations Review Committee is also submitted in the following section of this report.

PROCEDURE REQUEST FORM

1. Procedure Number FNP-0-M-030 Revision Number 0
Procedure Title Process Control Program

☒ Safety Related ☐ Non-Safety Related
☐ New Procedure Request
☒ Procedure Revision, New Revision Number 1
☐ Temporary Procedure Change, Effective until next permanent change, TCN ______
☐ Temporary Procedure Change, Req'd. by Plant Conditions, TCN ___
☐ Temporary Procedure Change, One Time Use, TCN ____
☐ Delete procedure

2. Change Summary
2.1 Procedure Page Numbers Affected by Change See attached list of effective pages that reflect FNP revision one

2.2 Description of Changes All changes submitted by vendor, Westinghouse Hittman Nuclear Incorporated

2.3 Reason for Change Vendor update of procedures

3. Prepared By ______, Westinghouse Hittman Tec. Rep., 7-16-84
Signature Title Date

4. Reviewed By J. M. Warden, Radwaste Supervisor, 7-16-84
Signature Title Date

5. Cross-Disciplinary/PORC Review

Group	Signature	Title	Date
PORC	J D Woodard	PM	7-17-84

6. Temporary Change Approval (Signature/Date)

☐ Member Group Staff ______/______
☐ Shift Foreman ______/______
☐ Senior Reactor Operator ______/______
☐ Plant Manager ______/______

7. Final Approval (Signature/Date, required within 60 days of temporary approval)

☐ Group Supervisor ______/______
☑ Plant Superintendent C. D. Nesbitt / 7-17-84
☐ MSAER ______/______
☐ Vice President - Nuclear Generation ______/______
☐ ______ ______/______
☑ Plant Manager J D Woodard / 7-17-84

FARLEY NUCLEAR PLANT
NUCLEAR SAFETY EVALUATION CHECK LIST
10 CFR 50.59

(1) UNIT 1&2

(2) CHECK LIST APPLICABLE TO: FNP-0-M-030 Revision 1 TCN ________

(3) SAFETY EVALUATION - PART A

The procedure, procedure change or modification to which this evaluation is applicable represents:

(3.1) Yes ________ No X A change to the plant as described in the FSAR?
(3.2) Yes ________ No X A change to procedures as described in the FSAR?
(3.3) Yes ________ No X A test or experiment not described in the FSAR?
(3.4) Yes ________ No X A change to the Technical Specifications or Operating License?

If the answer to question 3.1, 3.2 or 3.3 is "YES," complete Item (4) and attach a 10 CFR 50.59 evaluation. If the answer to all of the above is "No," omit Item (4) and Item (9) If the answer to question 3.4 is "Yes," complete a 10 CFR 50.92 check list.

(4) SAFETY EVALUATION - PART B

(4.1) Yes ________ No ________ Will the probability of an accident previously evaluated in the FSAR be increased?
(4.2) Yes ________ No ________ Will the consequences of an accident previously evaluated in the FSAR be increased?
(4.3) Yes ________ No ________ May the possibility of an accident which is different than any already evaluated in the FSAR be created?
(4.4) Yes ________ No ________ Will the probability of a malfunction of equipment important to safety previously evaluated on the FSAR be increased?
(4.5) Yes ________ No ________ Will the consequences of a malfunction of equipment important to safety different than any already evaluated in the FSAR be increased?
(4.6) Yes ________ No ________ May the possibility of a malfunction of equipment important to safety different than any already evaluated in the FSAR be created?
(4.7) Yes ________ No ________ Will the margin of safety as defined in the basis to any Technical Specification be reduced?

If the answer to any of the above questions is "Yes," an unreviewed safety question is involved. Explain the basis for each answer provided in Section 4.

(5) REMARKS: (Attach additional pages if necessary) This revision to the FNP Process Control Program does not reduce the overall conformance of the FNP solidified waste program to existing criteria for solid wastes.

(6) PREPARED BY: ________ DATE 7/17/84
(7) REVIEWED BY: ________ DATE 7-17-84
(8) PORC REVIEW: ________ DATE 7-17-84
(9) NORB REVIEW: ________ DATE ________

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Figure 3

FNP-0-M-030
July 10, 1984
Revision 1

ALABAMA POWER COMPANY

JOSEPH M. FARLEY NUCLEAR PLANT

UNITS 1 AND 2

SAFETY RELATED

PROCESS CONTROL PROGRAM

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Approved:

Technical Superintendent

Date Issued: 7-17-84

MISC #4

HITTMAN NUCLEAR & DEVELOPMENT CORPORATION	Document Number: STD-P-03-004	Rev: 5
		Rev Date: 9-30-83
	Title: Closure of HITTMAN RADLOK™ High Integrity Container Fill Port	

Rev.	Rev Date	Prepared by	Operations	Director Engineering	QA Manager		
0	4-7-82	JD Williams					
1	4-16-82	JD Williams			J. Pawlik for B. Rowe		ECN-82-091
2	4-28-82						ECN-82-096
3	9-10-82						ECN-82-182
4	3-1-83			J Phillips for CWM.			ECN-83-056
5	9-30-83						ECN-83-247

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CLOSURE OF HITTMAN RADLOK^{TM} HIGH INTEGRITY CONTAINER FILL PORT

1.0 PURPOSE

The purpose of this procedure is to describe the proper method of sealing the fill port opening on HITTMAN RADLOK High Integrity Containers.

2.0 APPLICABLE DOCUMENTS

The following drawings and documents are listed as applicable to this procedure:

STD-D-03-009, Users Manual for HITTMAN RADLOK-100 and RADLOK-200 Containers
STD-D-03-008, Users Manual for HITTMAN RADLOK-55

3.0 PRE-SEALING INSTRUCTIONS

These steps are to be taken prior to filling the container.

3.1 Compression Plug

3.1.1 Examine the O-ring (Item 1, Figure 1) and vertical gasket (Item 2, Figure 1) for signs of significant gouges, splits, cracks or brittleness. Damaged gaskets should be replaced.

3.1.2 Clean the O-ring and vertical gasket seats on the compression plug (Item 3, Figure 1) of all foreign matter.

3.1.3 Spray the O-ring and vertical gasket seats with silicone rubber adhesive. Place the O-ring in the seat area. Place the vertical gasket in the seat area. A liquid adhesive such as 3M Scotch-Weld, CA-4 Cyanoacrylate Adhesive may also be used.

3.1.4 Apply a liberal coating of lubricant grease on the exposed gasket surfaces. Acceptable lubricants include Vasoline and other petroleum jelly products.

3.1.5 Apply a liberal coating of lubricant grease to the threads on the fill port lid (Item 4, Figure 1).

3.1.6 Clean the gasket contact areas in the fill neck of all foreign material.

4.0 CONTAINER SEALING

These steps are to be taken after the container is filled.

4.1 Place the fill port closure assembly (Item 5, Figure 1) into the fill port opening. Screw the lid into the container to a minimum of 150 foot-pounds of torque.

4.2 When it has been assured that the plug is properly screwed down, the screw plug may be pinned by drilling out the pinning holes and inserting the locking pins. A security wire between one ear of the fill port lid and the top lip of the container may also be used.

NOTE: Securing the fill port lid need not be performed on containers to be shipped in Type A or Type B casks, or on containers to be shipped as strong tight packages.

6H

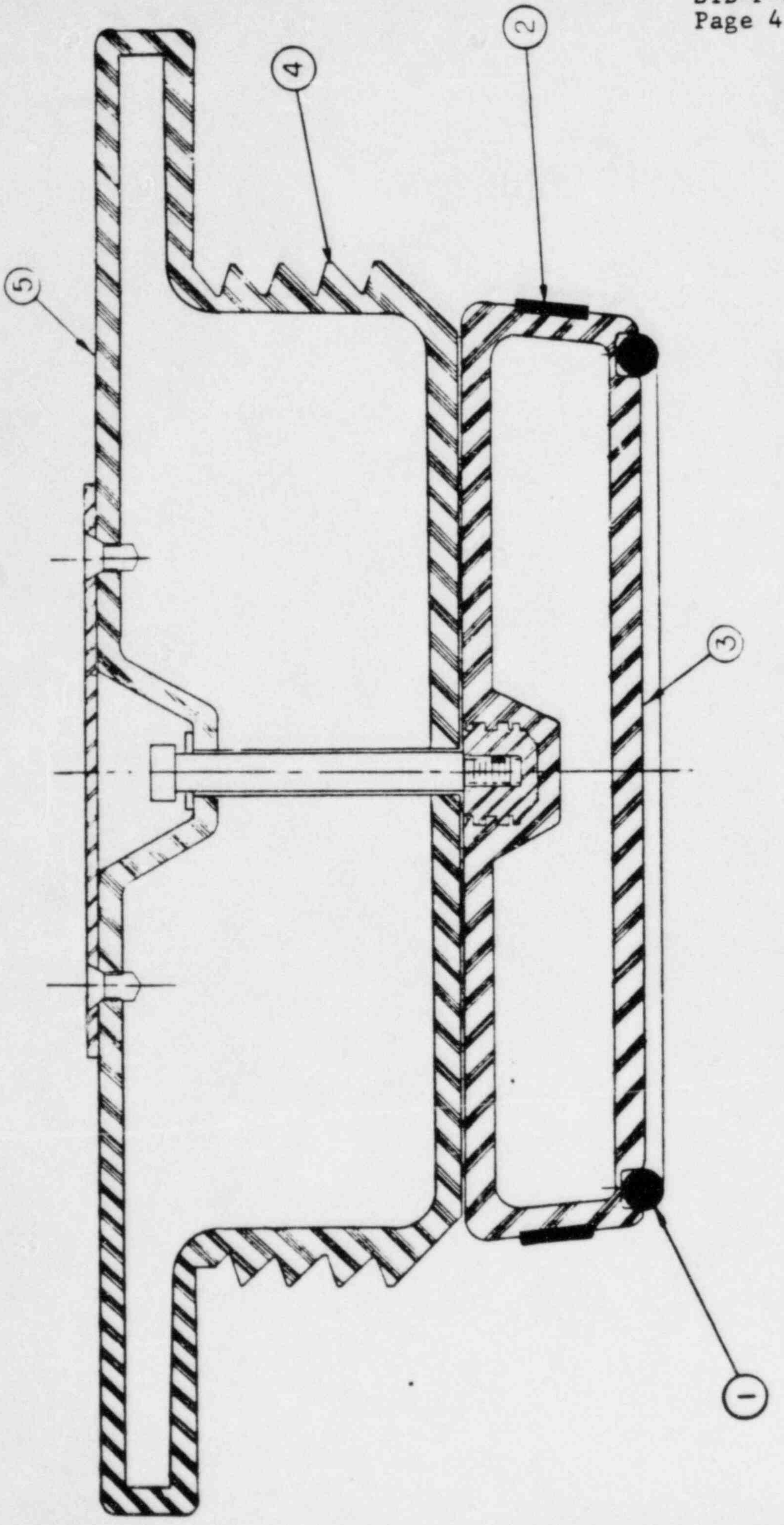


Figure 1

HITTMAN NUCLEAR & DEVELOPMENT CORPORATION	Document Number: STD-P-03-006	Rev: 1	Rev Date: 11-10-82
	Title: INSPECTION OF COMPLETED HNDC LINERS		

Rev.	Rev Date	Prepared by	Supervisor Field/Test	Director Engineering	Manager Field Services	QA Manager	
0	7-14-82		M. McCauley				TSR-81-305
1	11-10-82		M. McCauley				ECN-82-250

028

HNDC-01(A)

Page 1 of 9

INSPECTION OF COMPLETED HNDC LINERS

1.0 Scope

This procedure is applicable to all completed HNDC liners, with the exception of HNDC High Integrity Containers (H.I.C.), prior to or after delivery to client.

2.0 Purpose

The purpose of this procedure is to provide instructions for the inspection of items which could affect the performance, function, and/or safe operation and shipping of HNDC liners (except H.I.C.s).

3.0 General Instructions

3.1 For liner inspections performed at the job site, a Liner Inspection Report Form is to be used in conjunction with this document. A sample of this form is provided as Attachment A.

3.2 Care must be taken when removing, disassembling, replacing, or reassembling any components so as not to damage or misplace them.

3.3 All external threaded connections on liquid boundaries which are removed during inspection must be resealed using pipe dope or teflon tape and tightened to ensure that water tight integrity is maintained.

3.4 When removing and replacing resin loading hatch(es) care must be taken so as not to damage gaskets. Any gasket which is damaged or appears to be excessively compressed must be replaced or sealed using silicone sealant.

3.5 Upon completion of liner inspection, Field Services Coordinator is to be be notified immediately of all unacceptable items. In any event, the Liner Inspection Report Form shall be forwarded to the Field Services Coordinator, in a timely manner. Your on-site observations of equipment conditions are an important part of the service rendered by HNDC. If you have a recommendation or suggestions, note it on the Project Liner Inspection sheet or contact HNDC Quality Assurance.

3.6 Some items of this inspection procedure do not apply to all HNDC liners. When this occurs, those items not applicable to the liner being inspected may be so noted.

4.0 Inspection Instructions

4.1 Visually inspect the liner to determine the following:

4.1.1 Has the liner been painted?

4.1.2 Is the liner supplied with an appropriate cap?

4.1.3 Are there any holes, gouges, or dents in the liner skin? Location and size (length, depth, etc.) must be reported for any hole or gouge; or any dent more than 1/2" deep.

4.1.4 Examine the entire surface area of the dewatering hose for any indications that the hose has been kinked, cut, abraided, or in any other way damaged. Check the dewatering hose in its shipping configuration and insure that the minimum bend radius of 3" is not exceeded; and ensure that this condition will not exist in final use of the liner.

4.1.5 Look into the liner neck to determine if the dewatering hose is supported by a hanger.

4.1.6 If hose elbow is required look into the liner neck to determine if the two sections of dewatering hose are secured with hose clamps. Also determine if the threaded connections have been sealed with pipe dope or teflon tape.

4.1.7 If hose elbow is required, reach into the liner neck and attempt to turn hoses and threaded connections where the two sections of dewatering hose are joined to ensure that the hose clamps and threaded connections are tight.

4.2 Inspection Using Liner Neck Inspection Template

4.2.1 Slide dewatering hose through the appropriately marked hole on the template and place the template on the liner neck.

4.2.2 Align the three bolt holes on the template with the coupling nuts in the liner neck and screw in by hand three 3/4" x 10 bolts.

4.2.3 With jig in place and using the appropriate markings on the jig, check the following:

4.2.3.1 Is the wiper blade located properly?

4.2.3.2 Is the dewatering hose located properly?

4.2.3.3 Are two of the bolt holes in the jig parallel to the internal stiffeners in the liner (refer to Attachment B for location of stiffeners).

4.2.3.4 Remove the jig by unscrewing the three 3/4" x 10 bolts by hand and sliding the dewatering hose out of the hole. Easy removal of the 3/4" bolts by hand indicates that the liner neck coupling nuts were chased after welding and/or painting. If not, report this as a discrepancy.

4.3 Inspection with Liner Lifted

4.3.1 Place both liner lifting cables into crane hook making sure that the bottom (shorter) cable is placed onto the crane hook first.

4.3.2 Raise crane hook until liner just begins to lift off the ground. Observe the action of the thimbles in the lift lugs to ensure that they move freely.

4.3.3 Grab both cables and pull on them to ensure that both cables develop tension when lifting liner.

4.3.4 With tension still on the cables, examine the entire surface area of the slings to determine that the cables are intact, free of any cut strands or any other defects.

4.3.5 Raise the liner until the bottom can be visually examined and inspect bottom for sections 4.1.1 and 4.1.3.

4.3.6 If a crane is not available for lifting, a fork lift can be used to develop tension on the cables for the above mentioned inspections, provided the cables are lifted from a single point.

4.4 Removal and Inspection of Resin Loading Hatch(es)

4.4.1 Mark the resin loading hatch(es) in a manner that will ensure replacement in the original location.

4.4.2 Remove the resin loading hatch(es) by unscrewing the eight securing nuts for each hatch and carefully removing the hatch(es) and gasket(s), (see Section 3.4).

4.4.3 Examine the hatch(es) and the liner in the sealing area for any signs of excessive warpage, defects, or any other obstruction which could prevent proper sealing.

4.4.4 Inspect gasket(s) for any defects or excessive compression which could prevent proper sealing (see Section 3.4).

4.4.5 Do not replace resin loading hatch(es) until liner inspection is complete.

4.5 Inspection with Resing Loading Hatch(es) Removed

4.5.1 Reach into a resin loading hatch and spin the mixer blade (if applicable) to ensure that it will turn freely without any binding or interference.

4.5.2 Using a flashlight or trouble light, look into hatches and visually inspect the entire surface of the underdrain to ensure that it is level, intact, and free of debris and exposed piping.

4.5.3 Looking through the resin loading hatch under which the dewatering hose passes, locate the top of the dewatering standpipe (see Attachment B) and determine if the threaded connections at the elbow have been sealed with pipe dope or teflon tape, and that the hose has been equipped with a hose clamp.

4.5.4 Look to the bottom of the dewatering standpipe to determine if the threaded connection is sealed with pipe dope or teflon tape and properly sealed in the reducing basking at the surface of the underdrain.

4.5.5 Reach into resin loading hatch and grab the dewatering hose near the elbow located at the top of the dewatering standpipe. Attempt to turn hose, nipple, elbow, and standpipe where they are joined to ensure that the hose clamp and threaded connections are tight.

4.6 Inspection of Electrode Assy (if applicable)

4.6.1 Look into resin loading hatch nearest the electrode assy to ensure that the fill, divert, and ground electrodes are in their proper location (see Attachment B).

4.6.2 Look into resin loading hatch to ensure that the 1/2" pipes which shield the electrode rods are parallel to the liner side and each other.

4.6.3 Reach into resin loading hatch and grab the 1/2" pipes. Attempt to turn these pipes to ensure that the threaded connections are tight.

4.6.4 Look into the liner at the exposed ends of the electrode rods to ensure that they are trimmed free of insulation (2" for ground electrode and 1/2" for fill and divert electrodes).

4.6.5 Carefully examine the electrode plugs from the outside to ensure that the ceramic insulation is free of any paint, cracks, or defects.

4.6.6 Examine the threaded connections of the electrode plugs and the reducing bushings at the liner top to ensure that they have been properly sealed with pipe dope or teflon tape.

4.6.7 Examine the entire surface area of the electrode assy extension cord to ensure that the insulation is intact and free of any defects.

4.6.8 Examine the individual wires connected to the electrode assy plugs to ensure that they are slack enough to prevent strain and that they are wired properly (refer to Attachment B, green wire to ground, white wire to fill, black wire to divert).

4.6.9 Attempt to turn the electrode plugs and reducing bushings at the liner top to ensure that the threaded connections are tight.

4.6.10 Disassemble electode assy extension cord plug by loosening all screws until the plug housings separate enough to examine the wires to ensure that the plug is wired properly (green wire wo pin W, white wire to pin X, black wire to pin Y).

4.6.11 Reassemble plug by retightening all the screws on the plug until the plug housings and cord are tight.

4.7 Inspection of Dewatering Port-Side (if applicable)

4.7.1 Remove the threaded pipe plug from the final dewatering connection which is located on the outside of the liner at the bottom.

4.7.2 Insert a Hansen Series 3000 plug PN LL11 into quick coupling to ensure that it can be engaged and disengaged easily.

4.7.3 Replace threaded pipe plug.

4.8 Inspection of Dewatering Port-Top Option (if applicable)

4.8.1 Examine the 1/4" threaded pipe plug which is located on the top of the liner approximately 1" from the liner neck to ensure that it has been sealed with pipe dope or teflon tape and is screwed tightly into its coupling.

4.8.2 Examine the liner top to ensure that it is marked to indicate the dewatering port low point.

4.9 Replacement of Resin Loading Hatch(es)

4.9.1 Place the gasket(s) (see Section 3.4) on the liner top in original location.

4.9.2 Place the resin loading hatch(es) on the liner in original location (see Section 4.4.1).

4.9.3 Screw the eight securing nuts for each hatch onto the studs and tighten to ensure proper sealing.

4.10 Liner inspection is now complete.

4.11 Liner cap inspection

1. clips
2. gasket

4.12 Condition of protective packaging

1. Dewatering hose coiled and secured in neck of liner.
2. Plastic vapor barrier in place over neck.
3. Cap secured to or shipped with liner.

ATTACHMENT A

PROJECT LINER INSPECTION

This form will be filled out by the Senior Field Services operator at the project site when liner shipments are received. One copy is to be retained with the site records, and one copy sent to the Field Services Coordinator. (Please describe discrepancies in space provided in Comments - Section II)

DATE________________ P.O.#_______________ VENDOR__________________

TYPE HN-____________ LINER #_____________ CARRIER_________________

SITE/CUSTOMER____

Person Completing this Form____

I. General Conditions of Liner:

Dewatering hose coiled in neck and neck covered with plastic ___yes___no

Liner paint condition _____good _____poor

Condition of Skin______________________

Has liner been damaged? (Holes, dents, etc.) _____yes _____no

Are welds complete? _____yes _____no

Does the mixing blade turn freely by hand (ensure liner is resting on a flat support)?_______________________________

Condition of dewatering hoses: Installed: Secured: _____yes _____no

Is dewatering hose damaged? _____yes _____no

Condition of Underdrain: Foreign debris or damage? _____yes _____no

Have the mounting threads been chased? ___yes ___no Greased ___yes ___no

Caps Furnished _____yes _____no

II. Comments:____

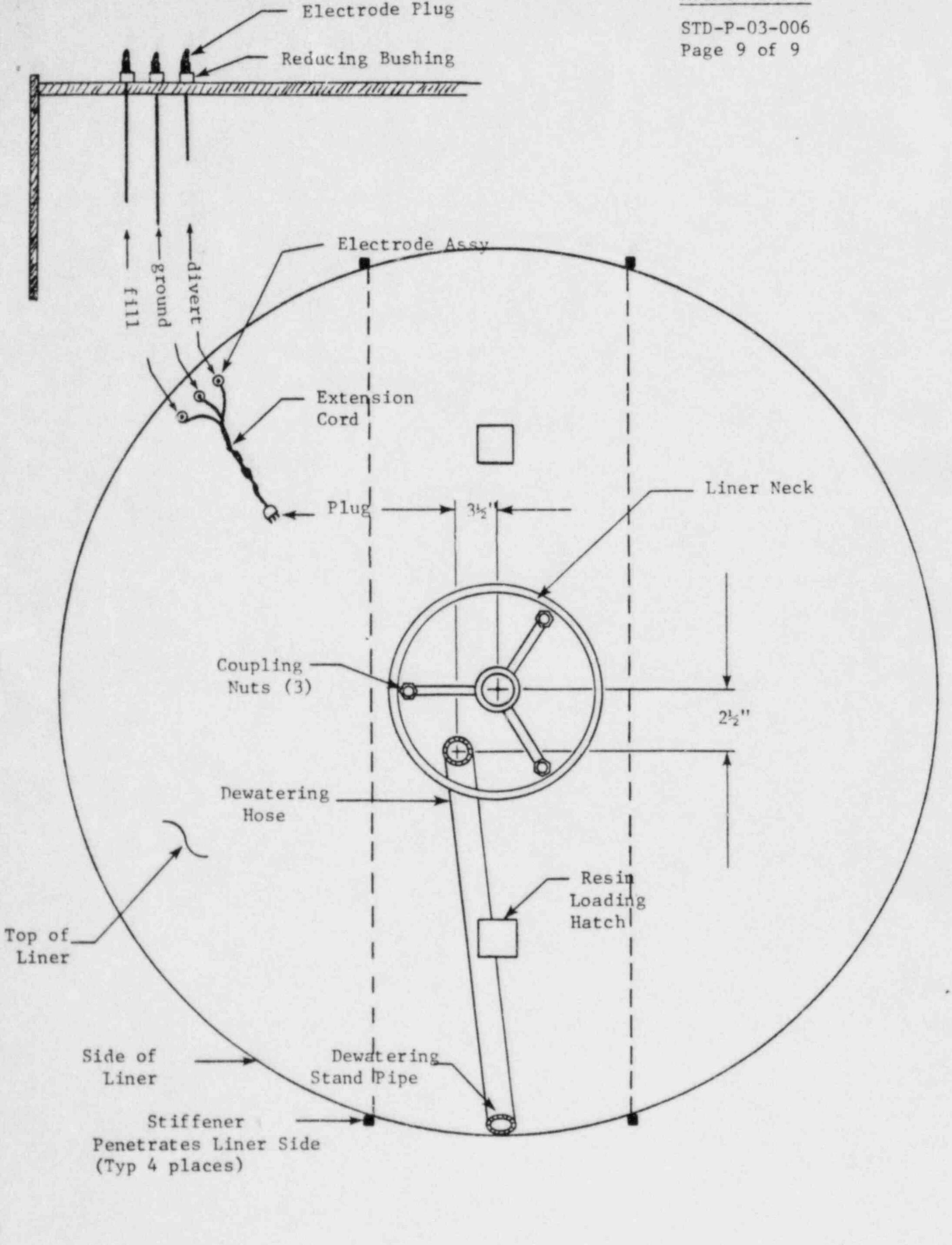
____

____

III. Recommendations/Suggesstions:____

____

Distribution: Field Services____ Purchasing____ Quality Assurance____ Other____


Electrode Plug
Reducing Bushing
fill
ground
divert
Electrode Assy
Extension Cord
Plug
3½"
Liner Neck
Coupling Nuts (3)
2½"
Dewatering Hose
Top of Liner
Resin Loading Hatch
Side of Liner
Dewatering Stand Pipe
Stiffener Penetrates Liner Side (Typ 4 places)

HITTMAN NUCLEAR & DEVELOPMENT CORPORATION	Document Number: STD-D-03-008	Rev: 5	Rev Date: 6-6-84
	Title: A Users Manual for the HITTMAN RADLOK-55		

Rev.	Rev Date	Responsible Engineer	Department Manager	Director Engineering	QA Manager	Project Manager	
0	4-16-82	J D Williams	J Phillips		J. Pawlik for B. ROWE	JD Williams	EWR-82-129
1	6-9-82	J Phillips	J Phillips			J Phillips	ECN-82-121
2	10-25-82	J Phillips	J Phillips				ECN-82-226
3	10-3-83	J Phillips	J Phillips				ECN-83-157
4	2-9-84						ECN-84-008
5	6-6-84						ECN-84-090

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HNDC-01(A)

Page 1 of 5

A USERS MANUAL FOR THE HITTMAN RADLOK-55

Purpose

The high integrity container is designed to provide waste isolation from the surrounding environment for a period of 300 years. Various unsolidified wastes may be disposed of at Barnwell; however, if the total specific activities of isotopes with half lives greater than five years is 1μCi/ml or greater, high integrity containers approved by the South Carolina Department of Health and Environmental Control must be used.

This document is intended to provide the user of the Hittman RADLOK™ drum with basic information required for the safe and proper use of the container. Included is a general description of the container, a listing of the approved contents, a listing of prohibited chemicals, and the storage requirements of a RADLOK container. Inspection requirements prior to usage, lift requirements, and closure methods are also provided.

Description of the RADLOK-55

The Hittman RADLOK-55 drum has been designed to closely approximate the size of present 55 gallon steel drums. The RADLOK drum has envelope dimensions of 35 inches high by 23 inches in diameter. The drum contains an 8 inch diameter fill port centered in the top. The container is fabricated from high density cross-linked polyethylene, molded to provide a one-piece body to the container.

Approved Contents

The Hittman RADLOK container has been designed to safely contain nuclear wastes including bead and powdered ion exchange resin, filter sludges, mechanical filters, stabilized incinerator ash, activated carbon, contaminated soil, and sandblasting grit. Procedures for loading metal filters, scrap metal and other non-compactible trash into the RADLOK container to ensure that protrusions and sharp edges do not damage the container must be submitted and approved by Hittman. The container may not contain free standing water greater than 1 percent of the waste volume.

Criteria for Packaging of Filter Elements and Scrap

The following criteria for the packaging of filter elements and scrap in Hittman RADLOK-55 containers shall be used in developing the required procedures.

Packaging Criteria
Waste Category

Parameter	Compactible Trash	Cartridge filters Elements	Rigid Metal Filter Elements with Exposed Ends, Noncompactible Trash with No Sharp Edges	Metal Scrap, Non-Compactible Trash with Sharp Edges
Maximum Length of of Individual Piece				
Placed Horizontal	none	20	20	20
Placed Vertical	none	24	24	18
Packing Material[1]	none	none	cement, vermiculite, sand, gravel, etc.	
Min. Depth of Packing[2] Material on Bottom	N/A	N/A	1"	2"
Padding[3]	none	none	none	pipe ends and sharp edges
Min. dist. waste to wall	none	none	none	2"
Packing between layers[4]	none	none	fill voids as loaded	2"
Maximum Depth of Waste	to underside of fill neck		2" below underside of fill neck	
Final Filling[4]	none	none	cover contents	cover contents plus 2"

[1] The packing material is used to protect the interior of the container and to prevent excessive settling of the waste during transit. Only required of waste that could potentially damage the container.

[2] To be placed in container prior to waste.

[3] To protect container walls if necessary. Among other items, rubber sheet or styrofoam blocks may be used. Only required on sharp edges or ends of rough cut pipe.

[4] Only necessary when packing material is used as defined in footnote number 1.

Prohibited Contents

Included in this guide, as Attachment A, is a copy of a MARLEX Resins Technical Service Memorandum from Phillips Chemical Company, No. TSM-293, Chemical Resistance of Marlex CL-100 and CL-50 Rotational Molding Cross linkable High Density Polyethylenes, dated December 1982. This document lists those chemicals that are incompatible with the material used in RADLOK high integrity containers. (Note: This document is oriented towards those applications where tanks manufactured using CL-100 (or CL-50) are used to store these chemicals in their pure form and not as contaminants in other materials.) When using a Hittman RADLOK, those chemicals listed in Table IV of the Appendix to Attachment A are considered prohibited and may not be disposed of in RADLOK high integrity containers. Chemicals listed elsewhere in the Appendix are not prohibited when disposed of as incidental contaminants to radioactive wastes.

Storage Conditions

The Hittman RADLOK drum may be stored under proper conditions for periods up to two years before use. As a photosensitive material, the containers shall be kept out of direct sunlight, and away from any other sources of ultraviolet radiation. Containers stored out of doors in direct sunlight must be used within one year of fabrication. Containers shall be stored in such a way that the bottom is flat and that no weight is located over the fill port area. This is to ensure that no potential deformation of the fill port area of the container or gasket material occurs. Each container shall be stored with its designated closure assembly to prevent mismatching.

Following closure of the container, it may be stored on-site prior to shipment for burial for up to five (5) years. The design of the facility must preclude the possibility of a wet or damp environment and keep the container out of any prolonged source of ultraviolet light. Short exposures to ultraviolet light, such as during placement or inspection are permitted. Storage of Hittman RADLOK containers for periods longer than five (5) years will require specific approval following a review of the storage facility design.

Inspection Prior to Use

Prior to the use of a container to receive waste material the following items must be checked. The fill port closure assembly, consisting of the fill port lid bolted to the compression plug and gaskets, is accounted for and in good condition. Gaskets are not hard or brittle and are free of defects. Thread areas and gasket areas are free of foreign matter that could impair the seal or thread engagement. The exterior surfaces shall be inspected for damage that may have occured during transport or storage that could lessen container integrity.

Lift Requirements

The RADLOK drum comes equipped with a lift band, and may be lifted by either fork lift tynes under the edges of the liftband or by the use of a standard drum grappler. Under maximum load conditions, the entire assembly would have a final weight of 950 pounds. The lift assembly is designed to accomodate this weight during a 3g abrupt lift. Note: Due to the nature of the container material, some bowing and deformation may be evident during lift. This is an anticipated condition.

Fill Port Use and Closure

The standard fill port on the Hittman RADLOK drum is an eight inch gasketed opening. The fill port is concentric with the top of the drum and is sealed with the fill port closure assembly. Two gaskets are attached to the compression plug of the fill port closure assembly. The assembly is then lowered into the opening and screwed into position to a prescribed torque.

If the container is to be used as a Type A container, the lid shall be secured for transportation to prevent illicit opening.

6F

ATTACHMENT A TO STD-D-03-008

CHEMICAL RESISTANCE OF MARLEX CL-100 AND CL-50 ROTATIONAL MOLDING CROSSLINKABLE HIGH DENSITY POLYETHYLENES

PHILLIPS CHEMICAL COMPANY
A SUBSIDIARY OF PHILLIPS PETROLEUM COMPANY
PLASTICS TECHNICAL CENTER
BARTLESVILLE OKLAHOMA 74004

MARLEX· RESINS
TECHNICAL SERVICE MEMORANDUM

TSM-293
DECEMBER, 1982

CHEMICAL RESISTANCE OF MARLEX CL-100 AND CL-50 ROTATIONAL MOLDING CROSSLINKABLE HIGH DENSITY POLYETHYLENES

INTRODUCTION

One of the most rapidly growing plastics applications is relatively large rotational molded storage tanks. This application and its growth has been keyed to the development and marketing of crosslinkable high density polyethylenes by Phillips Chemical Company. These polyethylenes are marketed under the designation of Marlex CL-100 and CL-50 rotational molding crosslinkable high density polyethylene.

Rotational molding is ideally suited for the manufacture of large tanks. In addition the unique toughness, chemical and stress crack resistance of the Marlex CL-100 and CL-50 resins are needed for the demanding requirements in industry and agriculture for chemical storage tanks and are the key to this expanding market. Today tanks are molded as large as 15,000 gallons (57,000 liters) and are used in such diverse storage applications as acids, insecticides, and chemical plant waste by-products.

The scope of this Technical Service Memorandum is to address the question of compatibility of chemicals with Marlex CL-100 and CL-50 resins in relation to storage tanks. Engineering principles used in determining the suitability of a given application are discussed. Lists of chemicals both suitable and not suitable are included in the appendix along with any limitations which may apply.

CHEMICAL RESISTANCE

"Chemical resistance" and "compatibility" are synonymous terms used in relation to the ability of a plastic to function in different environments. In regard to polyethylene chemical storage tanks, chemical resistance encompasses the total effect a product would have on a tank. The factors that make up the overall compatibility of a chemical to a rotomolded tank are chemical attack, solubility, absorption or permeation, and stress crack resistance. Each of these are discussed briefly.

Chemical Attack - By definition, chemical attack involves an actual chemical reaction with the plastic. This can be a breaking of molecular chains and/or addition of chemical groups to the molecule. For example, in the case of an oxidation reaction with polyethylene both occur with the addition of carbonyl groups. This causes an eventual loss of properties to the point that a tank would not be serviceable.

Polyethylene in general is one of the most inert plastics available. Very few chemicals react with polyethylene, and even with those that do the rate is relatively slow. The ultra high molecular weight characteristics of Marlex CL-100 and CL-50 resins after crosslinking makes these particular polyethylenes even more resistant than other grades. Therefore, chemical attack is not a factor in very many applications.

Permeation - This involves the physical absorption of the chemical into the polyethylene. If this is a volatile chemical, then an actual loss of the product can occur as the chemical vaporizes from the outer wall of the tank. The amount of absorption is generally limited to 3-7 percent by weight of the polyethylene. Also, the loss of volatile products is relatively small. For example, a [illegible]-gallon tank with a 50-mil wall will only lose between 5 and 6 grams of gasoline a day due to permeation. The thicker the wall, the lower the rate of loss.

The absorption of a product into the wall of a tank will cause some property changes. The tensile strength is reduced approximately 10%, stiffness approximately 25%, and a linear and radial swell of from 1 to 5% will occur. Normally this does not affect the utility of the tank nor prohibit the application. It does, however, limit the temperature at which the tank can be used because the loss of these properties becomes a detemining factor as the temperature is increased. Also, if a chemical has too low a boiling point, the vapor pressure may be so high as to cause prohibitive distortion of the tank. This is why such chemicals as ether, pentane, etc., would not be suitable for storage in a sealed tank.

Solubility and Stress Resistance - Although these factors are to be considered with other plastics it is of no significance with Marlex CL-100 or CL-50. There are no known solvents at ambient conditions for these resins. Also, when properly molded and used, the phenomena of stress cracking just doesn't occur.

APPLICATION ENGINEERING

The appendix contains tables of chemicals indicating their compatibility with tanks molded using Marlex CL-100 and CL-50 resins. Table I lists chemicals that are suitable up to 150°F (66°C) without further qualification. Table II and III lists chemicals that permeate or are absorbed by the polyethylene. In these cases the use conditions should be more thoroughly considered. For example, most of these chemicals are flammable. It should be determined if this would present a safety or code problem. Other considerations would be: 1) are the tanks vented, 2) are they in a confined or open space, and 3) personnel exposure.

In Table IV chemicals are listed that either attack polyethylene or have high vapor pressure and are not normally recommended for long service life of the tank. This does not automatically preclude tanks from being used with these chemicals. It may be economical to periodically replace the tank after a relatively short service life. Factors such as life of the currently used tanks, cost of tanks made using exotic materials, and the consequences if a failure occurs should all be considered.

SUMMARY

Marlex CL-100 and CL-50 rotational molding crosslinkable HDPE is one of the most chemical resistant plastics manufactured today. It is not without limits, however, and the attached tables should be used only as a guide in determining those applications which are suitable.

CHEM:126

APPENDIX

It has been well documented over the years the types of chemicals that are compatible with polyethylene, either through tests or experience. It would be impossible to list all the chemicals that may be involved in use with polyethylene storage tanks. Therefore, the included tables are only representative of typical chemicals.

Also, their rankings are specific to the application of chemical storage tanks and the superior properties of Marlex® CL-100 and CL-50. The following tables are to be used only as a guide for establishing those uses that would give satisfactory service. They are not a substitute for sound engineering.

TABLE I

The following chemicals do not attack nor permeate Marlex® CL-100 or CL-50 resins up to 150°F (66°C). For temperatures over 150°F (65°C) each application should be considered individually. All concentrations apply except where noted.

Acetic Acid
Aluminum Salts
Alum
Ammonium Hydroxide
Ammonium Salts
Amyl Alcohol
Antimony Salts
Arsenic Acid
Barium Hydroxide
Barium Salts
Benzene Sulfonic Acid
Bismuth Salts
Boric Acid
Bromic Acid
Butanediol
Butyl Alcohol
Calcium Hydroxide
Calcium Salts
Chromic Acid <50%
Citric Acid
Copper Salts
Detergents
Diazo Salts
Diethyl Carbonate
Diethanol Amine
Diethylene Glycol
Diglycolic Acid
Dimethylamine
Dimethyl Formamide
Ethyl Alcohol
Ethylene Glycol
Ferric Salts
Ferrous Salts
Fluoboric Acid
Flousilicic Acid
Formic Acid
Gallic Acid
Gluconic Acid
Glycol Ethers
Glycolic Acid
Hexanol
Hydrazine <35%
Hydrozine Hydrochloride
Hydriodic Acid
Hydrobromic Acid
Hydrocyanic Acid
Hydrochloric Acid
Hydrofluoric Acid
Hydrofluorsilicic Acid
Hydrogen Peroxide <30%
Hydrogen Phosphide
Hydroquinone
Hypochorous Acid
Iodine Solutions
Lactic Acid
Latex
Lead Acetate
Magnesium Salts
Mercuric Salts
Mercurous Salts
Mercury
Methyl Alcohol
Methylsulfuric Acid
Nickle Salts
Nicotinic Acid
Nitric Acid <30%
Oxalic Acid
Perchloric Acid
Phenol <10%
Potassium Hydroxide
Potassium Salts
Phosphoric Acid
Photographic Solutions
Propyl Alcohol
Propylene Glycol
Sea Water
Selenic Acid
Sewage
Silicic Acid
Silver Salts
Soap Solutions
Sodium Acrylates
Sodium Ferricyanide
Sodium Ferrocyanide
Sodium Hydroxide
Sodium Hypochlorite <16%
Sodium Salts
Sodium Sulfonates
Stanic Salts
Stannous Salts
Starch Solutions
Stearic Acid
Sulfuric Acid <98%*
Sulfurous Acid
Sugar Solutions
  Glucose
  Lactose
  Sucrose, etc.
Tannic Acid
Tanning Extracts
Tartaric Acid
Titinium Salts
Toluene Sulfonic Acid
Triethanolamine
Urea
Vinegar
Wetting Agents
Zinc Salts

*Under some conditions acid will discolor.

TABLE II

The following oils and organic chemicals do not attack Marlex® CL-100 or CL-50 resins. They will be absorbed into the wall of the tank but there should be no loss of product. Because of this absorption, if tanks would be used for other service, contamination may result as the absorbed oil is leached out. Service at elevated temperatures up to 150°F (66°C) can be recommended provided the effects of the absorption on the properties of the tank are not prohibitive.

Fatty Acids

- Butyric
- Lauric
- Linoleic
- Oleic
- Palmitic
- Stearic

Mineral Oils

- Lube
- Transformer
- Hydraulic

Vegetable Oils

- Corn
- Coconut
- Cottenseed
- Olive
- Peanut

Animal Fats

- Lard
- Fish oil
- Musk oil
- Whale oil

TABLE III

The following organic chemicals do not attack Marlex® CL-100 or CL-50 resins. They will be absorbed into the wall of the tank and a permeation loss will occur. Because of this premeation and the effect it has on the physical properties of the tank it is generally not recommended they be used above 100°F (38°C). However, their use largely depends on such factors as size of the tank, its location, toxicity of the chemical, and applicable codes such as NFPA, OSHA, etc. This is not to discourage these chemical storage applications in which considerable experience with many has been documented on various polyethylene containers. For example, polyethylene gasoline tanks are used on lawn mowers, tractors, trucks, ATVs, snowmobiles, and as portable containers-even approved safety cans.

Aniline
Benzene
Carbon Tetrachloride
Chlorabenzene
Cychohexanol
Cyclohexanone
Dibutylphthalate
Diesel Fuel
Dimethylamine
Ethyl Butyrate
Ethylene Chlorohydrin
Fuel Oil
Furfural
Aliphatic hydrocarbons
  (hexane, octane, hexene, octene, etc.)
Jet fuel
Gasoline
Nitrobenzene
Octyl Cresol
Propylene dichloride
Toluene
Xylene

TABLE IV

The following chemicals are not recommended for general storage in tanks molded using Marlex® CL-100 or CL-50 resins. Their effect is not immediate nor catastrophic in nature. Therefore, under certain circumstances, tanks could be used either for the short term or in a limited life situation. Temperature is especially important!

Chemical Attack

- Aqua Regia
- Bromine
- Chromic/Sulfuric acid
- Fuming Sulfuric acid
- Nitric Acid >50%
- Organic peroxides
- Phenol-concentrated

High Vapor Pressure

- Acetone
- Butane
- Carbon Disulphide
- Chloroform
- Ethyl Ether
- Ethylene Dichloride
- Methylene Chloride
- Methyl Ethyl Ketone
- Propane
- Pentane

TABLE V

APPLICATIONS OF CROSSLINKED HDPE CHEMICAL TANKS

AGRICULTURAL

Chemical Handled	Size of Tank (gallons)*	Type of Tank		Type of Use		Years in Service
		H*	V*	S*	P*	
Cattle Supplements	5600		X	X		7
Insecticides	50 to 1500	X	X	X	X	10
Herbicides (Bicep, Dual, Sutan, Lasso)	50 to 1500	X	X	X	X	10
Liquid Fertilizer	100 to 5600	X	X	X	X	8
Nitrogen Solution	5600		X	X		8
Phosphoric Acid	1500 to 5600		X	X		8
Sulphur Solution	5600		X	X		8
Treflan	200	X			X	6

INDUSTRIAL

Chemical Handled	Size of Tank (gallons)*	Type of Tank		Type of Use		Years in Service
		H*	V*	S*	P*	
Hydrochloric Acid (37% and lower)	5600		X	X		8
Hydrofluoric Acid	55 to 2500	X		X	X	6
Sulfuric Acid (98% and lower)	400 to 12,000		X	X		8
Propionic Acid	5600		X	X		8
Sodium Hypochlorite	4250 to 12,000		X	X		8
Sodium Hydroxide	1500 to 12,000		X	X		8
Hydrogen Peroxide (52%)	55 to 1600	X	X	X	X	5
Alum	5600		X	X		8
Cactus Juice	1500 to 6000		X	X		5
Detergents	100 to 6000	X	X	X	X	8
Floor Finishes & Cleaners	5600		X	X		8
Latex	6400		X	X		8
Oil Well Additives	200 to 1500	X	X	X	X	8
Plating Solutions	3000		X	X		4
Waste Water	12,000		X	X		8

H - Horizontal
V - Vertical
S - Stationary
P - Portable

*Constant to convert gallons to liters - gallons x 3.7854 = liters

WESTINGHOUSE HITTMAN NUCLEAR INCORPORATED	**Document Number:** STD-P-03-008	**Rev:** 4
		Rev Date: 6-6-84
	Title: Transfer & Dewatering Powdered Resin in Hittman RADLOK^{TM}-100 or -200 Containers with a Flexible Underdrain Assembly to Less Than 1% Drainable Liquid	

Rev.	Rev Date	Prepared by	Supervisor Laboratory Services	Director Engineering	Operations	QA Manager	
0	3-10-83	K McDaniel	E. Clochon	J Phillips			EWR-82-481
1	12-8-83			J Phillips for R. Leduc			ECN-83-267
2	3-19-84			RJ Leduc			ECN-84-044
3	5-17-84			RJ Leduc		J. Pawlik for B. Rowe	ECN-84-084
4	6-6-84			RJ Leduc			ECN-84-092

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TRANSFER AND DEWATERING POWDERED RESIN IN HITTMAN RADLOK^{TM}-100 OR -200 CONTAINERS WITH A FLEXIBLE UNDERDRAIN ASSEMBLY TO LESS THAN 1% DRAINABLE LIQUID

1.0 SCOPE

This procedure is applicable to RADLOK-100 and -200 High Integrity Containers with multi-layered flexible dewatering underdrains for dewatering unsolidified powdered ion exchange resins.

2.0 PURPOSE

To provide general instructions for the transfer and dewatering of powdered resin in RADLOK Containers with flexible dewatering underdrains to meet burial site criteria of less than one percent drainable liquid upon receipt at the site. This procedure also assures that there is no drainable liquid at the time of shipment from the plant.

3.0 REFERENCES

3.1 Hittman RADLOK^{TM} High Integrity Container Rad Services Manual, RSM-014.

3.2 Hittman drawing, STD-03-051, Sheet 4, RADLOK-100 Three Layer Underdrain Assembly.

3.3 Hittman drawing, STD-03-075, Equipment Arrangement for RADLOK-100 Container with Three Layer Underdrain.

3.4 Hittman drawing, STD-03-084, Sheet 4, RADLOK-200 Two Layer Underdrain Assembly.

3.5 Hittman drawing, STD-03-091, Equipment Arrangement for RADLOK-200 Container with Two Layer Underdrain.

3.6 Hittman report, STD-R-03-005, Summary Report of Powdered Resin Dewatering in a RADLOK^{TM} Container.

3.7 Hittman report, STD-R-03-006, Powdered Resin Dewatering in a Flat Bottom Container Using the Hittman Layered Underdrain System.

3.8 Hittman procedure, STD-P-03-003, RADLOK Manway Lid Closure and Sealing Procedure.

3.9 Hittman procedure, STD-P-03-004, Closure of Hittman RADLOK High Integrity Container Fill Port.

3.10 Hittman procedure, STD-P-03-020, RADLOK Inspection Procedure.

4.0 EQUIPMENT

4.1 Diaphragm pump 1-1/2" or equivalent with interconnecting hoses, quick disconnect fittings and clamps as required.

4.2 Hoses with fittings and clamps as required to connect from service air system to the diaphram pump. Minimum service air required is 40 SCFM at 100 psig.

4.3 Vacuum pump with minimum suction of 25 inches of mercury (29.9 inches Hg vacuum equals absolute vacuum) and 1/4 inch vacuum hoses.

4.4 Receiver tank with connecting hoses to the RADLOK container.

4.5 Overflow drum with connecting hoses to the RADLOK container (optional).

4.6 Liner level indicator panel.

4.7 Receiver tank level indicator panel.

4.8 Standpipes.

5.0 EQUIPMENT SET-UP

5.1 Prerequisites

5.1.1 The container has been satisfactorily inspected per STD-P-03-020.

5.2 Precautions

None.

5.3 Assembly

5.3.1 SET-UP equipment in accordance with Drawings STD-03-051, Sheet 4, and STD-03-075 for the RADLOK-100 or Drawings STD-03-084, Sheet 4 and STD-03-091 for the RADLOK-200.

6.0 TRANSFER AND DEWATERING

6.1 Prerequisites

6.1.1 The equipment is set up in accordance with Section 5.3.1 of this procedure.

6.1.2 An RWP is issued and Health Physics is notified prior to the waste transfer.

6.1.3 All valves on receiver tank except between tank and vacuum pump are closed.

6.2 Precautions

Be aware of changing radiological conditions as waste is transferred to the container and the container is dewatered.

6.3 Operating Steps

NOTE: Following establishment of initial vacuum in Step 6.3.1, the air inlet valve on the receiver tank shall be used to maintain vacuum between 15 and 20 inches of Hg during the entire dewatering process.

6.3.1 START the vacuum pump on the receiver tank and establish a vacuum of approximately 15 inches Hg.

NOTE: The diaphragm pump may be used to assist vacuum pump to establish desired vacuum.

6.3.2 START the transfer of waste in accordance with the appropriate system operating procedure.

6.3.3 TRANSFER until 50-100 gallons of waste are in the container and the bottom dewatering layer is covered.

6.3.4 OPEN the bottom dewatering layer isolation valve to the receiver tank while continuing the transfer.

NOTE: This valve will remain open throughout the entire operation.

6.3.5 START the dewatering pump when the receiver tank level indicator panel indicates "OP/HI".

NOTE: Maintain dewatering pump vacuum at least 5 inches of Hg greater than receiver tank vacuum.

6.3.6 Immediately STOP the waste transfer when the liner level indicator panel sounds an "OP/HI" alarm.

NOTE: The receiver tank vacuum shall be modulated to maintain water level in the receiver tank between the "OP/LOW" and "OP/HI" levels.

CAUTION: IF THE "HI/HI" LEVEL ON THE RECEIVER TANK ALARMS, TAKE IMMEDIATE ACTION TO REDUCE OR TERMINATE INFLUENT TO THE RECEIVER TANK UNTIL

THE "OP/HI" LEVEL CLEARS. THIS CAN BE ACCOMPLISHED BY SHUTTING THE ISOLATION VALVES OR BY DECREASING THE VACUUM IN THE RECEIVER TANK.

6.3.7 CONTINUE dewatering from the bottom lateral while allowing the solids to settle in the container for 30 minutes.

6.3.8 OPEN the dewatering layer isolation valves to all remaining dewatering layers.

6.3.9 When vacuum is lost, CLOSE top dewatering layer isolation valve. For RADLOK-200 containers, proceed to Step 6.3.12 at this time.

6.3.10 CONTINUE dewatering until vacuum is lost again.

6.3.11 CLOSE middle dewatering layer isolation valve.

6.3.12 RESTART waste transfer to liner until "OP/HI" alarms. Repeat Steps 6.3.6 through 6.3.10 until "OP/LOW" does not silence upon reaching loss of vacuum on the top laterals.

6.3.13 STOP the transfer operation.

NOTE: The waste transfer operation is now complete.

6.3.14 FLUSH the transfer line in accordance with the appropriate system operating procedure.

6.3.15 As the liquid level falls below the dewatering elements and vacuum in the receiver tank reduces by approximately ten (10) inches of mercury, CLOSE the dewatering element isolation valves sequentially starting at the top. Allow time between each isolation for the vacuum to recover and the container to dewater to the next lower layer.

6.3.16 CONTINUE the dewatering process through the lowest dewatering element for four hours after vacuum is lost. This completes the dewatering process.

7.0 DISCONNECTION AND CLOSURE OF CONTAINER

7.1 Prerequisites

The waste transfer and dewatering operations are complete and subsequent transfers of waste to the container are not planned.

7.2 Precautions

As hoses are disconnected, be careful not to spill any residual water.

7.3 Operating Steps

7.3.1 DISCONNECT the waste transfer line from the fill pipe extension.

7.3.2 REMOVE the fill pipe extension from the container.

7.3.3 DISCONNECT the dewatering hoses from the dewatering pipe extensions on the container.

7.3.4 REMOVE the dewatering pipe extensions from the container.

7.3.5 DISCONNECT the vent/overflow hose from the vent/overflow pipe extension.

7.3.6 REMOVE the vent/overflow pipe extension from the container.

7.3.7 DISCONNECT the electrical cables from container. This can be accomplished by cutting the wire close to the fill plate or by unplugging.

NOTE: At this time the container may be secured.

7.3.8 DRAIN the receiver tank.

WESTINGHOUSE HITTMAN NUCLEAR INCORPORATED	Document Number: STD-D-03-009	Rev: 6	Rev Date: 6-6-84
	Title: A Users Manual for the Hittman RADLOK-100 and RADLOK-200		

Rev.	Rev Date	Responsible Engineer	Department Manager	Director Engineering	QA Manager	Project Manager	
0 *	4-16-82	JDWilliams	JPhillips		J. Pawlik for B.ROWE	JDWilliams	EWR- 82-129
1*	6-9-82	JPhillips	JPhillips			JPhillips	ECN- 82-122
2 *	10-25-82	JPhillips	JPhillips				ECN- 82-227
3	1-4-83	JPhillips	JPhillips		J. Pawlik for B.ROWE		ECN- 82-297
4	10-3-83	JPhillips	JPhillips				ECN- 83-158
5	2-9-84						ECN- 84-009
6	6-6-84						ECN- 84-091

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*Revisions 0, 1 and 2 refer to RADLOK-100 only.

A USERS MANUAL FOR THE HITTMAN RADLOK-100 AND RADLOK-200

Purpose

The high integrity container is designed to provide waste isolation from the surrounding environment for a period of 300 years. Various unsolidified waste may be disposed of at Barnwell, however, if the total specific activities of isotopes with half lives greater than five years is 1μ Ci/ml or greater, high integrity containers approved by the South Carolina Department of Health and Environmental Control must be used.

This document is intended to provide the user of Hittman RADLOK^{TM} containers with basic information required for the safe and proper use of the container. Included is a general description of the containers, a listing of the approved contents, a listing of prohibited chemicals, and the storage requirements of a RADLOK container. Inspection requirements prior to usage, lift requirements, and closure methods are also provided.

Description of the Hittman RADLOK-100 and RADLOK-200

The Hittman RADLOK-100 container has approximate envelope dimensions of 6 ft high by 6 ft diameter. The Hittman RADLOK-200 container has approximate envelope dimensions of 5 feet 2 inches high by 4 feet 5 inches diameter. Both containers have a domed top that contains a concentric 16 inch diameter manway opening for possible underdrain installation and an 8 inch diameter fill port. Containers are fabricated from high density cross-linked polyethylene, molded to provide a one-piece body to the container. An underdrain system can be provided for both dewatering slurries transferred to the container or for disposable demineralizer application.

Approved Contents

Hittman RADLOK containers have been designed to safely contain nuclear wastes including bead and powdered ion exchange resin, filter sludges, mechanical filters, stabilized incinerator ash, activated carbon, contaminated soil, and sandblasting grit. It should be noted that dewatering ion-exchange resin that has been in contact with nitrates or other strong oxidizing agents can be hazardous and should be avoided. Procedures for loading metal filters, scrap and other non-compactible trash into a RADLOK container to ensure that protrusions and sharp edges do not damage the container must be submitted and approved by Hittman. The container may not contain free standing water greater than 1 percent of the waste volume. Hittman standard dewatering procedures, as given in the Hittman Rad Services Manual for RADLOK Containers, may be used by reference to the appropriate document number.

Packaging Criteria for RADLOK-100
Waste Category

Parameter	Compactible Trash	Cartridge filters Elements	Rigid Metal Filter Elements with Exposed Ends Noncompactible Trash with No Sharp Edges	Metal Scrap, Non-Compactible Trash with Sharp Edges
Maximum Length of Individual Piece				
Placed Horizontal	none	68	60	60
Placed Vertical	none	48	48	36
Packing Material[1]	none	none	cement, vermiculite, sand, gravel, etc.	
Min. Depth of Packing[2] Material on Bottom	N/A	N/A	1"	3"
Padding[3]	none	none	none	pipe end and sharp edges
Min. dist. waste to wall	none	none	none	3"
Packing between layers[4]	none	none	fill voids as loaded	2"
Maximum Depth of Waste	to underside of fill neck		3" below underside of fill neck	
Final Filling[4]	none	none	cover contents	cover contents plus 3"

[1] The packing material is used to protect the interior of the container and to prevent excessive settling of the waste during transit. Only required of waste that could potentially damage the container.

[2] To be placed in container prior to waste.

[3] To protect container walls if necessary. Among other items, rubber sheet or styrofoam blocks may be used. Only required on sharp edges or ends of rough cut pipe.

[4] Only necessary when packing material is used as defined in footnote number [1].

Packaging Criteria for RADLOK-200
Waste Category

Parameter	Compactible Trash	Cartridge filters Elements	Rigid Metal Filter Elements with Exposed Ends Noncompactible Trash with No Sharp Edges	Metal Scrap, Non-Compactible Trash with Sharp Edges
Maximum Length of Individual Piece				
Placed Horizontal	none	48	40	40
Placed Vertical	none	40	40	30
Packing Material[1]	none	none	cement, vermiculite, sand, gravel, etc.	
Min. Depth of Packing[2] Material on Bottom	N/A	N/A	1"	3"
Padding[3]	none	none	none	pipe end and sharp edges
Min. dist. waste to wall	none	none	none	3"
Packing between layers[4]	none	none	fill voids as loaded	2"
Maximum Depth of Waste	to underside of fill neck		3" below underside of fill neck	
Final Filling[4]	none	none	cover contents	cover contents plus 3"

[1] The packing material is used to protect the interior of the container and to prevent excessive settling of the waste during transit. Only required of waste that could potentially damage the container.

[2] To be placed in container prior to waste.

[3] To protect container walls if necessary. Among other items, rubber sheet or styrofoam blocks may be used. Only required on sharp edges or ends of rough cut pipe.

[4] Only necessary when packing material is used as defined in footnote number [1].

Criteria for Packaging of Filter Elements and Scrap

The tables provide the criteria for the packaging of filter elements and scrap in Hittman RADLOK-100 and RADLOK-200 containers that shall be used in developing the required procedures.

Prohibited Contents

Included in this guide, as Attachment A, is a copy of a MARLEX Resins Technical Service Memorandum from Phillips Chemical Company, No. TSM-293, Chemical Resistance of Marlex CL-100 and CL-50 Rotational Molding Cross linkable High Density Polyethylenes, dated December 1982. This document lists those chemicals that are incompatible with the material used in RADLOK high integrity containers. (Note: This document is oriented towards those applications where tanks manufactured using CL-100 (or CL-50) are used to store these chemicals in their pure form and not as contaminants in other materials.) When using a Hittman RADLOK, those chemicals listed in Table IV of the Appendix to Attachment A are considered prohibited and may not be disposed of in RADLOK high integrity containers. Chemicals listed elsewhere in the Appendix are prohibited when disposed of as incidental contaminants to radioactive wastes.

Storage Conditions

Hittman RADLOK containers may be stored under proper conditions for periods up to two years before use. As a photosensitive material, the containers shall be kept out of direct sunlight, and away from any other sources of ultraviolet radiation. Containers stored out of doors in direct sunlight must be used within one year of fabrication. To minimize any chance of damage to a container with an underdrain system, the container should be kept out of sub-freezing weather conditions. Containers shall be stored in such a way that the bottom is flat and that no weight is located over the manway/fill port area. This is to ensure that no potential deformation of the manway/fill port area of the container or gasket material occurs. Each container shall be stored with its designated closure assemblies to prevent mismatching.

Following closure of the container, it may be stored on-site prior to shipment for burial for up to five (5) years. The design of the facility must preclude the possibility of a wet or damp environment and keep the container out of any prolonged source of ultraviolet light. Short exposures to ultraviolet light such as during placement or inspection are permitted. Storage of Hittman RADLOK containers for periods longer than five (5) years will require specific approval following a review of the storage facility design.

Inspection Prior to Use

Prior to the use of a container to either receive waste material or to be put in service as a portable demineralizer, the following items must be checked. The fill port closure assembly, consisting of the fill port lid bolted to the compression plug and gaskets, is accounted for and in good condition. The manway assembly parts are installed on the container (usually shipped this way) and in good condition. Gaskets are not hard or brittle and are free of defects. Thread areas and gasket areas are free of foreign matter that could impair the seal or thread engagement. The exterior surfaces shall be inspected for damage that may have occured during transport or storage that could lessen container integrity.

The manway lid shall be inspected for sufficient closure. After closure, there should be less than a 3/4-inch space between the bottom of the manway lid and the container body. If this is not the case, refer to Hittman Procedure STD-P-03-003 in the Rad Services Manual for proper closure methods.

Lift Requirements

The Hittman RADLOK-100 and RADLOK-200 containers come equipped with a lift band, lift lugs, and two slings for lifting. Under maximum load conditions, the entire assembly would have a final weight of 10,500 pounds for the RADLOK-100 and 5,500 pounds for the RADLOK-200. The lift assembly for each container is designed to accomodate the respective weight when both slings are used and a 3g abrupt lift is applied. It is recommended that both slings be used when lifting the container in an empty condition. The container shall not be lifted by one sling if it is partially or totally full. Note: Due to the nature of the container material, some bowing and deformation may be evident during lift. This is an anticipated condition.

Remote grapples are also available for remote handling of RADLOK containers. Use of these grapples allows for remote pickup and set down in non-accessible areas such as interim and long-term storage facilities. The grapples are reusable and are removed when the containers are loaded for shipment.

Manway Use and Closure

The Hittman RADLOK-100 and RADLOK-200 containers are equipped with two concentric openings, a 16 inch diameter manway and an 8 inch diameter fill port. The manway opening is used in the installation of any internal appurtenances, and will be sealed prior to arrival at the client's site. If, for various reasons, it is desirable to use the manway as a large diameter "fill" port, the appropriate measures will be taken by Hittman.

Fill Port Use and Closure

The standard fill port on the Hittman RADLOK container is an eight inch gasketed opening. The fill port is concentric with the manway opening, and is sealed with the fill port closure assembly. Two gaskets are attached to the compression plug of the fill port closure assembly. The assembly is then lowered into the opening and screwed into position to a prescribed torque. For details of the closure procedure see Hittman procedure STD-P-03-004.

If the container is to be used as a Type A container the lids shall be secured for transportation to prevent illicit opening. Details concerning methods of securing the lid are also provided in STD-P-03-004.

ATTACHMENT A TO STD-D-03-009

CHEMICAL RESISTANCE OF MARLEX CL-100 AND CL-50 ROTATIONAL MOLDING CROSSLINKABLE HIGH DENSITY POLYETHYLENES

PHILLIPS CHEMICAL COMPANY
A SUBSIDIARY OF PHILLIPS PETROLEUM COMPANY
PLASTICS TECHNICAL CENTER
BARTLESVILLE OKLAHOMA 74004

MARLEX RESINS
TECHNICAL SERVICE MEMORANDUM

TSM-293
DECEMBER, 1982

CHEMICAL RESISTANCE OF MARLEX CL-100 AND CL-50 ROTATIONAL MOLDING CROSSLINKABLE HIGH DENSITY POLYETHYLENES

INTRODUCTION

One of the most rapidly growing plastics applications is relatively large rotational molded storage tanks. This application and its growth has been keyed to the development and marketing of crosslinkable high density polyethylenes by Phillips Chemical Company. These polyethylenes are marketed under the designation of Marlex CL-100 and CL-50 rotational molding crosslinkable high density polyethylene.

Rotational molding is ideally suited for the manufacture of large tanks. In addition the unique toughness, chemical and stress crack resistance of the Marlex CL-100 and CL-50 resins are needed for the demanding requirements in industry and agriculture for chemical storage tanks and are the key to this expanding market. Today tanks are molded as large as 15,000 gallons (57,000 liters) and are used in such diverse storage applications as acids, insecticides, and chemical plant waste by-products.

The scope of this Technical Service Memorandum is to address the question of compatibility of chemicals with Marlex CL-100 and CL-50 resins in relation to storage tanks. Engineering principles used in determining the suitability of a given application are discussed. Lists of chemicals both suitable and not suitable are included in the appendix along with any limitations which may apply.

CHEMICAL RESISTANCE

"Chemical resistance" and "compatibility" are synonymous terms used in relation to the ability of a plastic to function in different environments. In regard to polyethylene chemical storage tanks, chemical resistance encompasses the total effect a product would have on a tank. The factors that make up the overall compatibility of a chemical to a rotomolded tank are chemical attack, solubility, absorption or permeation, and stress crack resistance. Each of these are discussed briefly.

Chemical Attack - By definition, chemical attack involves an actual chemical reaction with the plastic. This can be a breaking of molecular chains and/or addition of chemical groups to the molecule. For example, in the case of an oxidation reaction with polyethylene both occur with the addition of carbonyl groups. This causes an eventual loss of properties to the point that a tank would not be serviceable.

Polyethylene in general is one of the most inert plastics available. Very few chemicals react with polyethylene, and even with those that do the rate is relatively slow. The ultra high molecular weight characteristics of Marlex CL-100 and CL-50 resins after crosslinking makes these particular polyethylenes even more resistant than other grades. Therefore, chemical attack is not a factor in very many applications.

Permeation - This involves the physical absorption of the chemical into the polyethylene. If this is a volatile chemical, then an actual loss of the product can occur as the chemical vaporizes from the outer wall of the tank. The amount of absorption is generally limited to 3-7 percent by weight of the polyethylene. Also, the loss of volatile products is relatively small. For example, a 25-gallon tank with a 50-mil wall will only lose between 5 and 6 grams of gasoline a day due to permeation. The thicker the wall, the lower the rate of loss.

The absorption of a product into the wall of a tank will cause some property changes. The tensile strength is reduced approximately 10%, stiffness approximately 25%, and a linear and radial swell of from 1 to 5% will occur. Normally this does not affect the utility of the tank nor prohibit the application. It does, however, limit the temperature at which the tank can be used because the loss of these properties becomes a detemining factor as the temperature is increased. Also, if a chemical has too low a boiling point, the vapor pressure may be so high as to cause prohibitive distortion of the tank. This is why such chemicals as ether, pentane, etc., would not be suitable for storage in a sealed tank.

Solubility and Stress Resistance - Although these factors are to be considered with other plastics it is of no significance with Marlex CL-100 or CL-50. There are no known solvents at ambient conditions for these resins. Also, when properly molded and used, the phenomena of stress cracking just doesn't occur.

APPLICATION ENGINEERING

The appendix contains tables of chemicals indicating their compatibility with tanks molded using Marlex CL-100 and CL-50 resins. Table I lists chemicals that are suitable up to 150°F (66°C) without further qualification. Table II and III lists chemicals that permeate or are absorbed by the polyethylene. In these cases the use conditions should be more thoroughly considered. For example, most of these chemicals are flammable. It should be determined if this would present a safety or code problem. Other considerations would be: 1) are the tanks vented, 2) are they in a confined or open space, and 3) personnel exposure.

In Table IV chemicals are listed that either attack polyethylene or have high vapor pressure and are not normally recommended for long service life of the tank. This does not automatically preclude tanks from being used with these chemicals. It may be economical to periodically replace the tank after a relatively short service life. Factors such as life of the currently used tanks, cost of tanks made using exotic materials, and the consequences if a failure occurs should all be considered.

SUMMARY

Marlex CL-100 and CL-50 rotational molding crosslinkable HDPE is one of the most chemical resistant plastics manufactured today. It is not without limits, however, and the attached tables should be used only as a guide in determining those applications which are suitable.

CHEM:126

APPENDIX

It has been well documented over the years the types of chemicals that are compatible with polyethylene, either through tests or experience. It would be impossible to list all the chemicals that may be involved in use with polyethylene storage tanks. Therefore, the included tables are only representative of typical chemicals.

Also, their rankings are specific to the application of chemical storage tanks and the superior properties of Marlex® CL-100 and CL-50. The following tables are to be used only as a guide for establishing those uses that would give satisfactory service. They are not a substitute for sound engineering.

TABLE I

The following chemicals do not attack nor permeate Marlex* CL-100 or CL-50 resins up to 150°F (66°C). For temperatures over 150°F (65°C) each application should be considered individually. All concentrations apply except where noted.

Acetic Acid
Aluminum Salts
Alum
Ammonium Hydroxide
Ammonium Salts
Amyl Alcohol
Antimony Salts
Arsenic Acid
Barium Hydroxide
Barium Salts
Benzene Sulfonic Acid
Bismuth Salts
Boric Acid
Bromic Acid
Butanediol
Butyl Alcohol
Calcium Hydroxide
Calcium Salts
Chromic Acid <50%
Citric Acid
Copper Salts
Detergents
Diazo Salts
Diethyl Carbonate
Diethanol Amine
Diethylene Glycol
Diglycolic Acid
Dimethylamine
Dimethyl Formamide
Ethyl Alcohol
Ethylene Glycol
Ferric Salts
Ferrous Salts
Fluoboric Acid
Flousilicic Acid
Formic Acid

Gallic Acid
Gluconic Acid
Glycol Ethers
Glycolic Acid
Hexanol
Hydrazine <35%
Hydrozine Hydrochloride
Hydriodic Acid
Hydrobromic Acid
Hydrocyanic Acid
Hydrochloric Acid
Hydrofluoric Acid
Hydrofluorsilicic Acid
Hydrogen Peroxide <30%
Hydrogen Phosphide
Hydroquinone
Hypochorous Acid
Iodine Solutions
Lactic Acid
Latex
Lead Acetate
Magnesium Salts
Mercuric Salts
Mercurous Salts
Mercury
Methyl Alcohol
Methylsulfuric Acid
Nickle Salts
Nicotinic Acid
Nitric Acid <30%
Oxalic Acid
Perchloric Acid
Phenol <10%
Potassium Hydroxide
Potassium Salts
Phosphoric Acid

Photographic Solutions
Propyl Alcohol
Propylene Glycol
Sea Water
Selenic Acid
Sewage
Silicic Acid
Silver Salts
Soap Solutions
Sodium Acrylates
Sodium Ferricyanide
Sodium Ferrocyanide
Sodium Hydroxide
Sodium Hypochlorite <16%
Sodium Salts
Sodium Sulfonates
Stanic Salts
Stannous Salts
Starch Solutions
Stearic Acid
Sulfuric Acid <98%*
Sulfurous Acid
Sugar Solutions
  Glucose
  Lactose
  Sucrose, etc.
Tannic Acid
Tanning Extracts
Tartaric Acid
Titinium Salts
Toluene Sulfonic Acid
Triethanolamine
Urea
Vinegar
Wetting Agents
Zinc Salts

*Under some conditions acid will discolor.

TABLE II

The following oils and organic chemicals do not attack Marlex® CL-100 or CL-50 resins. They will be absorbed into the wall of the tank but there should be no loss of product. Because of this absorption, if tanks would be used for other service, contamination may result as the absorbed oil is leached out. Service at elevated temperatures up to 150°F (66°C) can be recommended provided the effects of the absorption on the properties of the tank are not prohibitive.

Fatty Acids

Butyric
Lauric
Linoleic
Oleic
Palmitic
Stearic

Mineral Oils

Lube
Transformer
Hydraulic

Vegetable Oils

Corn
Coconut
Cottenseed
Olive
Peanut

Animal Fats

Lard
Fish oil
Musk oil
Whale oil

TABLE III

The following organic chemicals do not attack Marlex® CL-100 or CL-50 resins. They will be absorbed into the wall of the tank and a permeation loss will occur. Because of this premeation and the effect it has on the physical properties of the tank it is generally not recommended they be used above 100°F (38°C). However, their use largely depends on such factors as size of the tank, its location, toxicity of the chemical, and applicable codes such as NFPA, OSHA, etc. This is not to discourage these chemical storage applications in which considerable experience with many has been documented on various polyethylene containers. For example, polyethylene gasoline tanks are used on lawn mowers, tractors, trucks, ATVs, snowmobiles, and as portable containers-even approved safety cans.

Aniline
Benzene
Carbon Tetrachloride
Chlorabenzene
Cychohexanol
Cyclohexanone
Dibutylphthalate
Diesel Fuel
Dimethylamine
Ethyl Butyrate
Ethylene Chlorohydrin
Fuel Oil
Furfural
Aliphatic hydrocarbons
  (hexane, octane, hexene, octene, etc.)
Jet fuel
Gasoline
Nitrobenzene
Octyl Cresol
Propylene dichloride
Toluene
Xylene

TABLE IV

The following chemicals are not recommended for general storage in tanks molded using Marlex* CL-100 or CL-50 resins. Their effect is not immediate nor catastrophic in nature. Therefore, under certain circumstances, tanks could be used either for the short term or in a limited life situation. Temperature is especially important!

Chemical Attack

- Aqua Regia
- Bromine
- Chromic/Sulfuric acid
- Fuming Sulfuric acid
- Nitric Acid >50%
- Organic peroxides
- Phenol-concentrated

High Vapor Pressure

- Acetone
- Butane
- Carbon Disulphide
- Chloroform
- Ethyl Ether
- Ethylene Dichloride
- Methylene Chloride
- Methyl Ethyl Ketone
- Propane
- Pentane

TABLE V

APPLICATIONS OF CROSSLINKED HDPE CHEMICAL TANKS

AGRICULTURAL

Chemical Handled	Size of Tank (gallons)*	Type of Tank		Type of Use		Years in Service
		H*	V*	S*	P*	
Cattle Supplements	5600		X	X		7
Insecticides	50 to 1500	X	X	X	X	10
Herbicides (Bicep, Dual, Sutan, Lasso)	50 to 1500	X	X	X	X	10
Liquid Fertilizer	100 to 5600	X	X	X	X	8
Nitrogen Solution	5600		X	X		8
Phosphoric Acid	1500 to 5600		X	X		8
Sulphur Solution	5600		X	X		8
Treflan	200	X			X	6

INDUSTRIAL

Chemical Handled	Size of Tank (gallons)*	H*	V*	S*	P*	Years in Service
Hydrochloric Acid (37% and lower)	5600		X	X		8
Hydrofluoric Acid	55 to 2500	X		X	X	6
Sulfuric Acid (98% and lower)	400 to 12,000		X	X		8
Propionic Acid	5600		X	X		8
Sodium Hypochlorite	4250 to 12,000		X	X		8
Sodium Hydroxide	1500 to 12,000		X	X		8
Hydrogen Peroxide (52%)	55 to 1600	X	X	X	X	5
Alum	5600		X	X		8
Cactus Juice	1500 to 6000		X	X		5
Detergents	100 to 6000	X	X	X	X	8
Floor Finishes & Cleaners	5600		X	X		8
Latex	6400		X	X		8
Oil Well Additives	200 to 1500	X	X	X	X	8
Plating Solutions	3000		X	X		4
Waste Water	12,000		X	X		8

H - Horizontal
V - Vertical
S - Stationary
P - Portable

*Constant to convert gallons to liters - gallons x 3.7854 = liters

WESTINGHOUSE
HITTMAN NUCLEAR
INCORPORATED

Document Number: STD-P-03-010

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Title: Transfer & Dewatering Bead Resin in Hittman RADLOK™ -100 or -200 Containers with Single Layer Underdrain Assembly to Less Than 1% Drainable Liquid

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0	11-10-82	K. McDaniel					EWR-82-624
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TRANSFER AND DEWATERING BEAD RESIN IN HITTMAN RADLOK^{TM}-100 OR -200 CONTAINERS WITH SINGLE LAYER UNDERDRAIN ASSEMBLY TO LESS THAN 1% DRAINABLE LIQUID

1.0 SCOPE

This procedure is applicable to RADLOK-100 and -200 High Integrity Containers with single layer underdrains, for dewatering bead ion exchange resins, and other granular media.

2.0 PURPOSE

To provide general instructions for the transfer and dewatering, or just dewatering of bead ion exchange resins (or other granular media) to meet the burial site criteria of less than one (1) percent drainable liquid upon receipt at the site. This procedure also assures that there is no drainable liquid at the time of shipment from the plant.

3.0 REFERENCES

3.1 Hittman RADLOK^{TM} High Integrity Container Rad Services Manual, RSM-014.

3.2 ANSI/ANS-55.1-1979, Solid Radioactive Waste Processing System for Light Water Cooled Reactor Plants.

3.3 Hittman report, STD-R-03-002, Report on Dewatering of Bead Ion Exchange Resin and Activated Carbon in Hittman RADLOK High Integrity Containers.

3.4 Hittman procedure, STD-P-03-003, RADLOK Manway Lid Closure and Sealing Procedure.

3.5 Hittman procedure, STD-P-03-004, Closure of Hittman RADLOK High Integrity Container Fill Port.

3.6 Hittman procedure, STD-P-03-020, RADLOK Inspection Procedure.

3.7 Hittman drawing, STD-03-010, Sheet 4, RADLOK^{TM}-100 Single Layer Underdrain Assembly.

3.8 Hittman drawing, STD-03-083, Sheet, 4, RADLOK-200 Single Layer Underdrain Assembly.

4.0 EQUIPMENT

4.1 Diaphram pump, 1½" or equivalent, with interconnecting hoses, quick disconnect fittings and clamps as required.

4.2 Hoses with fittings and clamps as required to connect from the service air system to the diaphram pump. Minimum service air required is 40 SCFM at 100 psig.

4.3 Overflow drum with connecting hose to the container (optional).

4.4 Three (3) standpipes.

4.5 Liner level indicator panel.

4.6 Vacuum pump with minimum suction of 25 inches of mercury (29.9 inches Hg vacuum equals absolute vacuum) and ¼-inch vacuum hoses and clamp.

4.7 Glass collection bottle per Figure 1, minimum size of two (2) gallons.

5.0 EQUIPMENT SETUP

5.1 Prerequisites

5.1.1 The container has been satisfactorily inspected in accordance with STD-P-03-020.

5.2 Precautions

None.

5.3 Assembly for Transfer and Dewatering

5.3.1 CONNECT the stand pipes to the threaded connections on the fill plate. See STD-03-010 or STD-03-083.

5.3.2 CONNECT the electrode plug to the level indicator panel.

5.3.3 CONNECT the dewatering pump suction hose to the suction stand pipe.

5.3.4 CONNECT the dewatering pump to the service air system using service air hoses.

5.3.5 CONNECT the vacuum hose from the vacuum bottle to the final dewatering tube. See Figure 1.

5.3.6 CLAMP off hose near vacuum bottle.

5.3.7 CONNECT a 1" hose to the vent fitting and route the hose to an overflow drum, plant return line or plant drain as appropriate.

5.3.8 CONNECT the fill pipe to the plant's waste line.

5.4 Assembly for Dewatering Only

5.4.1 CONNECT one of the standpipes to the suction connection on the fill plate. See STD-03-010 or STD-03-083.

5.4.2 CONNECT the dewatering pump suction hose to suction standpipe.

5.4.3 CONNECT the dewatering pump to the service air system using service air hoses.

5.4.4 CONNECT the vacuum hose from the vacuum bottle to the final dewatering tube. See Figure 1.

5.4.5 CLAMP off hose near vacuum bottle.

5.4.6 CONNECT the pump discharge hose to the appropriate plant connection.

6.0 TRANSFER AND DEWATERING

6.1 Prerequisites

6.1.1 The equipment is set up in accordance with Section 5.3 or 5.4 of this procedure, as applicable.

6.1.2 An RWP is issued and Health Physics is notified prior to waste transfer.

6.2 Precautions

Be aware of changing radiological conditions as waste is transferred to the container and the container is dewatered.

6.3 Operating Steps, Transfer and Dewatering

6.3.1 BEGIN the waste transfer.

6.3.2 CONTINUE the waste transfer until the "OP/LOW" indicator alarm sounds. Once this alarm sounds terminate the waste transfer and allow the waste to settle for fifteen (15) minutes.

NOTE: If the "OP/HI" indicator alarm sounds, the waste is about to overflow the RADLOK container. Upon this event, the operator should take action to isolate flow to the container. If the waste flow is not stopped it will overflow the container. Before restarting the transfer operation, any overflow waste must be pumped out of the overflow drum and the "OP/HI" and "OP/LOW" indicator signals must be cleared.

6.3.3 START the diaphram pump and begin the dewatering operation. The waste level in the container will recede and the "OP/LOW" light will go out.

6.3.4 MAINTAIN a no-fill mode for three (3) minutes or until the dewatering pump loses suction. Loss of suction may be defined as less than ten (10) inches mercury vacuum.

6.3.5 RESUME waste transfer.

6.3.6 REPEAT steps 6.3.2 through 6.3.5 until the "OP/LOW" indicator light fails to go out. At this point the container is full and the transfer is completed. Any flushing of transfer lines should be done at this time.

<u>NOTE</u>: If during the flush operation, the "OP/HI" alarm sounds, immediately stop flush and do not resume it until the dewatering pump loses suction.

6.3.7 Continue to OPERATE the dewatering pump for four hours after loss of suction.

6.3.8 Twenty (20) hours after completion of Step 6.3.7, DEWATER with the dewatering pump for one (1) hour.

6.3.9 CONNECT vacuum pump to the collection bottle.

6.3.10 CHECK all connections for fit and secure with hose clamps where necessary.

6.3.11 ESTABLISH 15"-18" mercury vacuum in collection bottle. REMOVE pinch clamp. MONITOR water level in collection bottle.

<u>NOTE</u>: Should the liquid level in the bottle get close enough to the top to risk water being sucked into the vacuum pump, stop the pump and empty the collection bottle, using proper radiological procedures.

6.3.12 DEWATER via this method for one (1) hour after continuous flow is lost. Continuous flow is considered lost when air bubbles begin coming through the vacuum hose from the container.

6.3.13 Upon termination of the dewatering process as defined in Step 6.3.12, STOP the vacuum pump.

6.3.14 If the container is expected to remain on-site for more than four (4) days after completion of Step 6.3.14, REPEAT steps 6.3.11 through 6.3.13 within the twenty-four (24) hour period prior to shipment.

NOTE: The purpose of this final step is to ensure compliance with ANSI/ANS standard 55.1-1979 that there be no drainable liquid in the container at the time of shipment and need only be performed if it is plant policy to conform to this standard.

6.4 Operating Steps, Dewatering Only

6.4.1 START the dewatering pump and begin the dewatering operation.

NOTE: Depending on the quantity of water in the container, continuous pump flow may not be attained. If this is the case, begin timing the next step whenever convenient.

6.4.2 Continue to OPERATE the dewatering pump for four (4) hours after loss of suction. Loss of suction may be defined as less than ten (10) inches of mercury vacuum.

6.4.3 Twenty (20) hours after completion of step 6.4.2, DEWATER with the dewatering pump for one (1) hour.

6.4.4 CONNECT the vacuum pump to the collection bottle and remove the pinch clamp.

6.4.5 CHECK all connections for fit and secure with hose clamps where necessary.

6.4.6 ESTABLISH 15"-18" mercury vacuum in collection bottle. REMOVE pinch clamp. MONITOR water level in collection bottle.

NOTE: Should the liquid level in the bottle get close enough to the top to risk water being sucked into the vacuum pump, stop the pump and empty the collection bottle, using proper radiological precautions.

6.4.7 DEWATER via this method for one (1) hour after continuous flow is lost. Continuous flow is considered lost when air bubbles begin coming through the vacuum hose from the container.

6.4.8 Upon termination of the dewatering process as defined in step 6.4.7, STOP the vacuum pump.

6.4.9 If the container is expected to remain on-site for more than four (4) days after completion of step 6.4.9, REPEAT steps 6.4.6 through 6.4.8 within the twenty-four (24) hour period prior to shipment.

NOTE: The purpose of this final step is to ensure compliance with ANSI/ANS Standard 55.1-1979 that there be no drainable liquid in the container at the time of shipment and need only be performed if it is plant policy to conform to this standard.

7.0 DISCONNECTION AND CLOSURE OF CONTAINER

7.1 Prerequisites

No additional transfers of waste into the container are planned and dewatering is complete.

7.2 Precautions

As hoses are disconnected, be careful not to spill any residual water.

7.3 Operating Steps

7.3.1 DISCONNECT the vacuum hose from the container.

7.3.2 EMPTY the collection bottle.

7.3.3 DISCONNECT the waste transfer hose from the fill pipe.

7.3.4 DISCONNECT the overflow hose from the vent pipe.

7.3.5 DISCONNECT the dewatering hose from the suction connection standpipe.

7.3.6 CUT the final dewatering tube close to the packing gland nut.

7.3.7 UNSCREW the three (3) pipe extensions.

NOTE: The container is now ready to be closed and sealed for shipment to the burial site.

7.3.8 CLOSE container in accordance with Hittman procedure STD-P-03-004.

INSPECTION AND OPERATION CHECKLIST FOR RADLOK-100 AND 200 EQUIPPED WITH SINGLE UNDERDRAIN SYSTEM FOR BEAD RESINS

I. TRANSFER AND DEWATERING

Date: ______________________

Shipment No.: ______________

Container Serial Number: __________

	TIME	DATE	INITIALS
Container Inspected (In accordance with STD-P-03-020)			
Manway Lid Closure Installed (In accordance with STD-P-03-003)			
<u>Transfer and Dewater</u>			
The following steps should be performed: (In accordance with STD-P-03-010)			
1. Completed System Assembly (In accordance with 5.3)			
2. Completed Resin Transfer (In accordance with 6.3.1 through 6.3.6)			
3. Started Initial Dewatering (In accordance with 6.3.7)			
4. Completed Initial Dewatering (In accordance with 6.3.7)			
5. Started Final Dewatering (In accordance with 6.3.8 through 6.3.12)			
6. Completed Final Dewatering (In accordance with 6.3.13)			
7. Disconnected Container from all Connections (In accordance with 6.3.14 and 7.0)			
Install and Torque Fill Port (In accordance with STD-P-03-004)			

	TIME	DATE	INITIALS
Label the Container (In accordance with burial site criteria)			

Signature: ______________________________

Title: ________________________________

Date: _________________________________

II. DEWATERING ONLY

Date: ______________________________

Shipment No.: ______________________

Container Serial Number: ____________

TIME DATE INITIALS

Container Inspected
(In accordance with STD-P-03-020)

Manway Lid Closure Installed
(In accordance with STD-P-03-003)

Dewatering Only

The following steps should be performed:
(In accordance with STD-P-03-010)

1. Completed System Assembly
(In accordance with 5.4)

2. Started Initial Dewatering
(In accordance with 6.4.1)

3. Completed Initial Dewatering
(In accordance with 6.4.2)

5. Started Final Dewatering
(In accordance with 6.4.3 through 6.4.7)

6. Completed Final Dewatering
(In accordance with 6.4.8)

7. Disconnected Container from all Connections
(In accordance with 6.4.9 and 7.0)

Install and Torque Fill Port
(In accordance with STD-P-03-004)

Label the Container
(In accordance with burial site criteria)

Signature: ______________________________

Title: ______________________________

Date: ______________________________

Form STD-P-03-010-02
Sheet 1 of 1

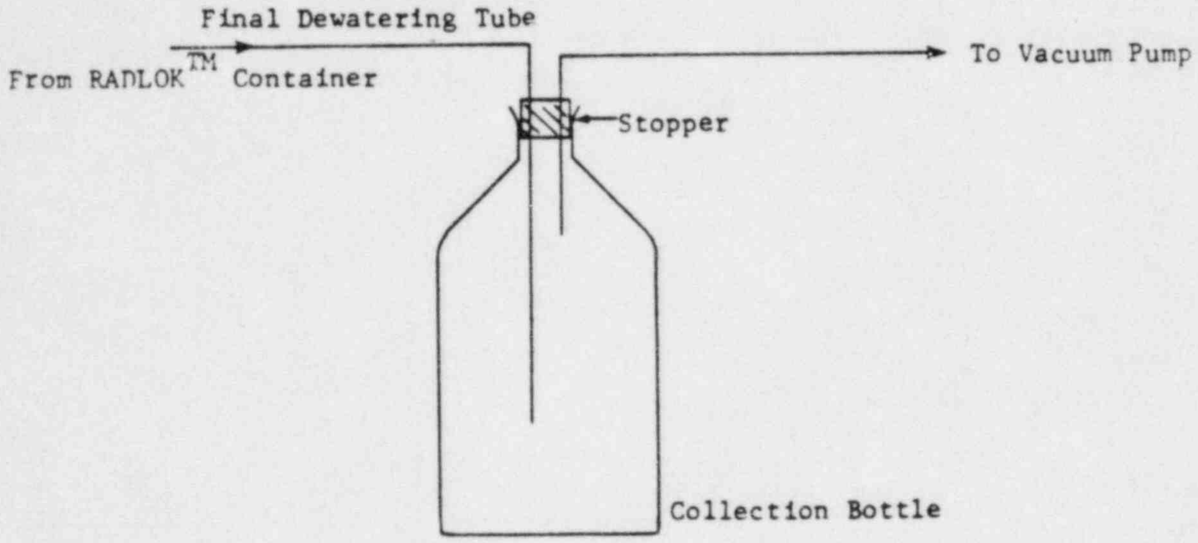
Final Dewatering Tube
From RADLOK™ Container
To Vacuum Pump
Stopper
Collection Bottle

Figure 1

WESTINGHOUSE HITTMAN NUCLEAR INCORPORATED	Document Number: STD-P-03-020	Rev: 2	Rev Date: 5-17-84
	Title: RADLOK Inspection Procedure		

Rev.	Rev Date	Director Engin.	Project Manager	QA Manager			
0	10-3-83						EWR-83-562
1	3-29-84						ECN-84-049
2	5-17-84			J. Pawlak for B Reeve			ECN-84-083

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FORM-01(B)

RADLOK Inspection Procedure

1.0 PURPOSE

To provide instructions for inspection of RADLOK High Integrity Containers.

2.0 SCOPE

This procedure is applicable to all RADLOK containers. Sections pertaining to the manway lid are not applicable to the RADLOK-55 or to large containers where the manway lid is presealed and should be marked N/A on the checklist.

3.0 REFERENCES

3.1 STD-D-03-008, A Users Manual for the Hittman RADLOK-55.

3.2 STD-D-03-009, A Users Manual for the Hittman RADLOK-100 and RADLOK-200 Container.

3.3 Drawing STD-03-007, RADLOK-100 User Drawing.

3.4 Drawing STD-03-006, RADLOK-55 User Drawing.

3.5 Drawing STD-03-104, RADLOK-200 User Drawing.

3.6 STD-P-03-003, RADLOK Manway Lid Closure and Sealing Procedure.

4.0 INSPECTION

4.1 Prerequisites.

None.

4.2 Precautions

Each container is matched with specific plugs and seals at time of manufacture. All components are identified using a common serial number. Should components become mismatched, contact your Regional Operations Manager prior to RADLOK use.

4.3 Pre-Use Inspection for All RADLOK Containers.

NOTE: Complete applicable portions of Attachment A as inspection steps are completed.

4.3.1 ENSURE all sealing components including fill port assembly, primary manway seal (if applicable) and manway lid (if applicable) are accounted for and in good condition.

4.3.2 ENSURE that all gaskets are accounted for. Gaskets shall be free of defects, not hard or brittle, and glued joints shall be intact.

4.3.3 CHECK gasket sizes to ENSURE proper fit.

4.3.4 ENSURE thread and gasket areas are free of foreign material.

4.3.5 ENSURE proper fit of manway lid (if applicable) and fill port assembly.

4.3.6 ENSURE exterior surfaces are free of damage.

<u>NOTE</u>: The following surface acceptance criteria has been compiled in keeping with the State of South Carolina's RADLOK Certificates of Compliance and provides guidance for inspection.

- o Container "pock" marks are acceptable.
- o Voids in the bottom (starting) thread of the container closures are acceptable.
- o Surface abrasions and scrapes are acceptable when depth of removed material is less than 1/32" on RADLOK-55, 1/16" on RADLOK-100 and 200.
- o Surface cuts (sharp, clearly defined separation of the container skin) and punctures shall be evaluated on a case-by-case basis. Report size and location of same to Hittman office so that an evaluation may be made.

4.3.7 INSPECT manway lid for closure (does not apply to RADLOK-55). (≤ 3/4 inch space between lid and container body).

4.3.8 ENSURE RADLOK certificate number and serial number are imprinted on container.

4.3.9 NOTIFY HITTMAN if any components are missing or damaged for repair or replacement as necessary.

4.4 Additional Pre-Use Inspection for RADLOK Containers With Dewatering Systems.

<u>NOTE</u>: Complete applicable portions of Attachment A marked by (*) as inspection steps are completed.

4.4. REMOVE fill port assembly.

4.4.2 REMOVE the manway lid. (See STD-P-03-003).

4.4.3 CAREFULLY lift the primary manway seal to allow visual inspection of the internals.

<u>NOTE</u>: For single layer dewatering systems inspect the dewatering system per Steps 4.4.3 through 4.4.6 and 4.4.9 and 4.4.10. For multi-layered dewatering systems inspection is per Steps 4.4.7 through 4.4.10.

4.4.4 VERIFY that the dewatering hose and the vacuum tube are secured to the proper fittings.

4.4.5 INSPECT the dewatering tubes for breakage.

4.4.6 INSPECT the hoses for kinks, crushing or tears.

4.4.7 Carefully lift the primary manway seal to allow visual inspection of internals. Do not lift primary manway seal so as to allow top layer of dewatering tubes to impinge on upper section of RADLOK body.

<u>NOTE</u>: Use of pipe extension on fill plate dewatering port will facilitate lifting of primary manway seal.

4.4.8 VERIFY that the dewatering tubes are intact by visual inspection.

4.4.9 REPLACE primary manway seal and manway lid as per RADLOK Manway Lid Closure and Sealing Procedure, STD-P-03-003.

4.4.10 NOTIFY HITTMAN if any components are missing or damaged for repairs or replacements.

ATTACHMENT A

Pre-Use Inspection Checklist for RADLOK Container

On-Site Inspector: ______________________________

Location: ____________________ Date: ____________________

Container Type/Options: ______________________________

Container Serial No.: ______________________________

(* - Applicable to RADLOK Containers with Dewatering Systems Only.)

Inspection Item	Initials/Date
All sealing components accounted for (4.3.1)	________
All gaskets accounted for and in good condition (4.3.2)	________
All gaskets fit properly (4.3.3)	________
Thread and gasket areas free of foreign material (4.3.4)	________
Sealing components fit property (4.3.5)	
Manway Assembly (if applicable)	________
Fill Port Assembly	________
Exterior surface free of damage (4.3.6)	________
Manway lid properly sealed (if pre-sealed) (4.3.7)	________
Serial number matches on all components (4.2)	________
Certificate number imprinted on container	________
Containers with Single Layer Dewatering Systems.	
* Dewatering hose and vacuum tube secure (4.4.4)	________
* Dewatering tubes intact (4.4.5)	________
* Hoses not kinked, crushed or torn (4.4.6)	________
Containers with Multi-Layered Dewatering Systems.	
* Dewatering tubes intact (4.4.8)	________

JOE WALDEN

HITTMAN NUCLEAR & DEVELOPMENT CORPORATION	Document Number: STD-P-04-002	Rev: 3	Rev Date: 4-23-84
	Title: Process Control Program for Dewatering Ion-Exchange Resin & Activated Charcoal Filter Media to ½% Drainable Liquid		

Rev.	Rev Date	Prepared by	Reviewed by	Responsible Manager	Director Engineering	Quality Assurance	
0	12-3-81						
1	5-19-83	K. McDaniel	E. Closran				ECN-83-133
2	9-28-83	K. McDaniel	E. Closran				ECN-83-241
3	4-23-84						ECN-84-081

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Page 1 of 6

PROCESS CONTROL PROGRAM FOR DEWATERING ION EXCHANGE RESIN AND ACTIVATED CHARCOAL FILTER MEDIA TO 1/2% DRAINABLE LIQUID

1.0 SCOPE

This procedure is applicable to Hittman steel liners having rigid underdrains for dewatering bead ion exchange resins or activated carbon.

2.0 PURPOSE

2.1 The purpose of the Process Control Program (PCP) for dewatered resin and activated carbon is to provide a program which will assure that at the time of arrival at the burial site the disposable liner contains less than one-half of one percent free liquid.

2.2 This document is complete in and of itself and can be used for demineralizer and carbon filter liners into which exhausted resins are transferred. Other Hittman procedures may also include procedures for connecting dewatering equipment to the liner prior to other operations. Should this be the case those procedures obviously need not be required.

3.0 REFERENCES

3.1 Report on Dewatering of Bead Ion Exchange Resin and Activated Carbon, Hittman Report STD-R-03-001.

4.0 EQUIPMENT

4.1 Diaphragm pump, 1½" or equivalent, with interconnecting hoses, quick disconnect fittings and clamps as required.

4.2 Hoses with fittings and clamps as required to connect from the service air system to the diaphragm pump. Minimum service air required is 40 SCFM at 100 psig.

4.3 Vacuum pump with minimum suction of 25 inches of mercury and 1/4-inch vacuum hoses and clamp.

4.4 Glass collection bottle per Figure 1, minimum size of two (2) gallons.

5.0 GENERAL REQUIREMENTS

5.1 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 shall be used to verify adequate dewatering of unsolidified wet radioactive wastes.

5.2 The PCP applies to shipments of resins transferred to Hittman liners and for Hittman liners used as portable demineralizers or carbon filters. These shipments shall be dewatered to meet burial site free liquid criteria according to Hittman's Liner Dewatering Test Report, STD-R-03-001, which has been filed, on behalf of Hittman clients, with the operator of the Barnwell, South Carolina burial facility.

5.3 For liners that are to be shipped unshielded, or when adequate shielding can be supplied at the plant, this 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.

5.4 In all cases, the liner must be tipped approximately 7° to 9° with the final dewatering element at the low point. The location of the final dewatering element is marked on the outside of the liner.

5.5 For liners to be dewatered in the shipping cask, the method of tipping the cask either on or off the trailer must be cleared with the responsible Hittman transportation office prior to commencement of work.

6.0 DEWATERING PROCEDURE

6.1 Disposable Demineralizers and Carbon Filters

6.1.1 Upon completion of the waste processing, CONTINUE DEWATERING the liner until pump suction is lost.

6.1.2 MOVE the liner to the location for final dewatering and set in the tipped configuration.

6.1.3 CONNECT the dewatering hose used during normal waste processing to a Warren-Rupp double diaphragm air operated pump or equivalent.

6.1.4 CONNECT the pump discharge hose to the appropriate plant drain.

6.1.5 REMOVE the 1/4 inch pipe plug from the final dewatering connection. This connection is located on the top of the liner approximately 2 inches outside the liner neck.

6.1.6 REPLACE the pipe plug with a 1/4-inch threaded pipe.

6.1.7 CONNECT the vacuum hose from the vacuum bottle to the final dewatering connection in Step 6.1.6. See Figure 1.

6.1.8 CLAMP off hose near vacuum bottle.

6.1.9 DEWATER the liner using the air operated pump for a minimum of four (4) hours at which time the pump is to be shut off, but not disconnected.

6.1.10 Allow the liner to SIT in this position for twenty (20) hours.

6.1.11 DEWATER using the pump for one (1) hour.

6.1.12 ESTABLISH vacuum pressure (15" - 18" mercury) in collection bottle. REMOVE pinch clamp. MONITOR waste level in collection bottle.

NOTE: Should the liquid level in the bottle get close enough to the top to risk waste being sucked into the vacuum pump, stop the pump and empty the collection bottle, using proper radiological procedures.

6.1.13 DEWATER via this method for one (1) hour after continuous flow is lost. Continuous flow is considered lost when air bubbles begin coming through the vacuum hose from the container.

6.1.14 REPEAT Steps 6.1.12 and 6.1.13 at 24-hour intervals for three days.

6.1.15 Upon completion of the fourth vacuum draining, the liner is dewatered and ready for shipment.

6.2 Resin Transfer Liners

6.2.1 Upon completion of the resin transfer operation, CONTINUE operating the dewatering pump until pump suction is lost.

6.2.2 DISCONNECT the dewatering pump from the liner.

6.2.3 PLACE the liner in the tipped configuration.

6.2.4 COMPLETE steps 6.1.3 through 6.1.15.

6.2.5 For liners containing greater than 140 cubic feet of resin, ADD one additional day of dewatering prior to shipment.

7.0 DISCONNECTING DEWATERING EQUIPMENT

7.1 DISCONNECT dewatering hose from the dewatering pump. The portion of this hose exiting the liner through the liner neck is to be pushed back into the liner prior to capping.

7.2 DISCONNECT the final dewatering line from the liner top and replace the 1/4 inch plug.

26A

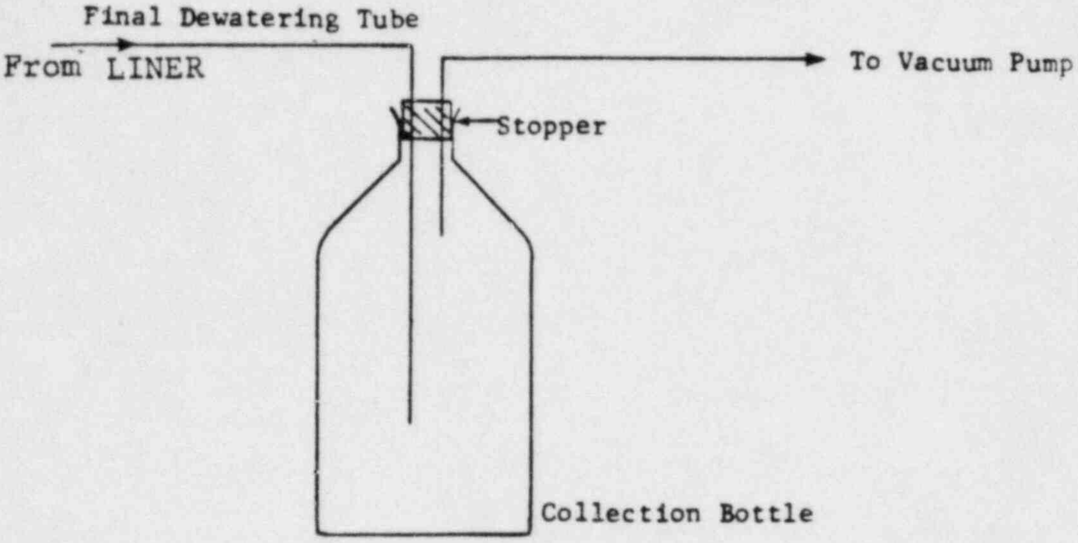
Final Dewatering Tube
From LINER
To Vacuum Pump
Stopper
Collection Bottle

Figure 1

JOE WALDEN

HITTMAN NUCLEAR & DEVELOPMENT CORPORATION	Document Number: STD-P-05-002	Rev: 3	Rev Date: 4-27-84
	Title: Process Control Program for Incontainer Solidification of Oily Waste		

Rev.	Rev Date	Prepared by	Supervisor Laboratory Services	Director Engineering	Manager Field Services	QA	
0	11-17-81	Phillips	E. Cholran				
1	6-9-82	Cholran	E. Cholran			J. Pawlik for B. ROWE	ECN-82-124
2	7-2-82	E. Cholran	E. Cholran				ECN-82-137
3	4-27-84	X	X				ECN-84-065 Rewritten

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PROCESS CONTROL PROGRAM
for
INCONTAINER SOLIDIFICATION OF OIL

1.0 SCOPE

This procedure is applicable to the solidification of oils classified as either Class A, Class B or Class C wastes. Class A Unstable waste meets the requirements under the NRC criteria of 10CFR61.55, Waste Classification. Class A Stable waste meets the stability requirements of Class B and C wastes under the criteria of 10CFR61.55, Waste Classification as required by the state of South Carolina.

2.0 PURPOSE

2.1 The purpose of the Process Control Program (PCP) for the incontainer solidification of oil is to provide a program which will assure a solidified 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 samples;

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

2.2 This document shall be considered complete only when used in concert with the Westinghouse Hittman Nuclear Incorporated procedures for field solidification. This document describes the methodology for determining the acceptable ratios of waste, additional water, cement and additive that will result in an acceptable product for transportation and burial. The Solidification Data Sheet then converts these ratios into the recommended quantity of cement that must be mixed with the waste.

3.0 COLLECTION AND ANALYSIS OF SAMPLES

3.1 General Requirements

3.1.1 As required by the Radiological Effluent Technical Specifications for PWRs and BWRs, the PCP shall be used to verify the solidification of at least one representative test specimen from every tenth batch of each type of radioactive waste.

3.1.2 For the purposes of the PCP a batch is defined as the quantity of waste required to fill a disposable liner with the appropriate quantity of waste prior to solidification.

3.1.3 If any test specimen fails to solidify, the batch under test shall be 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 may then be resumed using the alternate solidification parameters determined.

3.1.4 If the initial test specimen from a batch of waste fails to verify solidification, then representative test specimens shall be collected from each consecutive batch of the same type of waste until three (3) consecutive initial test specimens demonstrate solidification. The Process Control Program shall be modified as required to assure solidification of subsequent batches of waste.

3.1.5 For high activity wastes, where handling of samples could result in personnel radiation exposures which are inconsistent with the ALARA principle, representative non-radioactive samples will be tested. These samples should be as close to the actual wastes' chemical properties as possible.

3.1.6 Since it is unlikely that more than one batch of oil will have the same properties, it is recommended that a test solidification be performed for each liner unless large quantities of relatively pure oil are to be solidified.

3.2 Collection of Samples

3.2.1 Radiological Protection

3.2.1.1 Comply with applicable Radiation Work Permits.

3.2.1.2 Test samples which are actual waste shall be disposed of by placing in the solidified liner.

3.2.1.3 A Test Solidification Data Sheet will be maintained for each test sample solidified. Each data sheet will contain pertinent information on the test sample and the batch numbers of waste solidified based on each test sample.

3.2.2 Test Solidification Data Sheet

The Test Solidification Data Sheet will contain pertinent information on the characteristics of the test sample solidified so as to verify solidification of subsequent batches of similar waste without retesting.

3.2.2.1 The test sample data for oil will include, but not necessarily be limited to, the type of waste solidified, pH, volume of sample, amount of oil in sample and the volume ratio of oil to water.

3.2.2.2 The Test Solidification Data Sheet will include the Solidification Number, Liner Number, Waste Volume, and Date Solidified, for each batch solidified.

3.2.3 Collection of Samples

3.2.3.1 Two samples shall be taken for analysis. If the radioactivity levels are too high to permit full size samples to be taken then smaller samples shall be taken with the results corrected accordingly. Sample sizes shall be determined by the plant Health Physics Staff.

3.2.3.2 If possible, samples should be drawn at least two days prior to the planned waste solidification procedure to allow adequate time to complete the required testing and verification of solidification, and to allow for retesting if necessary. Class A Unstable wastes require approximately 6 hours and approximately 28 hours are required for Class A Stable, Class B and C wastes.

3.2.3.3 The waste to be solidified should be mixed for 10 minutes, or recirculated in the tank for at least three volume changes, prior to sampling to assure a representative sample.

3.2.3.4 If the contents of more than one tank are to be solidified in the same liner then representative samples of each tank should be drawn. The samples should be of such size that when mixed together they form samples of standard size as prescribed in Section 3.2.3.1. If the contents of a particular tank represent x% of the total waste quantity to be solidified then the sample of that tank should be of such size to represent x% of the composite samples.

3.3 Analysis of Samples

This document only defines the parameters to be analyzed and not the methodology. This is left to the plant staff.

Parameter	Acceptable
pH	>5
Detergents	No Appreciable Foaming
Oil (percent by volume)	40%

4.0 TEST SOLIDIFICATION AND ACCEPTANCE CRITERIA

4.1 Waste Conditioning

4.1.1 ALLOW the sample to stand undisturbed until the water/oil interface is clearly discernable.

4.1.2 DETERMINE the percent, by volume, of the sample that is oil.

NOTE: If the volume of oil is greater than 40 percent, ADD a sufficient quantity of water to reduce the percent oil to 40 percent. If the volume of oil is less that 40 percent, REMOVE a sufficient quantity of water to increase the percent to 40 percent.

4.1.3 RECORD the volume percent oil on the Test Solidification Data Sheet.

4.1.4 Prior to the test solidification, the oily waste is treated with a predetermined quantity of emulsifier.

NOTE: Maysol 776 is used as the emulsification agent at a ratio of 1 part emulsifier to 5.1 parts oil by volume. The emulsifier has a density of 1 gm/ml.

4.2 Test Solidification of Class A Stable and Unstable, Class B or C Wastes

4.2.1 PRETREAT the sample to be solidified as specified in Section 4.1.1 through 4.1.3.

4.2.2 For the test solidification of oil, MEASURE into the mixing vessel 350 ml of the waste to be solidified, at an oil concentration of 40 percent by volume.

NOTE: Test solidifications should be conducted using a 1,000 ml disposable beaker or similar size container.

4.2.3 RECORD the waste volume and percent oil on the Test Solidification Data Sheet.

4.2.4 MEASURE out 27.5 ml (27.5 gms) of Maysol 776.

4.2.5 RECORD the quantity of the emulsifier on the Test Solidification Data Sheet.

4.2.6 ADD the Maysol 776 to the waste and mix until a homogeneous mixture is obtained, at least five (5) minutes.

NOTE: Mixing should be accomplished by stirring with an electric mixer with blade. Any signs of pure oil may be an indication that the emulsion is breaking down. Should this occur, do not proceed. Contact Hittman for further instructions.

4.2.7 MEASURE out 447.3 gms of Portland Type I cement and 51.8 gms of anhydrous sodium metasilicate (ASMS).

4.2.8 RECORD the quantities of cement and ASMS on the Test Solidification Data Sheet.

4.2.9 Slowly ADD the cement to the test sample while it is being mixed.

NOTE: Mixing should be accomplished by stirring with an electric mixer and blade until a homogeneous mixture is obtained but in no case less than two (2) minutes.

4.2.10 After all the cement is added, slowly ADD the anhydrous sodium metasilicate to the test sample while it is being mixed.

4.2.11 MIX for two (2) minutes after all the anhydrous sodium metasilicate is added and a homogeneous mixture is obtained.

4.2.12 Seal the sample and cure at 120 ± 5°F for 24 hours.

NOTE: If at any time during the 24-hour cure time, the sample meets the acceptance criteria, the liner solidification may proceed. However, no test solidification shall be disqualified without at least 24 hours of cure. It is not mandatory to cure Class A Unstable wastes at 120 ± 5°F for 24 hours. Class A Unstable wastes may be cured at room temperature for 4 hours.

4.3 Solidification Acceptability

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

4.3.1 The sample solidifications are considered acceptable if there is no free standing water, and

4.3.2 If upon visual inspection the waste appears that it would hold its shape if removed from the mixing vessel, and

4.3.3 It resists penetration.

4.4 Solidification Unacceptability

4.4.1 If the waste fails any of the criteria set forth in Section 4.3, the solidification will be termed unacceptable and a new set of solidification parameters will need to be established under the procedures in Section 4.5.

4.4.2 If the test solidification is unacceptable then the same test procedures must be followed on each subsequent batch of the same type of waste until three (3) consecutive test samples are solidified.

4.5 Alternate Solidification Parameters

4.5.1 If a test sample fails to provide acceptable solidification of the waste, the following procedures should be followed.

4.5.1.1 Class A Unstable Wastes

(a) Mix equal weights of dry cement and water to ensure that the problem is not a bad batch of cement.

(b) Add caustic solution to raise the pH above 8.

(c) If the waste is only partially solidified, use modified waste to cement and anhydrous sodium metasilicate ratios. Using the recommended quantities of cement and anhydrous sodium metasilicate, change the waste sample volume by 25 ml. If the mix is too thick, increase the volume of waste, and if the mix is too thin, or watery, decrease the volume of waste. Continue with these 25 gm incremental changes until an acceptable product is achieved.

(d) If an acceptable product is still not achieved, or if additional information is needed, contact Hittman.

4.5.1.2 Class A Stable, Class B or C Wastes

Contact Hittman for specific instructions.

4A

Solidification No: ________
Liner No: ________
Sample No: ________
Date: ________

CLASS A UNSTABLE AND STABLE, CLASS B OR C TEST SOLIDIFICATION DATA SHEET

FOR OILY WASTE

I. SAMPLE PREPARATION

Sample Volume, ml: ________ (1)

Oil Volume, ml: ________ (2)

Percent Oil by Volume: ________ (3)

Quantity of Water Removed or Added to Obtain 40% Oil by Volume: ________ (4)

pH: ________ (5)

Quantity of Emulsifier Added, ml: ________ (6)

Grams of Portland Type I Cement: ________ (7)

Grams of Anhydrous Sodium Metasilicate (ASMS): ________ (8)

Additional batches solidified based on this sample solidification:

Liner No.	Waste Vol.	Date	Liner No.	Waste Vol.	Date	Liner No.	Waste Vol.	Date

II. SAMPLE INSPECTION

Sample cured for 24 hours[1] at 120 ± 5°F:

________ Verified By ________ Date

Sample contains "No Free Liquid":

________ Verified By ________ Date

Form STD-P-05-002-01
Sheet 1 of 2

Sample is "Free Standing Monolith":

______________________________ ______________________________
Verified By Date

III. PARAMETERS FOR FULL SCALE SOLIDIFICATION

Quantity of Maysol 776: ________________ (6) ml Maysol 776 from above x 0.0214 = gallons Emulsifier per ft^3 waste (including water). (9)

Quantity of Portland Type I Cement: ____________________ (7) gms cement from above x 0.1784 = lbs cement per ft^3 waste (including water). (10)

Quantity of Anhydrous Sodium Metasilicate: ______________ (8) gms ASMS from above x 0.1784 = _______________ lbs. ASMS per ft^3 waste (including water). (11)

FOOTNOTES:

[1] If the sample is qualified in less than 24 hours cure time, note the total hours cured. Class A Unstable wastes may be cured at room temperature for 4 hours.

CLASS A STABLE AND UNSTABLE, CLASS B AND C WASTE SOLIDIFICATION CALCULATION SHEET

Volume of waste[1] (including water) to be solidified[2], ft^3: ____________ (1)

Emulsifier Ratio, gallons/ft^3 ____________ Item 9 Form STD-P-05-002-01 (2)

Cement Radio, lbs/ft^3 ____________ Item 10 Form STD-P-05-002-01 (3)

ASMS Ratio, lbs/ft^3 ____________ Item 11 Form STD-P-05-002-01 (4)

Quantity of Emulsifier to be added:

____________ (1) x ____________ (2) = ____________ gallons (5)
Waste Volume (ft^3) gallons/ft^3

Quantity of Portland Type I Cement to be added:

____________ (1) x ____________ (3) = ____________ lbs. (6)
Waste Volume (ft^3) lbs/ft^3

Quantity of ASMS to be added:

____________ (1) x ____________ (4) = ____________ lbs. (7)
Waste Volume (ft^3) lbs/ft^3

FOOTNOTES:

---

[1] For the purposes of this PCP, the volume of waste is considered as the volume of oil plus the volume of water necessary for solidification.

[2] The volume of waste to be solidified cannot exceed the maximum volumes listed on Form STD-P-05-002-03, Class A Stable and Unstable, Class B and C Solidification Data Tables.

Form STD-P-05-002-02
Sheet 1 of 1

SOLIDIFICATION DATA TABLES FOR OIL CLASS A UNSTABLE AND STABLE, CLASS B AND C

	HN-100					HN-200	HN-600[(1)]			
	Series 1	Series 2	Series 3	LVM	100S		S	G	S&G	R
Usable Liner Volume (ft^3)	143	143	143	160	143	59.5	59.6	64.6	57.7	64.6
Maximum Waste Volume (oil & water), ft^3	86.4	84.3	101.0	113.0	101.0	42.0	42.1	45.6	40.7	45.6
Maximum Solidified Volume, ft^3	122.3	119.4	143.0	160.0	143.0	59.5	59.6	64.6	57.7	64.6
Maysol 776 Added at Maximum Waste Volume (gallons)	50.8	49.6	59.4	66.5	59.4	24.7	24.8	26.8	23.9	26.8
Portland Type I Cement Added at Maximum Waste Volume										
lbs:	6891.8	6724.4	8056.5	9014.2	8056.5	3352.2	3357.8	3639.5	3250.8	3639.5
94 lb bags:	73.3	71.5	85.7	95.9	85.7	35.7	35.7	38.7	34.6	38.7
ASMS Added at Maximum Waste Volume										
lbs:	794.6	775.2	928.8	1039.2	928.8	386.5	387.1	419.6	374.8	419.6
100 lb bags:	8.0	7.8	9.3	10.4	9.3	3.9	3.9	4.2	3.8	4.2
Maximum Rad Level R/hr contact	12	12	12	12	3	800	100	100	100	100

(1) S = HN-600 Stackable
G = HN-600 Grappable
S&G = HN-600 Stackable-Grappable
R = HN-600 Regular

Form STD-P-05-002-03

JOE WALDEN

HITTMAN NUCLEAR & DEVELOPMENT CORPORATION	Document Number: STD-P-05-004	Rev: 4	Rev Date: 4-23-84
	Title: Process Control Program for Incontainer Solidification of Bead Resin		

Rev.	Rev Date	Prepared by	Supervisor Laboratory Services	Director Engineering	Manager Field Services	QA	ECN
0	2-2-82		E. Cloeran				----
1	11-2-82	K. McDaniel	E. Cloeran				82-243
2	7-6-83	K. McDaniel	E. Cloeran				83-154
3	12-27-83					D Lillyman	ECN-83-286
4	4-23-84						84-078

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PROCESS CONTROL PROGRAM
FOR INCONTAINER SOLIDIFICATION OF BEAD RESIN

1.0 SCOPE

This procedure is applicable to the solidification of bead ion exchange resin of the mixed bed type classified as either Class A, Class B or Class C wastes under the requirements of 10CFR61.55, Waste Classification. Class A Unstable waste must meet the minimum requirements under the NRC criteria of 10CFR61.55, Waste Classification. Class A Stable waste must meet the same stability requirements of Class B and C wastes under the criteria of 10CFR61.55, Waste Classification as required by the state of South Carolina.

2.0 PURPOSE

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

The program consists of three major steps, which are:

(a) Procedures for collecting and analyzing samples;

(b) Procedures for solidifying samples;

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

2.2 This document shall be considered complete only when used in concert with the Hittman procedures for field solidification. This document describes the methodology for determining the acceptable ratio of waste, additional water, cement and additive that will result in an acceptable product for transportation and burial. The Solidification Data Sheet then converts these ratios into the recommended quantity of cement and additive that must be mixed with the waste.

3.0 COLLECTION AND ANALYSIS OF SAMPLES

3.1 General Requirements

3.1.1 As required by the Radiological Effluent Technical Specifications for PWR's and BWR's the PCP shall be used to verify the solidification of at least one representative test specimen from every tenth batch of each type of wet radioactive waste.

3.1.2 For the purpose of the PCP a batch is defined as quantity of waste required to fill a disposable liner with the appropriate quantity of waste prior to solidification.

3.1.3 If any test specimen fails to solidify, the batch under test shall be 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 may then be resumed using the alternate solidification parameters determined.

3.1.4 If the initial test specimen from a batch of waste fails to verify solidification, then representative test specimens shall be collected from each consecutive batch of the same type of waste until three (3) consecutive initial test specimens demonstrate solidifications. The Process Control Program shall be modified as required to assure solidification of subsequent batches of waste.

3.1.5 For high activity wastes, where handling of samples could result in personnel radiation exposures which are inconsistent with the ALARA principle, representative non-radioactive samples will be tested. These samples should be as close to the actual wastes' chemical properties as possible. Typical unexpended mixed bed resin shall be used to simulate the spent bead resin.

3.2 <u>Collection of Samples</u>

3.2.1 Radiological protection.

These procedures must be followed during sampling to minimize personnel exposure and to prevent the spread of contamination.

3.2.1.1 Comply with applicable Radiation Work Permits.

3.2.1.2 Test samples which use actual waste shall be disposed of by placing in the solidified liner.

3.2.1.3 A Test Solidification Data Sheet will be maintained for each test sample solidified. Each data sheet will contain pertinent information on the test sample and the batch numbers of waste solidified based on each test sample.

3.2.2 Test Solidification Data Sheet

The Test Solidification Data Sheet will contain pertiment information on the characteristics of the test sample solidified so as to verify solidification of subsequent batches of similar waste without retesting.

3.2.2.1 The test sample data for spent resin will include, but not necessarily be limited to, the type of waste solidified, volume of sample, sample number and the quantity of any additive used to precondition the waste.

3.2.2.2 The appropriate Test Solidification Data Sheet will include the Solidification Number, Liner Number, Waste Volume, and Date Solidified, for each batch solidified.

3.2.3 Collection of Samples

3.2.3.1 Two samples shall be taken for analysis. If the radioactivity levels are too high to permit full size samples to be taken then smaller samples shall be taken with the results corrected accordingly. Sample sizes shall be determined by the plant Health Physics Staff.

3.2.3.2 If possible, samples should be drawn at least two days prior to the planned waste solidification procedure to allow adequate time to complete the required testing and verification of solidification, and to allow for retesting if necessary. For Class A Unstable Waste, approximately 6 hours are required to perform and verify the test solidification. For Class A Stable, Class B and C wastes, approximately 28 hours are required.

3.2.3.3 The waste to be solidified should be mixed for 10 minutes, or recirculated in the tank for at least three volume changes, prior to sampling to assure a representative sample.

3.2.3.4 If the contents of more than one tank are to be solidified in the same liner then representative samples of each tank should be drawn. The samples should be of such size that when mixed together they form samples of standard size as prescribed in Section 3.2.3.1.

If the contents of a particular tank represent x% of the total waste quantity to be solidified then the sample of that tank should be of such size to represent x% of the composite samples.

3.3 Analysis of Samples

This document only defines the parameters to be analyzed and not the methodology. This is left to the plant staff.

Parameter	Acceptable
pH	>6
Detergents	No Appreciable Foaming
Oil	<1%

4.0 Test Solidification and Acceptance Criteria

4.1 Waste Conditioning

4.1.1 If large (i.e., foam causing) quantities of detergents are present, the sample should be treated with an anti-foaming agent. The quantity of anti-foaming agent required shall be recorded on the Test Solidification Data Sheet.

4.1.2 If oil is present in quantities greater than 1% by volume, the oil shall be reduced to less than 1% by skimming. Emulsification agents should be used to break up the remaining oil. The quantity of any substance added to the sample for this purpose shall be recorded on the Test Solidification Data Sheet.

NOTE: Wastes with oil greater than 1% by volume may not be shipped to Barnwell, South Carolina, but must be shipped to Hanford, Washington. Emulsification agents need not be used until the volume of oil exceeds 3% of the waste volume. Oil in concentrations greater than 12% by volume may not be solidified under this procedure.

4.1.3 pH Conditioning

4.1.3.1 For Class A Unstable waste, if the pH is <6.0, it shall be adjusted to greater than 6.0 by the addition of a 50 weight percent sodium hydroxide. The quantity of sodium hydroxide added to the sample shall be recorded on the Test Solidification Data Sheet.

4.1.3.2 pH conditioning of Class A Stable, Class B and Class C wastes is accomplished as part of the solidification process.

4.2 Test Solidification of Class A Unstable Waste

4.2.1 PRETREAT the sample to be solidified as specified in Section 4.1.

4.2.2 For the test solidifications of resin, MEASURE into the mixing vessel 240 gm of dewatered resin and add 90 gm of water.

NOTE: Test solidifications should be conducted using a 1,000 ml disposal beaker or similar size container.

4.2.3 MEASURE out 189 gm of Portland Type I Cement and 19 gm of anhydrous sodium metasilicate.

4.2.4 Slowly ADD the cement to the test sample while it is being mixed.

NOTE: Mixing should be accomplished by stirring with a rigid stirrer until a homogeneous mixture is obtained, but in no case for less than two minutes.

4.2.5 After all the cement is added, slowly ADD the anhydrous sodium metasilicate to the test sample while it is being mixed.

4.2.6 After mixing for approximately two (2) minutes once all the cement and additive are added, and a homogeneous mixture is obtained, allow the waste to CURE for a minimum of 4 hours.

4.3 Test Solidification of Class A Stable, Class B and Class C Wastes

4.3.1 PRETREAT the sample to be solidified as specified in Section 4.1.

4.3.2 For the test solidification of bead resin, MEASURE into the mixing vessel 320 gm of dewatered resin and add 235.3 gm of water.

NOTE: Test solidifications should be conducted using a 1,000 ml disposable beaker or similar size container.

4.3.3 MEASURE out 653.6 gm of Portland Type I cement and approximately 18 grams of Calcium Hydroxide, $Ca(OH)_2$, also known as hydrated lime.

4.3.4 Slowly ADD the calcium hydroxide to the bead resin slurry, two (2) grams at a time. Mix for three (3) minutes between additions until the pH of the slurry is at least 11.5. ADD an additional three (3) grams of calcium hydroxide. This final addition may or may not alter the pH of the slurry.

NOTE: Mixing should be accomplished by stirring with an electric mixing motor with blade until a homogeneous mixture is obtained approximately one minute or less if mixture begins to set.

4.3.5 RECORD the quantity of calcium hydroxide added to the slurry on the Class A Stable, Class B and C Test Solidification Data Sheet.

4.3.6 Slowly ADD the cement to the test sample while it is being mixed.

4.3.7 MIX for two (2) minutes after all the cement is added to obtain a homogeneous mix.

4.3.8 Allow the sample to CURE for up to 24 hours at 120 ± 5°F.

NOTE: If at any time during the 24-hour cure time, the sample meets the acceptance criteria, the liner solidification may proceed. However, no test solidification shall be disqualified without at least 24 hours of cure.

4.4 Solidification Acceptablility

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

4.4.1 The sample solidifications are considered acceptable if there is no free standing water, and

4.4.2 If upon visual inspection the waste appears that it would hold its shape if removed from the mixing vessel, and

4.4.3 It resists penetration.

4.5 Solidification Unacceptability

4.5.1 If the waste fails any of the criteria set forth in Section 4.4, the solidification will be termed unacceptable and a new set of solidification parameters will need to be established under the procedures in Section 4.6.

4.5.2 If the test solidification is unacceptable then the same test procedures must be followed on each subsequent batch of the same type of waste until three (3) consecutive test samples are solidified.

4.6 Alternate Solidification Parameters

4.6.1 If a test sample fails to provide acceptable solidification of the waste, the following procedures should be followed.

4.6.1.1 Class A Unstable Wastes

(a) Mix equal weights of dry cement and water to ensure that the problem is not a bad batch of cement.

(b) Add additional caustic solution to raise the pH above 8.

(c) If the waste is only partially solidified, use modified waste to cement and anhydrous sodium metasilicate ratios. Using the recommended quantities of cement and anhydrous sodium metasilicate, change the dewatered waste sample weight by 25 grams. Continue using 90 gm of water. If the mix is too thick, reduce the quantity of dewatered resin, and if the mix is too thin, or watery, increase the quantity of dewatered resin. Continue with these 25 gm incremental changes until an acceptable product is achieved.

(d) If an acceptable product is still not achieved, or if additional information is needed, contact Hittman.

(2) Class A Stable, Class B or C Wastes

Contact Hittman for specific instructions.

Solidification No.: ____________
Liner No.: ____________
Sample No.: ____________
Date: ____________

CLASS A UNSTABLE TEST SOLIDIFICATION DATA SHEET
for Bead Resin

Sample Volume, ml: ____________ (1)

Sample pH: ________ Volume NaOH solution used to adjust pH, ml: ____ (2)

Quantity of oil %: ____________ (3)

Quantity of emulsifier (20% by volume of oil), ml[1]: ____________ (4)

Quantity of anti-foaming agent, ml: ____________ (5)

Temperature at Solidification, °F: ____________

Quantity of Cement Added: Cement Ratio[2] (lbs/ft^3 Waste)

Sample ____________ gms Sample ____________ (6)

Quantity of Additive Added: Additive Ratio[3] (lbs/ft^3 Waste)

Sample ____________ gms Sample ____________ (7)

Product Acceptable: Sample A____Yes____No (If no, refer to Section 4.6 and proceed as directed)

Additional batches solidified based on this sample solidification:

Liner No.	Waste Vol.	Date	Liner No.	Waste Vol.	Date	Liner No.	Waste Vol.	Date

PCP Performed by ____________ Date ____________

Acceptance Verified by ____________ Date ____________

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Sheet 1 of 2

NOTES:

[1] See NOTE following Section 4.1.2. If emulsification is not accomplished, call Hittman.

[2] The cement ratio is defined as the pounds of cement required to solidify one cubic foot of dewatered waste. The ratio in this PCP is 39.3 lbs/ft^3.

[3] The additive ratio is defined as the pounds of additive required to solidify one cubic foot of dewatered waste. The ratio in this PCP is 3.93 lbs/ft^3.

CLASS A UNSTABLE SOLIDIFICATION CALCULATION SHEET

Waste Volume[1], ft^3: ______________________________ (1)

Cement Ratio, lbs/ft^3: Sample ______________________________ (2)
Item 6 Form STD-P-05-004-01

Additive: ______________________________

Additive Ratio, lbs/ft^3:Sample ______________________________ (3)
Item 7 Form STD-P-05-004-01

Cement Quantity[2]

______________(1) x ______________(2) = ____________ lbs. (4)
Waste Volume

Additive Quantity[2]

______________(1) x ______________(3) = ____________ lbs. (5)
Waste Volume

Quantity of Water to be added in gallons:

______________(1) x 2.25 = ______________ gallons (6)
Waste Volume

Quantities of additional additives that must be added to the liner are found by multiplying the volume of the additive used in the test solidification, in ml, by 0.0249 and then by the volume of waste to be solidified. Volumes of additional additives are taken from items 2, 4, and 5 on Form STD-P-05-004-01.

__________________ ml x 0.0249 x __________ (1) = ______ gallons[3]
Item 2,4 or 5
Form STD-P-05-004-01

FOOTNOTES:

[1] The quantity of dewatered waste to be solidified in a single liner cannot exceed the maximum waste volume listed on the attached Solidification Data Tables. Form STD-P-05-004-03

[2] (4) and (5) define the recommended quantity of cement and additive respectively that must be mixed with the waste to assure solidification.

[3] Reduce the quantity of waste in the liner by 1 ft^3 for every 10 gallons of additional additives.

Form STD-P-05-004-02
Sheet 1 of 1

CLASS A UNSTABLE WASTE

SOLIDIFICATION DATA TABLES
for Bead Resin

	HN-100					HN-600*			
	Series 1	Series 2	Series 3	100-S	HN-200	S	G	S+G	R
Usable Liner Volume (cu.ft.)	143.0	143.0	143.0	143.0	59.5	59.6	64.6	57.7	64.6
Max. Dewatered Waste Volume (cu.ft.)	105.0	102.3	110.0	110.0	48.3	48.3	52.4	46.8	52.4
Max. Solidified Waste Vol. (cu.ft.)	129.5	126.2	143.0	143.0	59.5	59.6	64.6	57.7	64.6
Cement Added at Max. Waste Volume									
Weight (lbs.)	4126.1	4020.8	4320.7	4320.7	1896.4	1899.6	2059.0	1839.0	2059.0
Volume (bags)	43.9	42.8	46.0	46.0	20.2	20.2	21.9	19.6	21.9
Anhydrous Sodium Metasilicate Added at Max. Waste Vol.									
Weight (lbs.)	412.6	402.1	432.1	432.1	189.6	190.0	205.9	183.9	205.9
Volume (bags)	4.1	4.0	4.3	4.3	1.9	1.9	2.1	1.8	2.1
Water Added to Max. Waste Vol. (Gallons)	236.2	230.2	247.3	247.3	108.6	108.8	117.9	105.3	117.9
Max. Rad. Level R/hr contact	12	12	12	3	800	100	100	100	100

*
S = HN-600 Stackable
G = HN-600 Grappable
S+G = HN-600 Stackable - Grappable
R = HN-600 Regular

Form STD-P-05-004-03
Sheet 1 of 1

Solidification No.: ________________
Batch No.: ________________
Sample No.: ________________
Date: ________________

CLASS A STABLE, CLASS B AND C TEST SOLIDIFICATION DATA SHEET
for Bead Resin

I. Sample Preparation

Sample Volume, ml: ________________ (1)

Initial pH: ____________ Quantity of Oil(1) %: ____________

Grams $Ca(OH)_2$ to raise pH to ≥ 11.5(2), gm: ________________ (2)

Grams Portland Type I Cement added, gm: ________________ (3)

Additional batches solidified based on this sample solidification:

Liner No.	Waste Vol.	Date	Liner No.	Waste Vol.	Date	Liner No.	Waste Vol.	Dat

II. SAMPLE INSPECTION

Sample cured for 24 hours(3) @ 120° ± 5° F:

________________ ________________
Verified by Date

Sample contains 'No Free Liquid':

________________ ________________
Verified by Date

Sample is a 'Free Standing Monolith':

________________ ________________
Verified by Date

III. PARAMETERS FOR FULL SCALE SOLIDIFICATION

Quantity of $Ca(OH)_2$: ____________ (2) gm $Ca(OH)_2$ from above x 0.156 = ____________ lb $Ca(OH)_2$ per ft^3 dewatered resin (4)

Form STD-P-05-001-04
Sheet 1 of 2

Quantity of Cement: ____________ (3) gm cement from above x 0.156 = __________ lb Cement per ft^3 dewatered resin (5)

FOOTNOTES:

[1] Must be ≦1% of waste volume.

[2] Added in accordance with Section 4.3.4.

[3] If the sample is qualified in less than 24 hours cure time, note the total hours cured.

CLASS A STABLE, CLASS B AND C WASTE SOLIDIFICATION CALCULATION SHEET

Volume dewatered resin to be solidified,[1] ft^3: ____________ (1)

Ca$(OH)_2$ Ratio, lbs/ft^3 ______________ Item 4, Form STD-P-05-004-04 (2)

Cement Ratio, lbs/ft^3 ______________ Item 5, Form STD-P-05-004-04 (3)

Quantity of Water to be Added:

________________ (1) x 4.4 gallons/ft^3 = _________ gallons (4)
Waste Volume (ft^3)

Quantity of Calcium Hydroxide (Ca$(OH)_2$) to be added:

________________ (1) x _____________ (2) = _________ lbs. (5)
Waste Volume (ft^3) lb/ft^3

Quantity of Cement (Portland Type I) to be added:

________________ (1) x _____________ (3) = _________ lbs. (6)
Waste Volume (ft^3) lb/ft^3

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[1] The volume of dewatered bead resin to be solidified cannot exceed the maximum waste volume listed on Form STD-P-05-004-04, Class A Stable, Class B and C Test Solidification Data Sheet for Bead Resin.

CLASS A STABLE, CLASS B AND C WASTE

SOLIDIFICATION DATA TABLES

for Bead Resin

	HN-100					HN-600[1]			
	Series 1	Series 2	Series 3	100-S	HN-200	S	G	S+G	R
Usable Liner Volume (cu.ft.)	143	143	143	143	59.5	59.6	64.6	57.7	64.6
Max. Dewatered Waste Volume (cu.ft.)	61.5	59.9	77.9	77.9	32.4	32.5	35.2	31.4	35.2
Max. Solidified Waste Vol. (cu.ft.)	112.8	109.9	143	143	59.5	59.6	64.6	57.7	64.6
$Ca(OH)_2$ Added at Max. Waste Volume[2]									
Weight (lbs.)	172	168	218	218	91	91	99	88	99
Volume (bags)	3.4	3.4	4.4	4.4	1.8	1.8	2.8	1.8	2.0
Portland Type I Cement Added at Max. Waste Vol[2]									
Weight (lbs.)	6273	6110	7945.8	7945.8	3304.8	3315	3590.4	3202.8	3590.4
Volume (bags)	66.7	65.0	84.5	84.5	35.2	35.3	38.2	34.1	38.2
Water Added to Max. Waste Vol. (Gallons)	271	264	343	343	143	143	155	138	155
Max. Rad. Level R/hr contact	12	12	12	3	800	100	100	100	100

(1) S = HN-600 Stackable
G = HN-600 Grappable
S+G = HN-600 Stackable - Grappable
R = HN-600 Regular

(2) Approximate values - actual quantity determined on Form STD-P-05-004-05

STD-P-05-004-06
Sheet 1 of 1

HITTMAN NUCLEAR & DEVELOPMENT CORPORATION	Document Number: STD-P-05-011	Rev: 0	Rev Date: 9-3-82
	Title: Process Control Program for Incontainer Solidification of Granular Activated Carbon (12-40 MESH)		

Rev.	Rev Date	Prepared by	Responsible Engineer	Director Engineering	Field Services Manager	QA Manager	
0	9-3-82	K. McDonald	E. Cloeran	C. Meister		J. Pawlik for B Rawe	EWR- 82-505

DOCUMENT CONT
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HNDC-01(A)

PROCESS CONTROL PROGRAM
FOR IN-CONTAINER SOLIDIFICATION
OF GRANULAR ACTIVATED CARBON (12-40 MESH)

1.0 Purpose

1.1 The purpose of the Process Control Program (PCP) for the in-container solidification of granular activated carbon is to provide a program which will assure a solidified product with no free liquid prior to transportation for disposal.

The program consists of four major steps, which are:

(a) Procedures for collecting and analyzing samples;

(b) Procedures for solidifying samples;

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

(d) Calculation of minimum and recommended quantities of cement and anhydrous sodium metasilicate to be used in full scale liner solidification.

1.2 This document shall be considered complete only when used in concert with the HNDC procedures for field solidification. This document describes the methodology for determining the range of acceptable ratios of waste, additional water, cement and additive that will result in an acceptable product for transportation and burial. The Solidification Data Sheet then converts these ratios into minimum and recommended quantity of cement and additive that must be mixed with the waste. Assurance that quanitites of cement and additive between these ranges are actually mixed with the waste is covered in the Field Services Weekly Report.

2.0 System Description

To be added for each specific plant.

3.0 Collection and Analysis of Samples

3.1 General Requirements

3.1.1 As required by the Radiological Effluent Technical Specifications for PWR's and BWR's, the PCP shall be used to verify the solidification of at least one representative test specimen from every tenth batch of each type of wet radioactive waste.

3.1.2 For the purposes of the PCP a batch is defined as the quantity of waste required to fill a disposable liner to the waste level indicator.

3.1.3 If the initial test specimen from a batch of waste fails to verify solidification, representative test specimens shall be collected from consecutive batches of the same type of waste. When three consecutive test specimens demonstrate solidification using the initial solidification parameters, the testing may be suspended until every tenth batch.

3.1.4 If any test specimen from paragraph 3.1.3 fails to solidify using the initial solidification parameters, alternate parameters must be established. These new parameters will be tested until three consecutive batches demonstrate solidification.

3.1.5 For high activity wastes where the handling of samples could result in personnel radiation exposures which are inconsistent with the ALARA principle, representative non-radioactive samples will be tested. These samples should be as close as possible to the actual waste in their physical and chemical properties to verify proper solidification parameters.

3.2 Collection of Samples

3.2.1 Radiological Protection

These procedures must be followed during sampling to minimize personnel exposure and to prevent the spread of contamination.

3.2.1.1 Comply with applicable Radiation Work Permits.

3.2.1.2 Test samples which use actual waste will be disposed of by placing in the disposal liner after solidification.

3.2.1.3 A Waste Solidification Data Sheet will be maintained for each test sample solidified. Each data sheet will contain pertinent information on the test sample and the batch numbers of wastes solidified based on each test sample.

3.2.2 Waste Solidification Data Sheet

The Waste Solidification Data Sheet will contain pertinent information on the characteristics of the test sample solidified so as to verify solidification of subsequent batches of similar wastes without retesting.

3.2.2.1 The test sample data will include, but not be limited to, the type of waste solidified, pH, volume of sample, amount of oil in sample and the ratio of the sample volume to the final volume of the solidified product.

3.2.2.2 The Waste Solidification Data Sheet will include the Batch Number, Batch Volume, and Date Solidified, for each batch solidified.

3.2.3 Collection of Samples

3.2.3.1 Two samples shall be taken for solidification. If the radioactivity levels are too high to permit full size samples to be taken then smaller samples shall be taken with the results corrected accordingly. Sample sizes shall be determined by the plant Health Physics Staff.

3.2.3.2 If possible, samples should be drawn at least two days prior to the planned waste solidification procedure to allow adequate time to complete the required testing and verification of solidification, and to allow for retesting if necessary.

3.2.3.3 The waste to be solidified should be mixed or recirculated in the tank for at least three volume changes prior to sampling to assure a representative sample.

3.2.3.4 If the contents of more than one tank are to be solidified in the same liner then representative samples of each tank should be drawn. The samples should be of such size that when mixed together they form samples of standard size as prescribed in Section 3.2.3.1 If the contents of a particular tank represents x% of the total waste quantity to be solidified then the sample of that tank should be of such size to represent x% of the composite samples.

3.3 Analysis of Samples

This document only defines the parameters to be analyzed and not the methodology. This is left to the plant staff. These parameters are pH, detergents and oil.

4.0 Test Solidification and Acceptance Criteria

4.1 Waste Conditioning

4.1.1 If large quantities of detergents are present, the sample should be treated with an anti-foaming agent. The quantity of anti-foaming agent required shall be recorded.

4.1.2 If oil is present in quantities greater than 1% by volume, the oil shall be reduced to less than 1% by skimming. Emulsification agents should be used to break up the remaining oil. The quantity of any substance added to the sample for this purpose shall be recorded.

4.1.3 If necessary, adjust the pH to greater than 7 using 50 weight percent sodium hydroxide solution. The quantity of sodium hydroxide added shall be recorded.

4.2 Test Solidification

4.2.1 Any sample to be solidified shall be pretreated as specified in Section 4.1.

4.2.2 Test solidifications should be conducted using a 1000 ml disposable beaker or similar size container. Mixing should be accomplished by stirring with a rigid stirrer until a homogeneous mixture is obtained, but in no case less than two minutes.

4.2.3 For the test solidification of granular activated carbon (12-40 mesh), measure into two mixing vessels 300 grams (400 ml) of dewatered waste and add 150 grams of water.

4.2.4 Measure out the required quantities of cement and anhydrous sodium metasilicate as shown below.

	Grams Cement		Grams Anhydrous Sodium Metasilicate	
Waste	Sample A	Sample B	Sample A	Sample B
Granular Activated Carbon	300.0	375.0	30.0	37.5

4.2.5 Mix the cement and additive together and slowly add this mixture to the test sample while it is being stirred.

4.2.6 After mixing for approximately two minutes once all the cement and additive is added, and a homogeneous mixture is obtained, allow the waste to stand for a minimum of 4 hours.

4.3 Solidification Acceptability

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

4.3.1 The sample solidifications are considered acceptable if there is no free standing water.

4.3.2 The sample solidifications are considered acceptable if upon visual inspection the waste appears that it would hold its shape if removed from the beaker and it resists penetration by a rigid stick.

4.3.3 The sample solidifications establish a range for the ratios of cement to waste that will result in an acceptable product.

4.4 Solidification Unacceptability

4.4.1 If the waste fails any of the criteria set forth in Section 4.3, the solidification will be termed unacceptable and a new set of solidification parameters will need to be established under the procedures in Section 4.5.

4.4.2 If the test solidification is unacceptable then the same test procedures must be followed on each subsequent batch of the same type of waste until three consecutive test samples are solidified.

4.5 Alternate Solidification Parameters

4.5.1 If a test sample fails to provide acceptable solidification of the waste, the following procedures should be followed.

(1) Mix equal volumes of dry cement and water to ensure that the problem is not a bad batch of cement.

(2) Add additional caustic solution to raise the pH above 8.

(3) If the waste is only partially solidified, use lower waste to cement and additive ratios. Using the recommended quantities of cement and additive, reduce the dewatered waste sample to 275 grams (367 ml) and the water to 137.5 grams and continue reducing by this increment until the acceptability criteria of Section 4.3 are met.

Batch No: ____________________

Sample No: ____________________

Date: ____________________

WASTE SOLIDIFICATION DATA SHEET
For
Granulated Activated Carbon

Sample Volume, ml: Sample A ____________________ Sample B ____________________ (1)

Sample pH: ________ Volume NaOH solution used to adjust pH, ml: ________ (2)

Quantity of Oil %: ________________

Temperature at Solidification, °F: ____________________

Quantity of Cement Added: Cement Ratio[1] (#/ft^3 Waste)

Sample A ____________ gms Sample A ____________________ (3)

Sample B ____________ gms Sample B ____________________ (4)

Quantity of Additive Added: Additive Ratio[2] (#/ft^3 Waste)

Sample A ____________ gms Sample A ____________________ (5)

Sample B ____________ gms Sample B ____________________ (6)

Packaging Efficiency: Dewatered Waste to Product: Sample A ____________________

Sample B ____________________ (7)

Product Acceptable: Sample A _____ Yes _____ No (If no, refer to Section 4.5 and proceed as directed)

Sample B _____ Yes _____ No

Additional batches solidified based on this sample solidification:

Batch No.	Batch Vol.	Date	Batch No.	Batch Vol.	Date	Batch No.	Batch Vol.	Date
2			5			8		
3			6			9		
4			7			10		

PCP Performed by ________________________________ Date ____________________

---

[1] The cement ratio is defined as the pounds of cement required to solidify one cubic foot of dewatered waste. Ratios in this PCP yield cement ratios of 46.8 lbs/ft^3 and 58.5 lbs/ft^3 for samples A and B respectively.

[2] The additive ratio is defined as the pounds of additive required to solidify one cubic foot of dewatered waste. Ratios in this PCP yield additive ratios of 4.68 lbs/ft^3 and 5.85 lbs/ft^3 for samples A and B respectively.

SOLIDIFICATION CALCULATION SHEET

Waste Volume[1], ft^3: ______________________________ (1)

Cement Ratio, #/ft^3: Sample A ______________________________ (2A)

Sample B ______________________________ (2B)

Additive: ______________________________

Additive Ratio, #/ft^3: Sample A ______________________________ (3A)

Sample B ______________________________ (3B)

Cement Quantity[2]

______________(1) x ______________(2A) = ______________ lbs. (4A)

______________(1) x ______________(2B) = ______________ lbs. (4B)

Additive Quantity[2]

______________(1) x ______________(3A) = ______________ lbs. (5A)

______________(1) x ______________(3B) = ______________ lbs. (5B)

Quantity of Water to be Added in Gallons

______________(1) x 2.81 = ______________ gallons (6)

---

[1] The quantity of dewatered waste to be solidified in a single liner cannot exceed the maximum waste volume listed on the attached Solidification Data Tables.

[2] 4A and 5A define the minimum quantity of cement and additive respectively that must be mixed with the waste to assure solidification. The recommended quantities of cement and additive to use are represented by 4B and 5B.

SOLIDIFICATION DATA TABLES

I. For the Minimum Amount of Cement and Additive

	HN-100						HN-600**			
	Series 1	Series 2	Series 3*	Series 3A	100-S	HN-200	S	G	S&G	R
Usable Liner Volume (cu. ft.)	143.00	143.00	143.00	143.00	143.00	59.50	59.60	64.60	57.70	64.60
Max. Dewatered Waste Volume (cu. ft.)	96.54	94.07	116.40	116.40	116.40	48.43	48.51	52.58	46.97	52.58
Max. Solidified Waste Vol. (cu. ft.)	118.60	115.57	143.00	143.00	143.00	59.50	59.60	64.60	57.70	64.60
Cement Added at Max. Waste Volume										
Weight (lbs.)	4517.92	4402.57	5447.61	5447.61	5447.61	2266.66	2270.47	2460.95	2198.09	2460.95
Volume (bags)	48.06	46.84	57.95	57.95	57.95	24.11	24.15	26.18	23.38	26.18
Anhydrous Sodium Metasilicate Added at Max. Waste Vol.										
Weight (lbs.)	451.79	440.26	544.76	544.76	544.76	226.67	227.05	246.09	219.81	246.09
Volume (bags)	4.52	4.40	5.45	5.45	5.45	2.27	2.27	2.46	2.20	2.46
Water Added to Max. Waste Vol. (Gallons)	271.27	264.34	327.09	327.09	327.09	136.10	136.33	147.76	131.98	147.76
Max. Rad. Level R/hr. Contact	12	12	12	12	3	800	100	100	100	100

* Permit may be required due to gross vehicle weight.

**

S = HN-600 Stackable
G = HN-600 Grappable
S&G = HN-600 Stackable-Grappable
R = HN-600 Regular

SOLIDIFICATION DATA TABLES

II. For the Recommended Amount of Cement and Additive

	HN-100						HN-600**			
	Series 1	Series 2	Series 3*	Series 3A*	100-S	HN-200	S	G	S&G	R
Usable Liner Volume (cu. ft.)	143.00	143.00	143.00	143.00	143.00	59.50	59.60	64.60	57.70	64.60
Max. Dewatered Waste Volume (cu. ft.)	87.31	85.08	111.82	113.26	105.88	47.12	47.20	51.16	45.70	51.16
Max. Solidified Waste Vol. (cu. ft.)	110.23	107.42	141.19	143.00	133.69	59.50	59.60	64.60	57.70	64.60
Cement Added at Max. Waste Volume										
Weight (lbs.)	5107.35	4976.95	6541.76	6625.48	6194.02	2756.75	2761.39	2993.05	2673.36	2993.05
Volume (bags)	54.33	52.95	69.59	70.48	65.89	29.33	29.38	31.84	28.44	31.84
Anhydrous Sodium Metasilicate Added at Max. Waste Vol.										
Weight (lbs.)	510.74	497.70	654.18	662.55	619.40	275.68	276.14	299.30	267.34	299.30
Volume (bags)	5.11	4.98	6.54	6.63	6.19	2.76	2.76	2.99	2.67	2.99
Water Added to Max. Waste Vol. (Gallons)	245.33	239.06	314.23	318.25	297.52	132.42	132.64	143.77	128.41	143.77
Max. Rad. Level R/hr. Contact	12	12	12	12	3	800	100	100	100	100

* Permit may be required due to gross vehicle weight.

**

S = HN-600 Stackable
G = HN-600 Grappable
S&G = HN-600 Stackable-Grappable
R = HN-600 Regular

HITTMAN NUCLEAR & DEVELOPMENT CORPORATION	Document Number: STD-P-05-023	Rev: 0	Rev Date: 9-30-83
	Title: INCONTAINER SOLIDIFICATION SYSTEM (ICSS) OPERATIONAL INSPECTION PROCEDURE (Sections A and B)		

Rev.	Rev Date	Director Eng.	Project Manager	QA Manager			
0	9-30-83						EWR-83-563

DOCUMENT CONTROL
CONTROLLED
No. 005

INCONTAINER SOLIDIFICATION SYSTEM (ICSS)
OPERATIONAL INSPECTION PROCEDURE
(Sections A and B)

Section A

Pre-Operational Checkout of Solidification System

Items Listed in Checkout Include Both Hydraulic System and Electric System Equipment. The following is to be performed prior to the System Readiness Verification, Section B, and may be performed before mobilization or during System Setup.

Initial/Date

1.0 CEMENT FEED SYSTEM CONTROL PANEL
(Electric or Hydraulic)

Notes:
(1) Replace or repair all defective items.
(2) Examine subassemblies, structural components and electrical cords and connectors for damage.
(3) Verify proper fuses and starter overloads are installed.
(4) Supply 480 volt 3 phase power to panel.

Verify:

1.1 With main breaker off, all panel lights are off and all switches are inactive. ____________

1.2 With main breaker on, phase rotation light illuminates, if not secure main power and change phasing. ____________

1.3 Control switch for 120 volt receptacle functions. ____________

1.4 120 volts at receptacle. ____________

1.5 Mixer-forward and mixer reverse starters and interlocks operate. ____________

1.6 Conveyor, dust collector and spare motor starters operate. ____________

1.7 Level indicator panels operate correctly. ____________

Initial/Date

2.0 LEVEL CONTROL PANEL - (Hydraulic System)

Notes:

(1) Replace or repair all defective items.

(2) Examine subassemblies, structural components and electrical cords and connectors for damage.

(3) Check: proper fuse size and type.

(4) Check: starter overloads are installed.

(5) Supply 480 volt 3 phase power to panel.

2.1 With main breaker off, all panel lights are off and all switches are inactive. ____________

2.2 With main breaker on, phase rotation light illuminates, if not secure main power and change phasing. ____________

2.3 Attach extension cord from control panel to fill/divert valve. Supply 60-100 psig air to valve operator. ____________

2.4 Panel switches on auto, push process start. ____________

2.5 Filling light is on. Radwaste valve is in fill position. ____________

2.6 Jumper primary level electrode receptacle between common and divert terminals. ____________

2.7 After time delay, 110 volt is supplied to dewater pump solenoid receptacle, valve moves to divert position and divert light illuminates. ____________

2.8 Remove jumper from common/divert terminals, dewater pump receptacle remains at 110 volts and fill/divert valve moves to fill. ____________

2.9 Jumper between common and fill terminals. Dewater pump receptacle voltage is 110 volts and fill/divert valve remains at fill. Leave jumper connected. ____________

2.10 Jumper primary level electrode receptacle between common and divert terminals. ____________

Initials/Date

2.11 After time delay, inlet valve shifts to divert position. Divert light is on. ____________

2.12 Leave jumper connected between the common and fill terminals. Remove jumper between the common and the divert terminals. Valve then shifts to fill. Fill light illuminates. ____________

2.13 Jumper the terminals at the alarm level electrode receptacle. Alarm horn will sound, fill/divert valve moves to divert. Removing jumper silences alarm and moves valve to fill. ____________

2.14 Dewatering pump switch in manual position energizes dewater receptacle. ____________

2.15 Fill/divert switch operates fill/divert valve. ____________

2.16 Waste pump switch in manual energizes waste pump receptacle. ____________

3.0 MIXER DRIVE ASSEMBLY

Note: (1) Replace or repair all defective items.

3.1 Items Common to Hydraulic/Electric Systems

3.1.1 Examine subassemblies and structural components for damage. Insure the proper number of fasteners are installed and tightened. ____________

3.1.2 Examine all wiring and connections. Insure wire is in good condition and all connections are secure. ____________

3.1.3 Dewatering packing gland with O-Rings installed. ____________

3.1.4 B&W level probe holder is installed with electrodes and functions properly. ____________

3.1.5 Check all quick connects for cracks, sealing surface damage and protective caps. ____________

3.1.6 Mixer head tie down bolts and threads are clean, in good condition and equipped with bolt gaskets. ____________

Initials/Date

3.1.7 Operate all ball valves. Check for damage. ____________

3.1.8 Start 1.5 HP cement conveyor motor. Running amps do not exceed nameplate value. Motor rotation is clockwise from fan end. ____________

3.1.9 Inspect storage stand structure. ____________

3.2 Electric Mixer

3.2.1 Check 5 HP motor.

(a) Phase rotation: C-Clockwise from fan end. ____________

(b) Running amps: Not to exceed 4 amps. No load. ____________

3.2.2 Gear reducer oil level: Check and replace with EP3 or EP4 lubricant. Apply EP Type 2 grease to weldment grease fittings. ____________

3.3 Hydraulic Mixer

3.3.1 Inspect quick connects on the hydraulic drive motor for cracks or other damage. All quick connects should have dust caps. ____________

3.3.2 Operate the radwaste inlet shut-off ball valve. Insure valve operates smoothly throughout its full 90° of travel. ____________

4.0 HYDRAULIC POWER PACK - (Hydraulic)

Note: (1) Replace or repair all defective items.

(2) Examine subassemblies, structural components and electrical cords and connectors for damage.

(3) Verify proper fuses and starter overloads are installed.

(4) Supply 480 volt 3 phase power to panel.

4.1 Inspect all hydraulic hoses and quick connects for damage. ____________

Initials/Date

4.2 Connect the one inch hydraulic hoses to the power pack. Then connect the hose ends together. ____________

4.3 Reservoir is filled to proper level. ____________

4.4 Oil filter by-pass indicator is in the down position. If after starting unit the indicator button rises and will not reset, replace filters. ____________

4.5 With main breaker off, all panel lights are off and all switches are inactive. ____________

4.6 With main breaker on, phase rotation light illuminates. Temperature okay light is on. ____________

4.7 Green "Temperature O.K." light should be on if oil temperature is within operating range. If temperature is below operating range "Heater On" light is illuminated until proper temperature is reached. ____________

4.8 Oil cooler will energize when switch is turned to manual. (After manual check, turn switch to auto position.) ____________

4.9 With manual control valves in the center position, press "Pump Start". Pump starts and "Pump Run" light is now on. Allow oil to recirculate for 10 minutes. ____________

4.10 Press "Hyd. Forward" button. Solenoid valve shifts position. Forward light illuminates. ____________

4.11 Press "Hyd. Stop" button. Valve shifts to center position. No position lights are on. ____________

4.12 Press "Hyd. Reverse". Valve shifts position. Reverse light illuminates. ____________

4.13 Shift the position of the manual control valve located at the top of the valve board. The 0-50 gpm flowmeter should register approximately 21 gpm. ____________

4.14 Engage lower manual valve. The total flow should now be approximately 30 gpm. ____________

4.15 Inspect hoses for leakage. ____________

Initials/Date

4.16 Return all valves to center position and disconnect hoses from unit. ____________

4.17 Shift solenoid to "Hyd. Forward", completely open needle valve in 0-10 gpm bypass line and shift lower manual valve. Flow is approximately 9 gpm. ____________

4.18 Close needle valve, engage lower manual control valve, adjust relief valves to 2000 psig and return control valve to center position. ____________

4.19 Engage upper manual control valve, adjust the relief to 2000 psig and return solenoid operated and manual control valves to center position. Stop unit. ____________

5.0 CEMENT FEED SYSTEM - (Hydraulic or Electric)

Notes:
(1) Visually examine subassemblies and structural components for damage.

(2) Insure the proper number of fasteners are installed and tightened. Check all gaskets.

(3) Replace or repair all defective items.

5.1 Conveyor Assembly

Inspect the following:

5.1.1 Flexicon spiral/motor coupling for:

(a) Set screws and roll pins. ____________

(b) Two clamps and four cap screws. ____________

5.1.2 All wiring and connections. Insure wire and insulation is in good condition and all connections are secure. ____________

5.1.3 1.5 HP Motor

(a) Phase rotation clockwise from Fan End. ____________

(b) Running amps: Not to exceed nameplate amps.

Initials/Date

5.1.4 Cement feed ball valve should operate freely. ____________

5.2 Cement Bin, Bin Supports and Charging Adaptor

Inspect the following:

5.2.1 All welds. ____________

5.2.2 Lid gasket and clamps. ____________

5.2.3 Adaptor equipped with 4" steel pipe cap. ____________

5.2.4 Discharge slide gate. ____________

5.2.5 Interiors are free of excessive cement or additive buildup. ____________

5.3 Vibrator

Vibrator is equipped with 3/8" x 1/4" NPT reducing bushing and a Hansen quick connect. ____________

5.4 Filter-Regulator-Lubricator

Inspect the following:

5.4.1 Bowls should be clean, free of cracks and equipped with guards. ____________

5.4.2 With an air source connected to the supply side of the assembly and the vibrator connected to the discharge side, set lubricator to supply one drop per minute of oil (recommended lubricant is WD-40). ____________

5.5 Tube Sets

Inspect the following for excessive wear:

5.5.1 Inner rotating tube and mounting stud installation. ____________

5.5.2 Flexicon spiral. ____________

5.5.3 Flexicon outer tube. ____________

5.6 Dust Collector

Inspect:

5.6.1 Dust collector extension cord for damage. ____________

Initials/Date

5.6.2 Collector tray and shaker bags for cleanliness. ____________

5.6.3 Motor phase rotation as indicated by arrow on fan housing. ____________

5.6.4 Inlet collar. ____________

5.6.5 Hose conditioned and equipped with adaptor fitting, quick disconnect and two hose clamps. ____________

6.0 DEWATERING PUMP SKID AND HOSES
(Hydraulic or Electric)

Notes: (1) Replace or repair all defective items.

(2) Examine subassemblies and structural components for damage. Insure the proper number of fasteners are installed and tightened. Check all gaskets.

6.1 Pump and Plumbing

6.1.1 Quick disconnect caps installed on suction and discharge lines. ____________

6.1.2 Three way valve is closed. ____________

6.1.3 Bypass valve is open. ____________

6.1.4 Inspect flow meter sight glass. ____________

6.2 Air Supply System

6.2.1 Filter-regulator-lubricator bowls should be clean, free of cracks and equipped with bowl guards. Fill lubricator with WD-40. ____________

6.2.2 Energize air solenoid valve. ____________

6.2.3 Close manual shut-off valve. Connect air supply and adjust: ____________

(a) Relief valve to 90 psig. ____________

(b) Regulator to 40 psig. Discharge. ____________

6.2.4 Open shut-off valve and with pump running set lubricator at one drop per minute. ____________

Initials/Date

6.3 Hoses

6.3.1 Inspect suction, discharge and air hoses for defects. ____________

6.3.2 Insure all end fittings are equipped with quick disconnects and caps. ____________

6.4 Hydrostatic Test

Note: (1) Radiological restrictions prevent contaminated equipment from being subjected to hydrostatic test at HNDC.

The pump skid and liquid hoses when new shall be subjected to a hydrostatic test of 60 psig for a duration not less than 10 minutes.* All new replacement items shall be subjected to this pressure test. ____________

*The hydrostatic test pressure is 1-1/2 times the system working pressure of 40 psig.

7.0 SHIPPING CHECKLIST

If applicable, use the attached checklist during the packaging and and shipping process. The attached checklist is an example and includes items that may not be used at every job site. A checklist similar to this should be generated for each job site.

Activities Completed By: ________________________

Date: ________________________

System No: ________________________

Electric Drive Mixer Incontainer Solidification System

Check Items Applicable to Specific System

Components	Total	Weight	Additional Info
Electric Drive Mixer & Flexicon Cement Conveyor Drive Assy.	1	725#	
Storage Stand	1	625#	
Level Indicator Panel (mounted on control panel stand)	1	20#	With 2 extension cords
2" S.S. Thread Plug	1		Spare Parts Box
1-1/2" S.S. Threaded Cap	1		Spare Parts Box
Dewatering Connection (Packing gland)	1		Spare Parts Box
"O" Ring Tiedown Bolts or flat washers, if applicable	3		Spare Parts Box
"O" Rings for Dewatering Fitting	9		Spare Parts Box
2" x 1-1/2" S.S. Reducing Bushing	1		Spare Parts Box
3" S.S. Threaded Plug	1		Spare Parts Box
Torit Dust Collector	1	200#	
25' 4" Dust Collector Hose & Clamp w/PVC Fitting	1		Stored in Gang Box
Control Panel and Stand	1	400#	

Electric Drive Mixer Incontainer Solidification System - Cont'd.

Check Items Applicable to Specific System

Components	Total	Weight	Additional Info
Extension Cords	3		For elec. drive motor, flexicon conveyor and spare
Cement Bin	1	850#	
Cement Bin Supports	2	70#ea.	
Charger Adaptor Assy.	1	100#	
Cleveland Vibrator	2	20#	
Filter-Regulator-Lubricator	1	15#	
Bag Breaker (Optional)	1		
15' Flexicon Tube Complete with Morris Coupling	2	25#	Spare Parts Box
1/4-20 X 1-1/4" Long Cap Screw	4		Spare Parts Box
5/16-18 X 2" Long Cap Screw	4		Spare Parts Box
Conveyor Drive Coupling Complete	1		Spare Parts Box
Planks	6		Work Platform
Leveling Jack (ALTS)	12		Scaffolding
Outriggers (RT01)	4		Cement Bin Scaffolding
Swivel Clamps (CSA19)	4		Tie Work to Cement Bin Scaffolding

Electric Drive Mixer Incontainer Solidification System - Cont'd.

Check Items Applicable to Specific System

Components	Total	Weight	Additional Info
5' Scaffolding Ends (FL5)	6		
3' Scaffolding Ends (FL3)	2		
3' Cross Braces (B72X)	2		
5' Cross Braces (B74X)	6		
Guard Rail Post (GRPF)	8		
7' Guard Rails (GR-7)	24		
5' Guard Rails (GR-5)	8		
Wing Nuts (WN)	100		Into Parts Box for Scaffolding
Pins (RHP)	40		Into Parts Box for Scaffolding
Coupling Pins (CP)	4		Into Parts Box for Scaffolding
Liner Neck Gaskets	2		Spare Parts Box
BW Electrode Plugs	3		Gang Box
Dewatering Pump Skid & Cover	1	740#	
Dewatering Pump Skid Hoses - 1-1½" Suction 2-1" Discharge 2-3/4" Air	5		

Hydraulic Drive Mixer Incontainer Solidification System

Check Items Applicable to Specific System

Components	Total	Weight	Additional Info
Hydraulic Drive Mixer & Flexicon Cement Conveyor Drive Assy.	1	480#	
Storage Stand	1	625#	
2" SS Thread Plug	3		Spare
1½" SS Thread Cap	1		Spare
Dewatering Connection (Packing Gland)	1		Spare
"O" Rings for Dewatering Fitting	9		Spare
3" SS Threaded Plug	1		Spare
Torit Dust Collector	1	200#	
50' x 40" Dust Collector Hose & Clamp with PVC Fitting	1		Stored in Gang Box
2 Control Panels & Stand	1	1000#	
Extension Cords	7		
"O" Rings for Tiedown Bolts or Flat Washers if Applicable	9		
Cement Bin	1	850#	
Cement Bin Supports	2	70# ea.	
Charger Adaptor Assy.	1	100#	
Cleveland Vibrator	2	20#	
Filter/Regulator/Lubricator	1	15#	
Hydraulic Power Pac w/Control Panel	1	3000#	

Hydraulic Drive Mixer Incontainer Solidification System - Cont'd.

Check Items Applicable to Specific System

Components	Total	Weight	Additional Info
Hydraulic Hoses	3		
Bag Breaker (Optional)	1		
B/W Plugs	3		Spare
Dewatering Pump Skid & Cover	1	740#	
Dewatering Pump Skid Hoses 1-1½" Suction 2-1" Discharge 2-3/4" Air	5		
15' Flexicon Tube Complete	2	25#	
¼-20 x 1¼" Long Cap Screw	6		Spare
5/16-18 x 2" Long Cap Screw	3		Spare
Conveyor Drive Coupling Complete	1		Spare
Planks	6		Work Platform
Leveling Jack (ALIS)	12		Scaffolding
Outriggers (RT01)	4		Cement Bin Scaffolding
Swivel Clamps (CSA19)	4		Tie Work to Cement Bin Scaffolding
5' Scaffolding Ends (FL5)	6		
3' Scaffolding Ends (FL3)	2		
3' Cross Braces (B72X)	2		

Hydraulic Drive Mixer Incontainer Solidification System - Cont'd.

Check Items Applicable to Specific System

Components	Total	Weight	Additional Info
5' Cross Braces (B74X)	6		
Guard Rail Post (GRPF)	8		
7' Guard Rails (GR-7)	28		
5' Guard Rails (GR-5)	8		
Wing Nuts (WN)	100		For Scaffolding
Liner Neck Gaskets	6		Spare
"O" Rings for Hydraulic Supply & Return Hoses	12		Spare
"O" Rings for Hydraulic Bypass Hose	12		Spare
Coupling Pins	4		For Scaffolding
Pins & Clips	40		For Scaffolding
Morris Coupling	1		Spare
Oil Filters	4		Spare for Power Pak
B/W Probes	3		Spare

Section B

In-Plant System Readiness Verification

The following is to be performed after the system has been installed at the solidification site. Note: If Section A, Pre-Operational Checkout, is to be performed at site, Section B items may be done concurrently.

Initial/Date

1.0 ELECTRIC SYSTEM

1.1 Apply power to the cement feed control panel: Phase rotation light is on. __________

1.2 Energize the following motors: __________

1.2.1 Mixer motor: Counter-clockwise rotation when viewed from fan or top end yields clockwise rotation of mixer blades. __________

1.2.2 Flexicon motor: Rotates clockwise when viewed from fan end. __________

1.2.3 Dust collector motor: Pressure at exhaust port and rotation in accordance with arrow on fan. __________

1.3 Check mixer drive oil level: __________

1.4 Using non-radioactive water, begin filling liner. __________

Note: Remove liner fill hatch to allow visual inspection of liner level during the performance of Step 1.4 and 1.5.

1.4.1 Operating level alarm sounds. __________

1.4.2 Push silence button (red light remains on). __________

1.4.3 Hi-Level alarm sounds. __________

1.4.4 Push silence button (red light remains on). __________

Initials/Date

1.4.5 Check overflow path and liner neck gasket seal. __________

1.4.6 Stop filling. __________

Note: For the following steps, if the dewatering pump skid and hoses have been used in previous operations, the discharge should be processed as waste.

1.5 Using dewatering pump, remove water from liner and verify that: __________

1.5.1 Hi-Level and then operating level lights extinguish with decreasing water level. __________

1.5.2 Dewatering Pump lubricator is set to approximately one drop per minute, air regulator is set at 40 psig and pump flow rate is 20 gpm. __________

1.5.3 Partially closing pump discharge valve will result in an increase in discharge pressure. __________

1.5.4 With liquid level approximately 10 inches above the underdrain, pump suction gauge should display approximately 13" Hg. __________

1.5.5 All piping, hoses and connections are free of leaks. __________

1.5.6 Continue dewatering until pump discharge becomes intermittent. __________

2.0 HYDRAULIC MIXER SOLIDIFICATION SYSTEM

2.1 Cement Feed Control Panel

2.1.1 Apply power to the cement feed control panel: Phase rotation light is on. __________

2.1.2 Energize the following motors:

(a) Flexicon motor rotates clockwise when viewed from fan end. __________

(b) Dust collector: discharges at exhaust port. __________

Initial/Date

2.2 Hydraulic Power Pack

2.2.1 Check oil level in hydraulic reservoir. __________

2.2.2 Switch on main breaker, phase rotation light illuminates. __________

2.2.3 "Temp. OK" light is on. If temperature is below operating range "Heater On" light is illuminated until operating temperature is reached. __________

2.2.4 Oil cooler energizes when switched to manual. __________

2.2.5 Solenoid operated control valve will shift through forward, stop and reverse positions. Indicator lights illuminate. __________

2.2.6 Hydraulic hoses are free of leaks. __________

2.3 Level Control Panel

2.3.1 With power switches on, phase correct light illuminates. Push process start. __________

2.3.2 Dewater pump switch operates pump solenoid valve. Switch to auto position. __________

2.3.3 Fill/divert valve switch operates fill/divert valve. Switch to auto position. __________

2.3.4 Waste pump switch in manual position energizes waste pump receptacle. Switch to auto position. __________

2.4 Level Control System Check

2.4.1 Alternative A: Liner Filling With Non-Radioactive Water

2.4.1.1 Using the hydraulic drive, start the internal mixer blades of the solidification liner. The blade speed can be adjusted at this time. The blade should turn freely with no restrictions. Stop the mixer blade rotation. __________

Initial/Date

2.4.1.2 Defeat primary level control system. Only the secondary (high level) control system is used. __________

2.4.1.3 Place the 3-way valve selector switch in the fill position and open the 2-way throttling valve. The divert outlet of the 3-way valve should be capped at this time. __________

2.4.1.4 Fill the liner with non-radioactive water until the high level alarm sounds. The 3-way valve will move to the divert position. This will stop water flow to the liner and hydrotest the transfer line at plant water pressure. Check for leaks and repair if necessary. __________

2.4.1.5 When the high level alarm sounds, the dewater pump should be started manually. The high level alarm will sound until the water level is lowered by the dewater pump. The liner should be dewatered for three minutes once the water level is below the electrodes of the primary level control system. This can be verified by using the 3-way divert valve. This valve will not revert to the fill position if the primary level control system is engaged and the water level is above the electrodes. __________

2.4.1.6 Upon completion of the hydrotest, close the plant's radwaste supply valve and cycle the 3-way divert valve selector switch manually until the pressure is relieved in the 3-way divert valve and supply hose. Caution should now be exercised in removing the divert outlet cap. Connect the divert hose to the 3-way divert valve. __________

2.4.2 Alternative B: Simulated High Level

This alternative procedure should only be used in those instances where exposure to contamination may necessitate

Initials/Date

processing as waste the volume of water required to fill the liner.

2.4.2.1 With the hydraulic mixing head suspended over the liner, make the necessary electrical connections for the high level alarm. CAUTION: The bottom of the mixing head assembly may be contaminated and proper radiological procedures should be followed. __________

(NOTE: The original 2.4.1.1 should also be performed after the mixing head has been installed on the liner.)

2.4.2.2 Verify that the Fill/Divert selector switch is in the divert position and insert the high level alarm electrodes into a beaker containing clean water. This will activate the high level alarm. If not, arrange to have the electrical and mechanical connections reviewed. __________

(NOTE: The waste transfer is not to proceed if this alarm is not functional.)

2.4.2.3 Complete the set up of the transfer equipment. Perform step 2.4.1.1 of the System Readiness Verification. __________

2.4.2.4 After all connections have been made verify that the resin transfer hose is coupled to the mixing head assembly and the resin throttle valve is in the closed position. __________

2.4.2.5 Place the Fill/Divert selector switch in the auto. position and press the process control start button. The Fill/Divert valve will shift to the fill position and will be indicated by the fill light on the control panel. __________

2.4.2.6 Remove the cover plate of the high level electrode holder located on the mixer head. Using a jumper, connect the two electrodes in this holder __________

Initials/Date

together. This will activate the high level alarm and shift the Fill/Divert valve to the divert position, with no operator action.

2.4.2.7 Remove the jumper and replace the electrode holder cover in place. Press the control stop button and return the Fill/Divert selector switch to the divert position. __________

2.4.2.8 Dispose of the liquid used to test the high level alarm as radioactive waste. __________

Activities Completed By: ______________________

Date: ______________________

System No: ______________________

WESTINGHOUSE HITTMAN NUCLEAR INCORPORATED	Document Number: STD-P-05-027	Rev: 0	Rev Date: 3-7-84
	Title: Full Scale Test Solidification Procedure for Class B or C Bead Resin		

Rev.	Rev Date	Director Engr.	Project Manager	QA Manager			
0	3-7-84	J Phillips for R Leduc	J Phillips				

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FORM-01(B)

FULL SCALE TEST SOLIDIFICATION PROCEDURE FOR CLASS B OR C BEAD RESIN

1.0 SCOPE

This procedure is applicable to the solidification of Class B or C bead resin in an HN-100 UM liner using either an electric or hydraulic mixing motor.

2.0 PURPOSE

The purpose of this test procedure is three-fold:

2.1 To determine if adequate mixing can be achieved for this waste type in an HN-100 UM liner using an electric mixing motor.

NOTE: This test will be conducted using an hydraulic system operating at the speed of an electric system; 28 rpm. The hydraulic pressure required to turn the blades will be recorded during the solidification process. After completion of the test, this data will be analyzed to show that the power available in an electric system is sufficient to perform similar solidifications.

2.2 To obtain samples of the mix to perform 90-day immersion tests.

2.3 To demonstrate the scale up of the solidification process to full scale liners from previously generated lab data.

3.0 REFERENCES

3.1 STD-P-03-021 In Drum Test Solidification Procedure, Section 4.4, Bead Resin.

3.2 HNDC-TS-13000 Cement Feed System Instruction Manual.

3.3 HNDC-TS-17000 Mixer Head Drive Assembly. Mounting Procedure (Hydraulic and Electric).

3.4 HNDC-TS-18000 Field Assembly and Operating Procedure for Distribution and Level Control Module (Hydraulic Only).

3.5 Bead Resin Laboratory Notebook, page 45.

3.6 Calcium Hydroxide Addition Procedure, STD-P-05-022.

4.0 EQUIPMENT

4.1 In-container mixing system using hydraulic power pack.

4.2 HN-100 UM liner. The liner is modified to accommodate the placing of 10 cement molds in the liner for curing.

4.3 Overhead crane for lifting mixer.

4.4 Dynamometer capable of measuring up to 1,000 pounds.

4.5 Simulated waste and solidification agents.

4.6 Pump, hoses and pipe necessary for dewatering.

5.0 SET-UP

5.1 MOUNT the mixer head according to HNDC-TS-17000.

5.2 ASSEMBLE the cement feed system according to HNDC-TS-13000.

5.3 MAKE electrical connections according to HNDC-TS-18000.

6.0 PREPARATION OF SIMULATED WASTE

6.1 COVER bead resin in RADLOK-100 with water and let set a minimum of 24 hours.

6.2 MEASURE volume of resin in RADLOK-100.

6.3 ADD sufficient bead resin to bring total volume of bead resin up to at least 77.4 ft^3.

6.4 PUMP resin slurry into HN-100 UM for solidification.

NOTE: Contents should be mixed using mixer as convenient and appropriate.

6.5 DEWATER resin in HN-100 UM.

6.6 MEASURE volume of resin in liner.

6.7 ADJUST volume to 77.4 ft^3.

6.8 SAMPLE RADLOK contents for test solidification (Section 7.0).

6.9 RECORD volume of resin in liner on the Class B and C Bead Resin Waste Solidification Data Sheet.

7.0 TEST SOLIDIFICATION

7.1 Prerequisites

7.1.1 The resins for this test shall have been rehydrated (soaked in water) for at least 24 hours prior to being used.

7.2 Precautions

None.

7.3 Test Solidification Procedure

NOTE: A total of six (6) samples shall be prepared.

7.3.1 WEIGH out 320 grams of dewatered resin in a 1,000 ml beaker.

7.3.2 ADD 235.3 grams of tap water to the resin.

7.3.3 RECORD the slurry volume on Attachment A.

7.3.4 WEIGH out 18 grams of calcium hydroxide.

7.3.5 START mixing the resin-water slurry.

7.3.6 ADD two (2) grams of calcium hydroxide to the slurry.

7.3.7 MIX for three (3) minutes.

7.3.8 MEASURE the pH of the slurry.

NOTE: For best accuracy use narrow range pH paper.

7.3.9 Repeat Steps 7.3.6 through 7.3.8 until the pH is ≧ 11.5.

7.3.10 RECORD the pH on Attachment A.

7.3.11 ADD an additional three (3) grams of calcium hydroxide.

7.3.12 MIX for three (3) minutes.

7.3.13 MEASURE the final pH.

7.3.14 RECORD the final pH on Attachment A.

7.3.15 WEIGHT out 653.6 grams of Portland Type I Cement.

7.3.16 ADD the cement to the slurry slowly.

NOTE: Do not add cement faster than it mixes into the slurry.

7.3.17 MIX the product for two (2) minutes after all the cement has been added.

7.3.18 STOP mixing.

7.3.19 MEASURE the final volume.

7.3.20 RECORD the final volume on Attachment A.

7.3.21 POUR the mix into a labeled 3-inch diameter by 6-inch high plastic mold.

7.3.22 SEAL the sample in a plastic bag.

7.3.23 CURE at 120 ± 5°F for 24 hours.

7.3.24 FILL in remainder of data on the Data Sheet.

7.4 Acceptability Criteria

7.4.1 EVALUATE the samples for set.

NOTE: An acceptable set is characterized by a product that is hard and contains no free liquid.

7.4.2 SIGN the data sheet and note the sample as acceptable or unacceptable.

NOTE: Samples may be checked for acceptability of product with less than 24 hours of cure. If product acceptability is verified with less than 24 hours cure note the total hours cured on the data sheet. No samples should be rated as unacceptable with less than 24 hours cure.

8.0 FULL SCALE SOLIDIFICATION

8.1 Prerequisites

8.1.1 The test solidifications have been completed and found acceptable.

8.1.2 The dust collector is clean and empty.

8.1.3 Two cement hoppers are loaded with 7,890 pounds of Portland Type I cement. The first hopper contains 3,190 lbs. (34 bags) and the second hopper contains 4,700 lbs. (50 bags).

8.1.4 A dewatering pump is set up to draw suction on the liner underdrain and recirculate the water into the liner.

8.2 Precautions

None.

8.3 Procedure

8.3.1 MEASURE the height of the bead resin in the liner.

8.3.2 RECORD the height (and volume) of bead resin on Attachment B.

8.3.3 ADD 341 gallons of water to the liner.

8.3.4 MEASURE the height of the resin slurry in the liner.

8.3.5 RECORD the height (and volume) of the slurry on Attachment B.

8.3.6 START the hydraulic mixer and MIX for 5 minutes or until the slurry is homogeneous.

8.3.7 ADD the appropriate quantity of calcium hydroxide from Part 2, Attachment B through the charging adapter.

8.3.8 ADD additional calcium hydroxide per STD-P-05-022.

8.3.9 RECORD the quantity of calcium hydroxide added on Attachment B and the time necessary to complete the addition.

8.3.10 MIX for 15 minutes after the calcium hydroxide has been added.

8.3.11 STOP the mixer and check the pH of the waste slurry using narrow range pH paper.

8.3.12 START mixer.

8.3.13 If the pH is 11.5, PROCEED to Step 8.3.13.

8.3.14 If the pH is below 11.0, ADD more calcium hydroxide in 50 lbs. increments stirring 15 minutes between each addition until the pH is at least 11.5.

8.3.15 EXAMINE the dust collector for calcium hydroxide.

8.3.16 RECORD the quantity of calcium hydroxide in the dust collector on Attachment B.

8.3.17 RECORD the hydraulic pressure after the calcium hydroxide is added and every 5 minutes during the cement addition on Attachment C.

8.3.18 MOUNT the first hopper (34 bags of cement) on the scaffold.

8.3.19 START the cement feed.

8.3.20 When all the cement has been added, STOP the cement feed.

8.3.21 REMOVE the cement hopper from the scaffold when empty.

8.3.22 START the dewatering pump.

NOTE: The dewatering pump may be stopped if it is determined that it is not providing any suction of cement into the underdrain.

8.3.23 MOUNT the second hopper (50 bags of cement).

8.3.24 START the cement feed.

8.3.25 RECORD the quantity of cement and the time the cement feed was started on Attachment B.

NOTE: If the hydraulic pressure reaches the point of stall, ADD 5 gallons of water through the resin fill hatch. RECORD any water addition necessary for this purpose on Attachment C.

8.3.26 If there is a problem with the cement feed toward the end of the addition as evidenced by a build up of dry cement, FEED the cement in one minute intervals.

NOTE: The time interval can be adjusted according to the test.

8.3.27 STOP the cement feed.

8.3.28 STOP the dewatering pump.

8.3.29 RECORD any feed problems on Attachment B and NOTE the time interval necessary to correct the situation on Attachment B.

8.3.30 RECORD on Attachment B the total time necessary to add the cement.

8.3.31 MIX the product for 30 minutes after the cement addition is complete or until the mixer stalls.

8.3.32 RECORD the time on Attachment B.

8.3.33 STOP the mixer.

8.3.34 FILL 10 pre-labeled plastic molds 3 inch diameter by 6 inch high.

8.3.35 PLACE the molds on the rack in the extension box on the top of the liner.

8.3.36 CAP the liner and ALLOW to cure for 24 hours.

16M

ATTACHMENT A

Process Control Program Data Sheet

Part 1

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	
Quantity of Bead Resin							
Weight, gms:							(1)
Volume, mls:							(2)
Quantity of Water, gms:							(3)
Slurry Volume, ml:							(4)
Slurry Density, gml ((1)+(3))/(4):							(5)
Initial pH:							(6)
Total gms $Ca(OH)_2$ Added to pH 11.5:							(7)
Final pH:							(8)
Quantity of Portland Type I Cement Added gms:							(9)
Final Volume, ml:							(10)
Packaging Efficiency, % (2)/(10) x 100:							(11)
Product Description after 24-Hour Cure							(12)

Part 2

Calculation of Quantity of Calcium Hydroxide to Add to Liner

The quantity of calcium hydroxide to add to the liner is determined by the following equation:

gms $Ca(OH)_2$ from Part 1, (7) x ft^3 bead resin in liner x .156 = ______________
lbs. of $Ca(OH)_2$ to be added to liner

ATTACHMENT B

Solidification Data Sheet

Height of Bead Resin, inches: ____________________ (1)

Volume of Bead Resin, ft^3
(1) x 2.35 ft^3/inch = ____________________ (2)

Volume of Water Added, gallons ____________________ (3)

Volume of Slurry, ft^3
Depth (inches) x 2.35 ft^3/inch ____________________ (4)

Quantity of Calcium Hydroxide
Added, lbs: ____________________ (5)

Time Necessary to Add Calcium
Hydroxide, minutes: ____________________ (6)

pH of Waste: ____________________ (7)

Additional Calcium Hydroxide
Added, lbs: ____________________ (8)

pH after Additional Calcium
Hydroxide: ____________________ (9)

Quantity of Calcium Hydroxide in
Dust Collector, lbs: ____________________ (10)

Quantity of Portland Type I, lbs: ____________________ (11)
bags: (11) ÷ 94 = ____________________ (12)

Time at Start of Cement Feed: ____________________ (13)

Problems with Cement Feed: ____________________ (14)

Corrective Measure: ____________________ (15)

Time Cement Feed Completed: ____________________ (16)

Total Time for Cement Feed:
(16) - (13) ____________________ (17)

Mix Time After Cement Addition
is Complete, min: ____________________ (18)

Set Time ____________________ (19)

ATTACHMENT C

Hydraulic Pressure Readings

Time Initial	psi
16N	

HITTMAN NUCLEAR & DEVELOPMENT CORPORATION	Document Number: STD-R-03-001	Rev: 0	Rev Date: 12-3-81
	Title: Report on Dewatering of Bead Ion Exchange Resin and Activated Carbon		

Rev.	Rev Date	Prepared By	Reviewed By	Responsible Engineering Manager	Quality Assurance	Director Engineering	
0	12-3-81		S Phillips	S Phillips			

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Dewatering of Bead Ion Exchange Resin and Activated Carbon

No. STD-R-03-001

December 3, 1981

Hittman Nuclear & Development Corporation
Columbia, Maryland

TABLE OF CONTENTS

I. INTRODUCTION AND PURPOSE

This report covers bead resin dewatering tests performed in addition to those covered in the HITTMAN Liner Dewatering Test Report, No. 1-843-3, November 12, 1980. The data from the eight additional tests were analyzed together with the data from the two previous pertinent tests to ascertain:

- The minimum time required to dewater bead ion exchange resins in HITTMAN disposable liners to meet the current Barnwell burial site criteria of 0.5 percent drainable liquids for conventional liners.
- The influence of resin volumes and types on the minimum dewatering period; and
- The influence of dewatering equipment on the minimum dewatering period.

II. CONCLUSIONS AND RECOMMENDATIONS

Data presented in this report show that four days of dewatering by any of the methodologies described in this report will meet regulatory limits, namely:

- Standard HITTMAN liners, HN-200, HN-600, and HN-100 can be dewatered in four days using a combination of Jabsco and vacuum pumps or Warren-Rupp and vacuum pumps to 0.5 percent of free drainable liquid. These liners must, however, be tipped during the dewatering process.
- Standard HITTMAN liners, HN-200, HN-600, and HN-100, containing activated carbon can be dewatered to the applicable burial site criteria using the same techniques as recommended in this report for bead ion exchange resin. Results of testing performed by HITTMAN which demonstrate that this material can be dewatered to the same extent as, or better than bead ion exchange resin, are presented in Appendix A.

It is recommended, however, that an air operated pump (of Warren-Rupp type) be used to dewater HITTMAN liners to 0.5 percent of free drainable liquid. Use of such a pump will provide additional assurance that the 0.5 percent limit will be satisfied. The methodology of dewatering employed in tests 6 through 10 is recommended, therefore, as best: the liner is tipped throughout the dewatering procedure; a Warren-Rupp pump is used to pump the liner on the first day for at least four hours; 24 hours later the liner is pumped again by the Warren-Rupp pump for at least one hour and is vacuum drained for one hour after that and then daily for at least two additional days.

III. EQUIPMENT USED

A. Previous Tests, Resin Type A*

The two previous tests were performed using a disposable liner approximately the size of an HN-200 liner equipped with the standard HITTMAN underdrain system. Approximately 27 cubic feet of layered ion exchange resins were in the liner during these tests. These resins were chemically depleted, prior to the tests, by processing over 8000 gallons of nonradioactive water containing 500 ppm boron in the form of boric acid and 260 ppm sodium in the form of sodium sulfate through the resins. Each test started with the liner full of water. The liner was then dewatered using a Jabsco pump rated at approximately 20 gpm. For gravity drainage of the liner, a hole 3/4 inch in diameter was drilled in the side of the liner just above the bottom plate. For vacuum draining, the solid stopper was replaced with a single hole stopper. A tube was inserted through the hole and a specially designed filter element was attached to the tube. The stopper was then inserted into the hole in the liner and the end of the tube extending outside the liner was connected to a glass bottle. By installing an eductor in the discharge side of the Jabsco pump operating at 20 gpm, a suction pressure (vacuum) of approximately one-half atmosphere was created.

**Tests were conducted with various types of exhausted ion-exchange resins. Resin Type A is described in Section II.A. Resin Types B and C were obtained from various utility power plants and were nonradioactive. Exact resin types by manufacturer's name are not known.*

B. HN-600 Liner Dewatering Tests with Jabsco Pump, Resin Type B

These three tests were conducted in an HN-600 liner with the standard HITTMAN underdrain. The liner was filled with approximately 56 ft^3 of exhausted bead ion exchange resin, used as delivered from a power plant.

Horizontal and vertical filter elements with tubing for vacuum draining, were installed in the liner as shown in Figure 1. A monitoring hole was drilled in the side of the liner just above the bottom plate.

A Jabsco pump was used for the first day dewatering procedure (through the underdrain). A GAST vacuum pump was used for the daily follow-up drainings.

C. HN-600 Liner Tests with Warren-Rupp Air Operated Pump, Resin Type B

The equipment used in these tests differs from that used in tests B only in application of a Warren-Rupp air operated pump for the initial (through the underdrain) dewatering procedure.

D. HN-600 and HN-100 Liner Tests with Warren-Rupp Air Operated Pump, Resin Type C

In these two tests, HN-600 and HN-100 liners were filled with 56 ft^3 and 120 ft^3 respectively of exhausted resin which had been subjected to prolonged wet storage on-site.

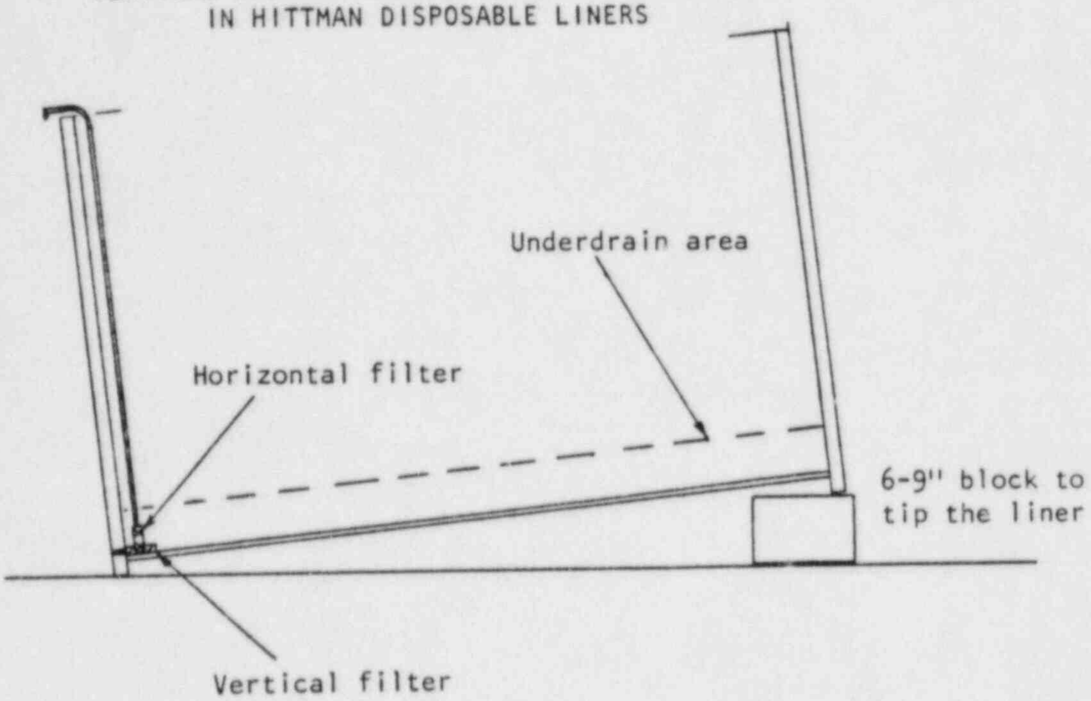
The HN-600 liner used was the same as in previous tests. The HN-100 liner had a hole drilled at the bottom and a top filter element identical to the one installed in the HN-600 liner. A Warren-Rupp pump was used for the initial dewatering and was followed by a GAST vacuum pump for the subsequent drainings.

IV. METHODOLOGY

An outline of the methodology used in each of the 10 tests is presented in Table 1. Tests 1 and 2 designate the

FIGURE I

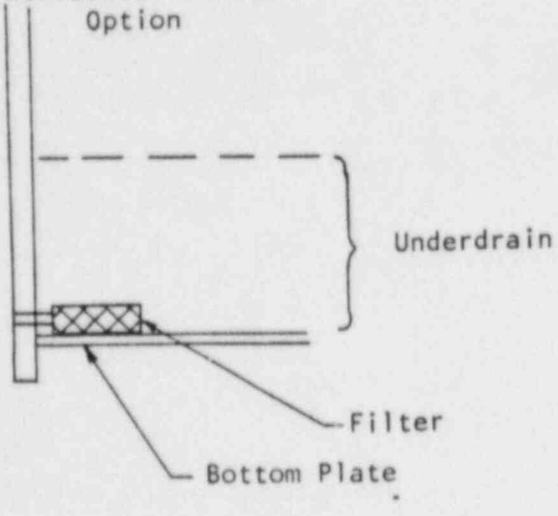
VERTICAL AND HORIZONTAL FILTER INSTALLATION
IN HITTMAN DISPOSABLE LINERS



HITTMAN DISPOSABLE LINER

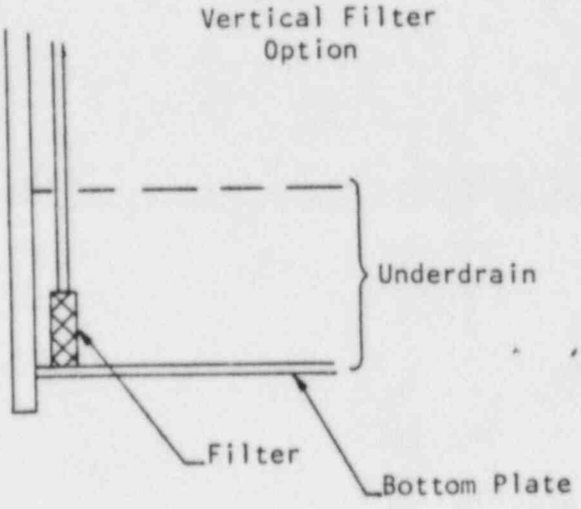
Detail A

Horizontal Filter Option



Detail B

Vertical Filter Option



data reported in HITTMAN Liner Dewatering Test Report No. 1-843-3 as tests 4 and 5. There are four main groups of tests covered in this table. The main features of these groups are:

- Group 1 - Tests 1 and 2. A combination of Jabsco pump and vacuum was used to dewater 27 ft^3 of resin, vacuum drainings continued for 8 to 10 days.
- Group 2 - Tests 3, 4, and 5. The methodology of these tests was similar to Group 1; a larger liner (56 ft^3 of resin) was used and tests 4 and 5 were conducted so as to compare the accumulation of water at the bottom under gravity with the cumulative amount vacuumed out daily in tests 1, 2, and 3. Hence, the liners in tests 4 and 5 were plugged at different times after the initial dewatering and final gravity drainings were taken on the tenth and eighth days, respectively (see Tables 2 and 3).
- Group 3 - Tests 6, 7, and 8. A Warren-Rupp pump was used on the first and second days for four hours and one hour, respectively. This was followed on the second day by an hour of vacuum draining. Experiments were performed with different time intervals between gravity drainings based on experience accumulated in previous tests.
- Group 4 - Tests 9 and 10. HN-600 and HN-100 were loaded with 56 ft^3 and 120 ft^3 of resin different from resins used in tests 1 through 8. The resin was stored on-site for a long time (see Section II). The main objective of this group of tests was to accumulate additional data using different waste material. The rest of the methodology was similar to Group 3.

TABLE 1. TEST METHODOLOGY

Test Number		Equipment Used	Dewatering Procedure
Group 1	1	4x4 liner, 27 ft^3 of resin, Jabsco pump, eductor	Liner is tipped, pumped with Jabsco over 8 hour period at 2 hour intervals, then again at 24 hours (water collected and measured), then vacuum drained daily.*
	2	4x4 liner, 27 ft^3 of resin, Jabsco pump, eductor	Liner is tipped, pumped with Jabsco till loss of suction, vacuum drained daily on the next day and thereafter.*
Group 2	3	HN-600 liner, 56 ft^3 of resin, Jabsco pump, GAST vacuum pump	Same as test #2.
	4	HN-600 liner, 56 ft^3 of resin, Jabsco pump, GAST vacuum pump	Same as test #2.
	5	HN-600 liner, 56 ft^3 of resin, Jabsco pump, GAST vacuum pump	Same as test #2.
Group 3	6	HN-600 liner, 56 ft^3 of resin, Warren-Rupp pump, GAST vacuum pump	Liner is tipped, pumped down for 4 hours by Warren-Rupp pump on the first day, for one hour on the second day (water discharged in this pumpdown collected and measured), vacuum drained for 1 hour immediately after pumpdown, and daily thereafter.*
	7	HN-600 liner, 56 ft^3 of resin, Warren-Rupp pump, GAST vacuum pump	Same as test #6.
	8	HN-600 liner, 56 ft^3 of resin, Warren-Rupp pump, GAST vacuum pump	Same as test #6.
Group 4	9	HN-600 liner, 56 ft^3 of resin, Warren-Rupp pump, GAST vacuum pump	Same as test #6.
	10	HN-100 liner, 120 ft^3 of resin, Warren-Rupp pump, GAST vacuum pump	Same as test #6.

*For frequency of vacuum and final gravity drainings, see Tables 2 and 3 for the results.

V. RESULTS

Table 2 shows the daily volumetric data for all 10 tests. It not only represents the volumes of water collected, but also the mode of dewatering/draining technique - pumping, vacuuming, or gravity draining. Although the data presented in this table afford a quick overview of the program, it must be considered in conjunction with Table 3.

Table 3 presents the data as volumes of drained liquid per unit volume of bead resin (i.e., liters of drained water per cubic foot of resin in the liner). Thus, tests 1 and 2, which were conducted with 27 ft^3 of resin, tests 3 through 9 (in an HN-600 with 56 ft^3 of resin), and test 10 (in an HN-100 liner with 120 ft^3 of resin), can be related to each other and to the disposal limits simultaneously. The disposal limits are: 0.5 percent of waste volume for conventional containers, i.e., 0.5 percent per each cubic foot of waste or 0.145 liters per cubic foot.

The following observations are evident by comparing Tables 2 and 3 and keeping in mind the differences in methodology of different test groups (see Table 1):

- The water drawn daily by vacuum in tests 1, 2, 3, 9, and 10 is not representative of the free water in the liner which would gravity drain to the liner bottom. This phenomenon can be explained by the fact that the free water (i.e., water not retained in the body of the bead) not removed by the initial pumping is held in dynamic equilibrium by the interstitially cohesive forces. Previous vibration tests showed (see HITTMAN Report No. 1843-3) that this equilibrium is not significantly altered by the typical transport of the containers. However, the application of a vacuum (one-half atmosphere) disrupts this equilibrium and creates a downward gradient much higher than that created by gravity. As a result, the application of a vacuum pulls out interstitial water which would not normally migrate under gravity to the liner bottom. Tests 4, 5, 6, 7, and 8 show that when the liner was plugged at different time intervals after the initial pump and vacuum dewatering, gravity drainings were either zero or lower by an order of magnitude than the cumulative vacuum drainings for the same period.

TABLE 2. TEST RESULT: VOLUMES OF WATER (LITERS) COLLECTED DAILY

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10
Test 1	46.8* P	14.64 V	1.75 V	0.96 V	0.6 V	0.45 V	0.35 V	0.29 V	0.23 V	0.2 V
Test 2	52.2* V	4.11 V	1.77 V	0.98 V	0.76 V	0.55 V	0.38 V	0.27 V		
Test 3	46.3* V	5.5 V	2.65 V	1.8 V	1.3 V	1.05 V	1.0 V	0.82 V	0.0 G	
Test 4	58.3* V	4.8 V	1.85 V	0.8 V	-	-	-	-	-	0.6 G
Test 5	64.3* V	2.25 V	-	-	-	-	-	0.6 G	-	-
Test 6	Not collected	17 P; 1.9V	-	-	-	-	0.9 G			
Test 7	Not collected	8.4P; 1.9V	0.85 G							
Test 8	Not collected	17 P; 2.6V	-	-	1.2 G					
Test 9	156* P	15P; 3.9V	4.1 V	1.5 V	1.6 V	-	-	0.0 G		
Test 10	129* P	35P; 7.7V	7.2 V	6.1 V	2.2 V	2.4 V	2.3 V	0.0 G		

Symbols:
P = pumped, V = vacuumed, G = gravity drained.
* Pumped after loss of suction, differences due to subjective nature of measurement.
\- Indicates days drainings were not performed.

- The application of an air operated, Warren-Rupp type pump speeds up the dewatering process and provides extra assurance that the limit will be met in the recommended dewatering period (see conclusions). As can be seen from Tables 2 and 3, tests 6 through 10 (which used the Warren-Rupp pump) showed, on the average, much lower cumulative amounts of drained water than tests 1 through 5.

- Neither resin volume nor resin type impact significantly on the dewatering efficiency. Table 3, which shows volumes of drainage per volume of waste, demonstrates conclusively that the amount of water drained at any particular time during the procedure depends almost entirely on the equipment and methodology used.

TABLE 3. TEST RESULTS: VOLUMES OF WATER PER UNIT VOLUME OF RESIN (ℓ/ft^3)

Test Group	Test No.	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Cumulative From 5th Day	Disposal Limit (ℓ/ft^3 of waste)	Cumulative From 5th Day as Percent of Limit
1-27 ft^3, Resin A	1	0.54	0.065	0.035	0.022	0.016	0.013	0.011	0.008	0.007	0.077	0.145	53
	2	0.15	0.065	0.036	0.028	0.020	0.014	0.010			0.072	0.145	49
2-56 ft^3, Resin B	3	0.098	0.047	0.032	0.023	0.019	0.018	0.015	0.0*		0.075	0.145	52
	4	0.086	0.033	0.014	-	-	-	-	-	0.011*	0.011	0.145	7
	5	0.04	-	-	-	-	-	0.011*			0.011	0.145	7
3-56 ft^3 Warren-Rupp	6	0.34	-	-	-	-	0.016*				0.016	0.145	11
	7	0.18	0.015										
	8	0.35	-	-	0.021*						0.021	0.145	14
4-Warren-Rupp, Resin C	9	0.34	0.073	0.027	0.028	-	-	0.0*			0.028	0.145	19
	10	0.36	0.06	0.051	0.018	0.020	0.019	0.0*			0.057	0.145	39

*Final gravity drainings.

APPENDIX A

COMPARISON OF DEWATERING RATES OF ACTIVATED CARBON AND BEAD RESIN

Laboratory scale dewatering tests were conducted to compare the dewatering rates of activated carbon and bead ion exchange resin. Two types of activated carbon (Calgon types, F-300 and F-400) were used. Water in these tests was first gravity drained and then vacuum was applied (see Table A-1.).

The results of these tests are shown in Table A-1. The amount of water collected is shown in this table as a percent of total water added in the beginning of the test. The data were then plotted in Figure A-1.

As can be seen from Table A-1 and Figure A-1, both the rate and the extent of dewatering were better for activated carbon than for the bead resin.

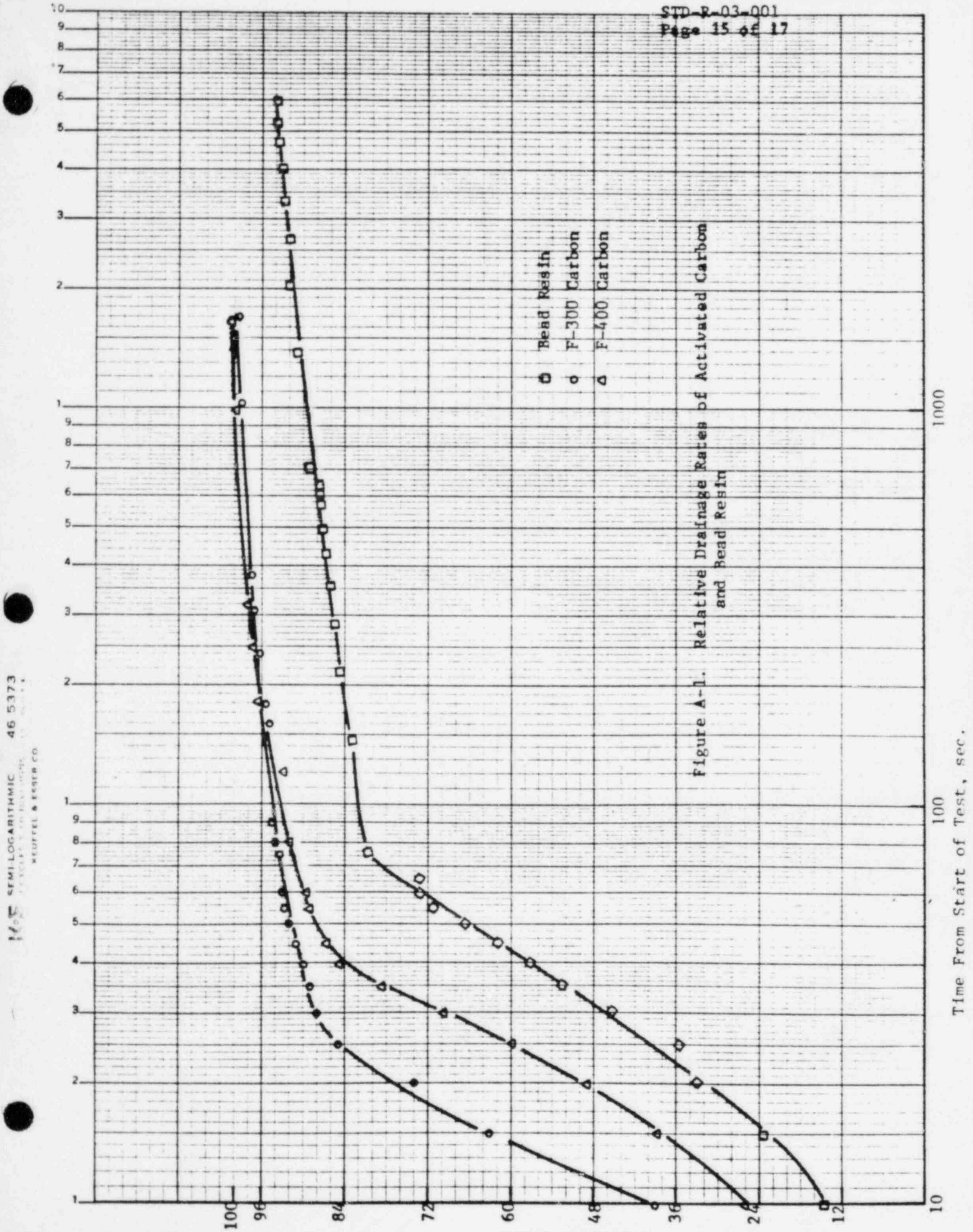


Figure A-1. Relative Drainage Rates of Activated Carbon and Bead Resin

TABLE A-1. ACTIVATED CARBON VERSUS ION EXCHANGE BEAD RESIN DEWATERING RATES

	Percent of Total Drained		
Cumulative Time (sec)	Activated Carbon (F-300)	Activated Carbon (F-400)	Ion-Exchange Bead Resin
5	20	13	5.7
10	39	26	14.2
15	63	39	23.8
20	74	49	33.3
25	85	60	35.7
30	88	70	45.7
35	89	79	52.4
40	90	85	57.1
45	91	86.5	61.9
50	92	-	66.7
55	92.5	89	71.4
60	93	89.5	73.3
65	-	-	73.3
75	93.5	-	80.3*
80	94	92	-
90	94.5	-	-
120	-	93	-
145	-	-	82.9
155	-	-	-
160	95	-	-
180	95.5	96.3*	-
215	-	-	84.4
240	96.45*	-	-
250	-	97.2	-
285	-	-	85.5
310	97.1	-	-
320	-	97.9	-
355	-	-	86
380	97.7	-	-
425	-	-	86.7
495	-	-	87.1
565	-	-	87.4
635	-	-	87.8
705	-	-	88.6**
980	-	99.7**	-
1040	99.1**	-	-
1365	-	-	89.1
1640	-	100	-
1700	100	-	-
2025	-	-	89.9
2685	-	-	90
3345	-	-	90.4

TABLE A-1. (CONTINUED)

	Percent of Total Drained		
Cumulative Time (sec)	Activated Carbon (F-300)	Activated Carbon (F-400)	Ion-Exchange Bead Resin
4665	-	-	91.5
5325	-	-	91.8
5985	-	-	92.9

*Begin 10 seconds of vacuum at one-minute intervals.
**Begin 60 seconds of vacuum at ten-minute intervals.

PROPRIETARY DATA

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REPORT ON DEWATERING OF BEAD ION EXCHANGE RESIN AND ACTIVATED CARBON IN HITTMAN RADLOK™ HIGH INTEGRITY CONTAINERS

I. INTRODUCTION AND PURPOSE

This report covers bead resin dewatering tests performed by Hittman and previously reported in our report, Report on Dewatering of Bead Ion Exchange Resin and Activated Carbon, STD-R-03-001. The data presented in that report has been reanalyzed to ascertain:

- The minimum time required to dewater bead resin in Hittman RADLOK™ high integrity containers with rigid sand-epoxy underdrain systems to meet the current Barnwell burial site criteria of 1.0 percent drainable liquid.
- The influence of resin volumes and types on the minimum dewatering period; and
- The influence of dewatering equipment on the minimum dewatering period.

Additional testing was performed using a RADLOK container with underdrain designs, similar to the previous testing, that do not require tipping of the container during dewatering. The data from these tests was then analyzed to determine:

- The minimum time required to dewater bead resin in Hittman RADLOK high integrity containers with flexible underdrain systems to meet the current Barnwell burial site criteria of 1.0 percent drainable liquid.

Further testing was performed on a level (untipped) RADLOK container with rigid lateral underdrain to determine:

- Ability to meet the current Barnwell burial site criteria of 1.0 percent drainable liquid using previously developed dewatering procedure.

II. CONCLUSIONS AND RECOMMENDATIONS

Data presented in this report show that one day of dewatering by any of the methodologies described in this report will meet regulatory limits, namely:

- RADLOK containers with rigid sand-epoxy underdrains can be dewatered in a twenty-four (24) hour period using a combination of Jabsco and vacuum pumps or Warren-Rupp and vacuum pumps to 1.0 percent of free drainable liquid. These containers must be tipped during the dewatering process.
- RADLOK containers with flexible underdrains can be dewatered in a twenty-four (24) hour period using a combination of Warren-Rupp and vacuum pumps to 1.0 percent of free drainable liquid. These containers do not have to be tipped during the dewatering process.
- RADLOK containers with either rigid sand-epoxy or flexible underdrains containing activated carbon can be dewatered to the applicable burial site criteria using the same techniques as recommended in this report for bead ion exchange resin. Results of testing performed by Hittman which demonstrate that this material can be dewatered to the same extent as, or better than bead ion exchange resin, are presented in Appendix A.

It is recommended, however, that an air operated pump (of Warren-Rupp type) be used to dewater Hittman RADLOK containers to 1.0 percent of free drainable liquid. Use of such a pump will provide additional assurance that the 1.0 percent limit will be satisfied. The methodology of dewatering employed in tests 6 through 10 is recommended, therefore, as best: the container is tipped or elevated as required by the dewatering procedure throughout the dewatering procedure; a Warren-Rupp pump is used to pump the container on the first day for at least four hours; 24 hours later the liner is pumped again with the Warren-Rupp pump for at least one hour and is vacuum drained for one hour after that.

Subsequent testing has demonstrated that a RADLOK container with a rigid lateral underdrain can be dewatered to 1.0 percent of free drainable liquid in a twenty-four (24) hour period using a combination of Warren-Rupp and vacuum pumps. These containers need not be tipped during the dewatering process. The methodology employed in this test (13) was the same as that in test 11 and 12. The second pump down with the Warren-Rupp was started 20 hours after the initiation of the first pump down.

III. EQUIPMENT USED

A. HN-200 Tests, Resin Type A*

Two tests were performed using a disposable liner approximately the size of an HN-200 liner equipped with the standard Hittman rigid sand-epoxy underdrain system. Approximately 27 cubic feet of layered ion exchange resins were in the liner during these tests. These resins were chemically depleted, prior to the tests, by processing over 8000 gallons of nonradioactive water containing 500 ppm boron in the form of boric acid and 260 ppm sodium in the form of sodium sulfate through the resins. Each test started with the liner full of water. The liner was then dewatered using a Jabsco pump rated at approximately 20 gpm. For gravity drainage of the liner, a hole 3/4 inch in diameter was drilled in the side of the liner just above the bottom plate. For vacuum draining, the solid stopper was replaced with a single hole stopper. A tube was inserted through the hole and a specially designed filter element was attached to the tube. The stopper was then inserted into the hole in the liner and the end of the tube extending outside the liner was connected to a glass bottle. By installing an eductor in the discharge side of the Jabsco pump operating at 20 gpm, a suction pressure (vacuum) of approximately one-half atmosphere was created.

B. HN-600 Liner Dewatering Tests with Jabsco Pump, Resin Type B

These three tests were conducted in an HN-600 liner with the standard Hittman rigid sand-epoxy underdrain. The liner was filled with approximately 56 ft^3 of exhausted bead ion exchange resin, used as delivered from a power plant.

Horizontal and vertical filter elements with tubing for vacuum draining, were installed in the liner as shown in Figure 1. A monitoring hole was drilled in the side of the liner just above the bottom plate.

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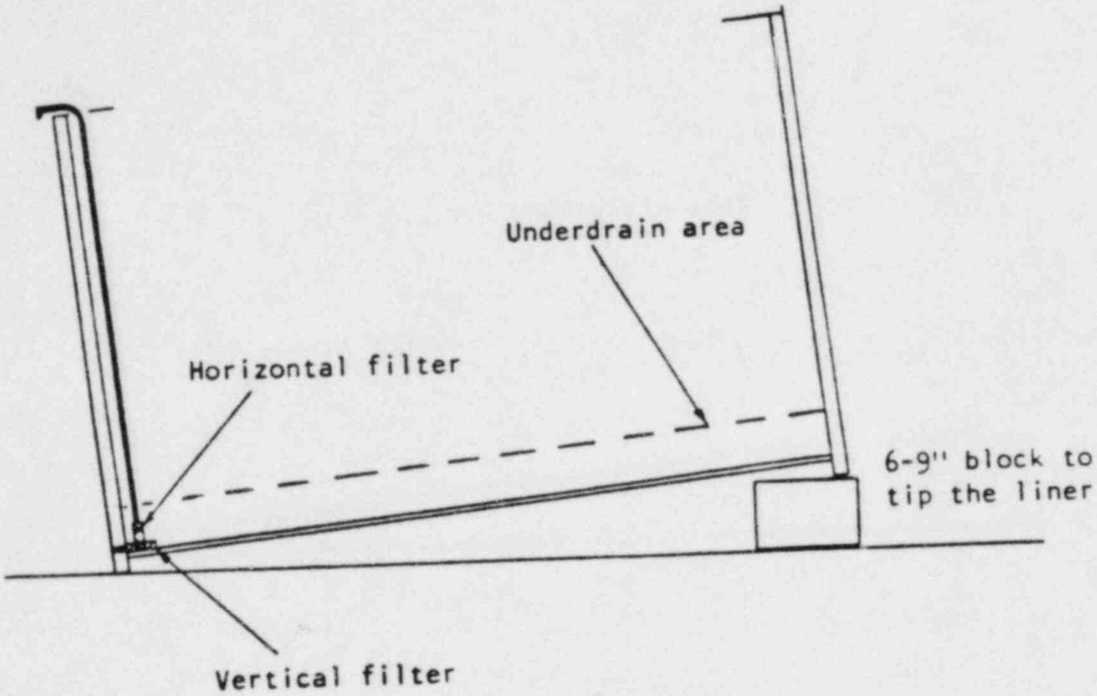
*Tests were conducted with various types of exhausted ion-exchange resins. The resin in this liner was provided by Epicor, Inc. to simulate a disposable demineralizer used in the Epicor II system at TMI Unit 2. The types and relative quantities are proprietary to Epicor, Inc. Resin Types B and C were obtained from various utility power plants and were nonradioactive. Exact resin types by manufacturer's name are not known.

FIGURE 1

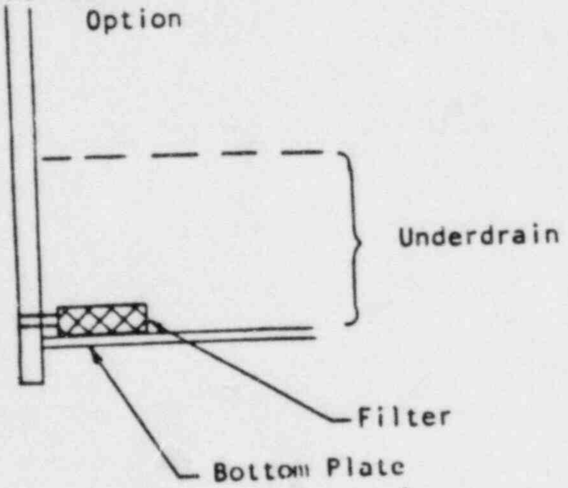
VERTICAL AND HORIZONTAL FILTER INSTALLATION IN HITTMAN DISPOSABLE LINERS



HITTMAN DISPOSABLE LINER

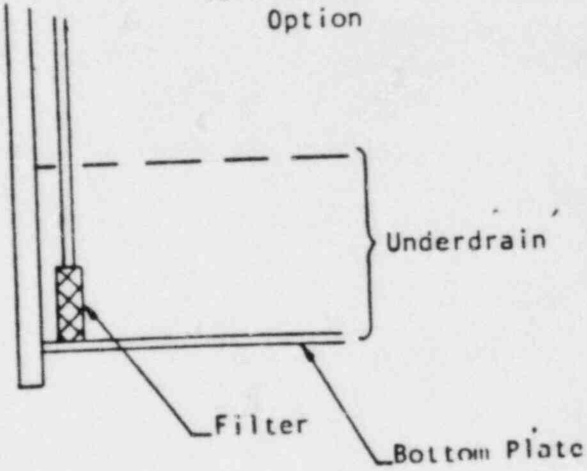
Detail A

Horizontal Filter Option



Detail B

Vertical Filter Option



A Jabsco pump was used for the first day dewatering procedure (through the underdrain). A GAST vacuum pump was used for the daily follow-up drainings.

C. HN-600 Liner Tests with Warren-Rupp Air Operated Pump, Resin Type B

The equipment used in these tests differs from that used in tests B only in application of a Warren-Rupp air operated pump for the initial (through the underdrain) dewatering procedure.

D. HN-600 and HN-100 Liner Tests with Warren-Rupp Air Operated Pump, Resin Type C

In these two tests, HN-600 and HN-100 liners were filled with 56 ft^3 and 120 ft^3 respectively of exhausted resin which had been subjected to prolonged wet storage on-site.

The HN-600 liner used was the same as in previous tests. The HN-100 liner had a hole drilled at the bottom and a top filter element identical to the one installed in the HN-600 liner. A Warren-Rupp pump was used for the initial dewatering and was followed by a GAST vacuum pump for the subsequent drainings.

E. HN-100 Size Containers with Flexible Underdrains, Resin Type C

A RADLOK-100 container was filled with bead resin in a manner which simulated a bead resin transfer. The container was equipped with a flexible underdrain for dewatering the resin using a Warren-Rupp air operated pump and a final dewatering filter with tubing for vacuum draining. A monitoring hole was drilled in the bottom of the container for gravity drain tests. Two underdrains, of identical configurations, using slightly different materials were tested.

F. RADLOK-200 Container With Rigid Lateral Underdrain, Bead Resin

A RADLOK-200 container was filled with approximately 56 ft^3 of bead resin in a manner which simulated a bead resin transfer. The container was equipped with a rigid lateral underdrain for dewatering the resin using a Warren-Rupp pump. A final dewatering filter was also provided for final draining using a vacuum pump. A hole was drilled in the center of the bottom of the container for the gravity drain tests and inspection.

IV. METHODOLOGY

An outline of the methodology used in each of the 10 tests is presented in Table 1. There are five main groups of tests covered in this table. The main features of these groups are:

- Group 1 - Tests 1 and 2. A combination of Jabsco pump and vacuum was used to dewater 27 ft^3 of resin, vacuum drainings continued for 8 to 10 days.

- Group 2 - Tests 3, 4, and 5. The methodology of these tests was similar to Group 1; a larger liner (56 ft^3 of resin) was used and tests 4 and 5 were conducted so as to compare the accumulation of water at the bottom under gravity with the cumulative amount vacuumed out daily in tests 1, 2, and 3. Hence, the liners in tests 4 and 5 were plugged at different times after the initial dewatering and final gravity drainings were taken on the tenth and eighth days, respectively (see Tables 2 and 3).

- Group 3 - Tests 6, 7, and 8. A Warren-Rupp pump was used on the first and second days for four hours and one hour, respectively. This was followed on the second day by an hour of vacuum draining. Experiments were performed with different time intervals between gravity drainings based on experience accumulated in previous tests.

- Group 4 - Tests 9 and 10. An HN-600 and an HN-100 liner were loaded with 56 ft^3 and 120 ft^3 respectively of resin different from resins used in tests 1 through 8. The resin was stored on-site for a long time (see Section II). The main objective of this group of tests was to accumulate additional data using different waste material. The rest of the methodology was similar to Group 3.

- Group 5 - Test 11 and 12. The Warren-Rupp pump was used on the first and second days for four hours and one hour respectively. One hour vacuum drainings were performed daily thereafter preceded by a one hour gravity draining.

- Group 6 - Test 13. Same methodology used as in Test 11 and 12.

TABLE 1. TEST METHODOLOGY

Test Number	Equipment Used	Dewatering Procedure
1	4x4 liner, 27 ft^3 of resin, Jabsco pump, eductor	Liner is tipped, pumped with Jabsco over 8 hour period at 2 hour intervals, then again at 24 hours (water collected and measured), then vacuum drained daily.*
2	4x4 liner, 27 ft^3 of resin, Jabsco pump, eductor	Liner is tipped, pumped with Jabsco till loss of suction, vacuum drained daily on the next day and thereafter.*
3	HN-600 liner, 56 ft^3 of resin, Jabsco pump, GAST vacuum pump	Same as test #2.
4	HN-600 liner, 56 ft^3 of resin, Jabsco pump, GAST vacuum pump	Same as test #2.
5	HN-600 liner, 56 ft^3 of resin, Jabsco pump, GAST vacuum pump	Same as test #2.
6	HN-600 liner, 56 ft^3 of resin, Warren-Rupp pump, GAST vacuum pump	Liner is tipped, pumped down for 4 hours by Warren-Rupp pump on the first day, for one hour on the second day (water discharged in this pumpdown collected and measured), vacuum drained for 1 hour immediately after pumpdown, and daily thereafter.*
7	HN-600 liner, 56 ft^3 of resin, Warren-Rupp pump, GAST vacuum pump	Same as test #6.
8	HN-600 liner, 56 ft^3 of resin, Warren-Rupp pump, GAST vacuum pump	Same as test #6.
9	HN-600 liner, 56 ft^3 of resin, Warren-Rupp pump, GAST vacuum pump	Same as test #6.
10	HN-100 liner, 120 ft^3 of resin, Warren-Rupp pump, GAST vacuum pump	Same as test #6.
11	RADLOK-100, 120 ft^3 of resin, Warren-Rupp pump, GAST vacuum pump	Container flat, the rest of the procedure same as test #6, with one hour gravity drainings preceding each vacuum drainings.
12	RADLOK-100, 120 ft^3 of resin, Warren-Rupp pump, GAST vacuum pump	Container flat, same as test #11.
13	RADLOK-200, 56 ft^3 of resin, Warren-Rupp pump, GAST vacuum pump	Container flat, same as test #11.

*For frequency of vacuum and final gravity drainings, see Tables 2 and 3 for the results.

V. RESULTS

Table 2 shows the daily volumetric data for all 12 tests. It not only represents the volumes of water collected, but also the mode of dewatering/draining technique - pumping, vacuuming, or gravity draining. Although the data presented in this table afford a quick overview of the program, it must be considered in conjunction with Table 3.

Table 3 presents the data as volumes of drained liquid per unit volume of bead resin (i.e., liters of drained water per cubic foot of resin in the liner). Thus, tests 1 and 2, which were conducted with 27 ft^3 of resin, tests 3 through 9 (in an HN-600 with 56 ft^3 of resin), test 10 (in an HN-100 liner with 120 ft^3 of resin), tests 11 and 12 in a RADLOK-100 container with 120 ft^3 of resin, and test 13 in a RADLOK-200 container with 56 ft^3 of resin can be related to each other and to the disposal limits simultaneously. The disposal limits are: 1.0 percent of waste volume for conventional containers, i.e., 1.0 percent per <u>each</u> cubic foot of waste or 0.290 liters per cubic foot.

The following observations are evident by comparing Tables 2 and 3 and keeping in mind the differences in methodology of different test groups (see Table 1):

o The water drawn daily by vacuum in tests 1, 2, 3, 9, and 10 <u>is not representative</u> of the free water in the liner which would gravity drain to the liner bottom. This phenomenon can be explained by the fact that the free water (i.e., water not retained in the body of the bead) not removed by the initial pumping is held in dynamic equilibrium by the interstitially cohesive forces. Previous vibration tests showed (see Hittman Report No. 1843-3) that this equilibrium is not significantly altered by the typical transport of the containers. However, the application of a vacuum (one-half atmosphere) disrupts this equilibrium and creates a downward gradient much higher than that created by gravity. As a result, the application of a vacuum pulls out interstitial water which would not normally migrate under gravity to the liner bottom. Tests 4, 5, 6, 7, and 8 show that when the liner was plugged at different time intervals after the initial pump and vacuum dewatering, gravity drainings were either zero or lower by an order of magnitude than the cumulative vacuum drainings for the same period.

TABLE 2. TEST RESULT: VOLUMES OF WATER (LITERS) COLLECTED DAILY

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10
Test 1	46.8* P	14.64 V	1.75 V	0.96 V	0.6 V	0.45 V	0.35 V	0.29 V	0.23 V	0.2 V
Test 2	52.2* V	4.11 V	1.77 V	0.98 V	0.76 V	0.55 V	0.38 V	0.27 V		
Test 3	46.3* V	5.5 V	2.65 V	1.8 V	1.3 V	1.05 V	1.0 V	0.82 V	0.0 G	
Test 4	58.3* V	4.8 V	1.85	0.8 V	-	-	-	-	-	0.6 G
Test 5	64.3* V	2.25 V	-	-	-	-	-	0.6 G	-	-
Test 6	Not collected	17 P; 1.9V	-	-	-	-	0.9 G			
Test 7	Not collected	8.4P; 1.9V	0.85 G							
Test 8	Not collected	17 P; 2.6V	-	-	1.2 G					
Test 9	156* P	15P; 3.9V	4.1 V	1.5 V	1.6 V	-	-	0.0 G		
Test 10	129* P	35P; 7.7V	7.2 V	6.1 V	2.2 V	2.4 V	2.3 V	0.0 G		
Test 11	Not collected	32.2P; 0.0G 3.7V	0.0G 5.7V	0.0G 3.7V	0.0G 3.2V	-	0.0G 3.0V	0.0G 2.1V	0.0G** 1.4V	
Test 12	Not collected	45.4P 5.4V	0.0G 8.8V	0.0G 6.3V	0.0G 4.0V	0.0G 2.7V	0.0G 2.2V	0.0G 1.7V	0.0G 1.4V	
Test 13	Not collected	22.7P 0.0V	0.0G 0.0V	- -	- -	- -	- -	- -	- -	

Symbols:
P = pumped, V = vacuumed, G = gravity drained.
* Pumped after loss of suction, differences due to subjective nature of measurement.
\- Indicates days drainings were not performed.
** Gravity drained continuously for 4-days with no measurable drainage.

TABLE 3. TEST RESULTS: VOLUMES OF WATER PER UNIT VOLUME OF RESIN (ℓ/ft^3)

Test Group	Test No.	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Cumulative from 3rd Day	Disposal Limit (ℓ/ft^3 of waste)	Cumulative from 3rd Day as Percent of Limit
1-27 ft^3, Resin A	1	0.54	0.065	0.035	0.022	0.016	0.013	0.011	0.008	0.007	.177	.290	61
	2	0.15	0.065	0.036	0.028	0.020	0.014	0.010			.173	.290	60
2-56 ft^3, Resin B	3	0.098	0.047	0.032	0.023	0.019	0.018	0.015	0.0*		.154	.290	53
	4	0.086	0.033	0.014	-	-	-	-	-	0.011*	.058	.290	20
	5	0.04	-	-	-	-	-	0.011*			.011	.290	4
3-56 ft^3 Warren-Rupp	6	0.34	-	-	-	-	0.016*				.016	.290	6
	7	0.18	0.015								.015	.290	5
	8	0.35	-	-	0.021*						.021	.290	7
4-Warren-Rupp, Resin C	9	0.34	0.073	0.027	0.028	-	-	0.0*			.128	.290	44
	10	0.36	0.06	0.051	0.018	0.020	0.019	0.0*			.168	.290	60
5-RADLOK-100 120 ft^3.	11	0.30	0.48	0.031	0.027	-	0.025	0.017	0.012	0.0*	.160	.290	55
	12	0.42	0.073	0.052	0.033	0.022	0.018	0.014	0.012	0.0*	.224	.290	77
6-RADLOK-200 56 ft^3	13	0.41	0.0*								.00	.290	0

*Final gravity drainings.

Additional evidence to this phenomenon is shown in tests 11 and 12 where each vacuum draining was preceded with a gravity draining from the center of the bottom of the container. Not one of these gravity drainings, including one that lasted four (4) days, ever resulted in any liquid draining from the container.

- The application of an air operated, Warren-Rupp type pump speeds up the dewatering process and provides extra assurance that the limit will be met in the recommended dewatering period (see conclusions). As can be seen from Tables 2 and 3, tests 6 through 10 (which used the Warren-Rupp pump) showed, on the average, much lower cumulative amounts of drained water than tests 1 through 5.

- Neither resin volume nor resin type impact significantly on the dewatering efficiency. Table 3, which shows volumes of drainage per volume of waste, demonstrates conclusively that the amount of water drained at any particular time during the procedure depends almost entirely on the equipment and methodology used.

- The results of the subsequent testing conducted with the rigid lateral underdrain in the RADLOK-200 (equipment test set-up III.F) demonstrated the ability of this configuration to achieve the less-than-1.0 percent criteria. Following the conclusion of the final vacuum draining on the second day, no water was obtained in subsequent gravity drainings. Further, vibration of the container over a two-hour period did not induce any water to drain; the inspection hole in the container bottom remained completely dry. It is concluded that equivalent results would be obtained with the RADLOK-100 with rigid lateral underdrain. This because the volume of the container beneath the underdrain in the RADLOK-100 is smaller (in proportion to its internal capacity) than the volume beneath underdrain in the RADLOK-200.

APPENDIX A

COMPARISON OF DEWATERING RATES OF ACTIVATED CARBON AND BEAD RESIN

Laboratory scale dewatering tests were conducted to compare the dewatering rates of activated carbon and bead ion exchange resin. Two types of activated carbon (Calgon types, F-300 and F-400) were used. Water in these tests was first gravity drained and then vacuum was applied (see Table A-1.).

The results of these tests are shown in Table A-1. The amount of water collected is shown in this table as a percent of total water added in the beginning of the test. The data were then plotted in Figure A-1.

As can be seen from Table A-1 and Figure A-1, both the rate and the extent of dewatering were better for activated carbon than for the bead resin.

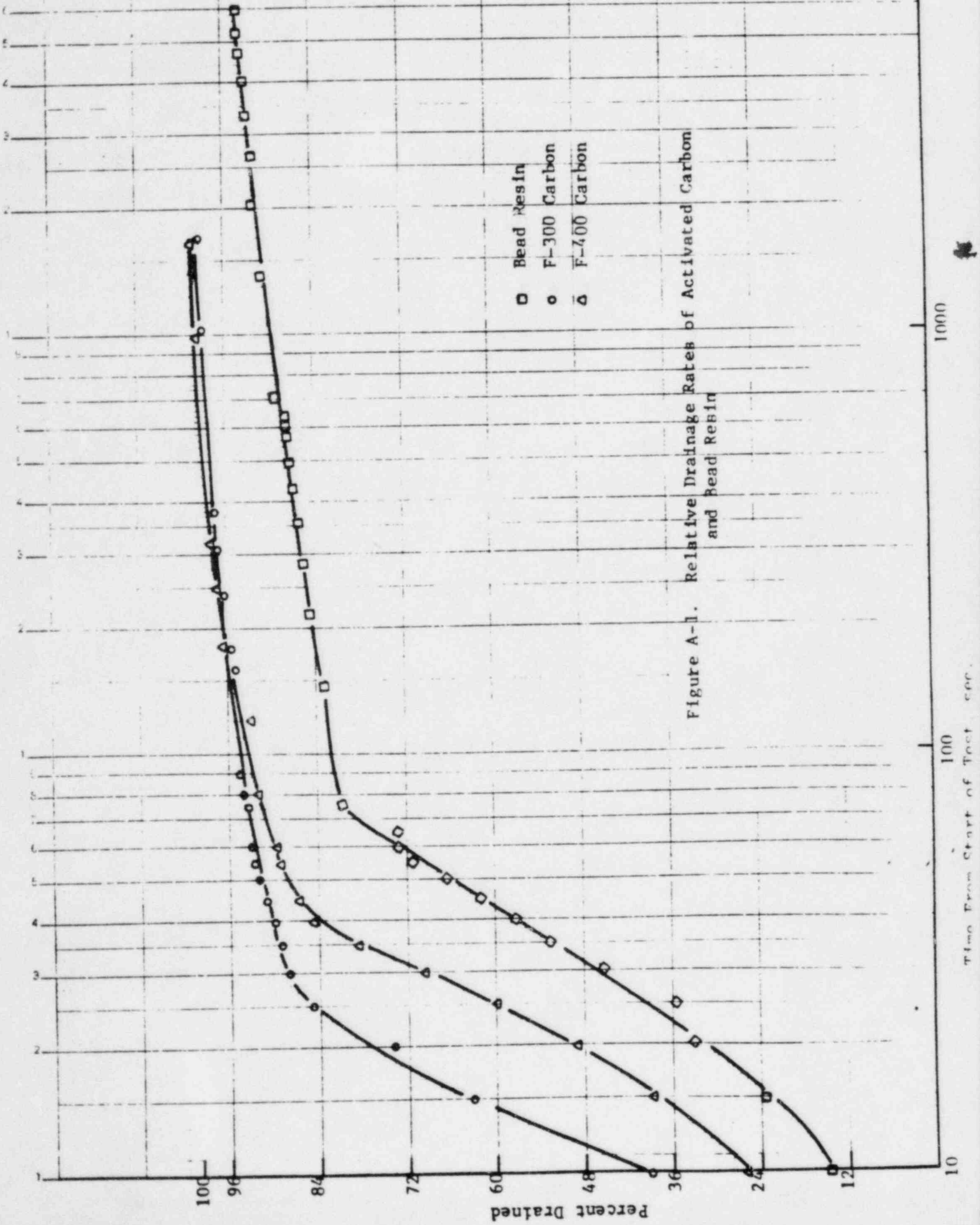


Figure A-1. Relative Drainage Rates of Activated Carbon and Bead Resin

TABLE A-1. ACTIVATED CARBON VERSUS ION EXCHANGE BEAD RESIN DEWATERING RATES

Cumulative Time	Percent of Total Drained		
	Activated Carbon (F-300)	Activated Carbon (F-400)	Ion-Exchange Bead Resin
5	20	13	5.7
10	39	26	14.2
15	63	39	23.8
20	74	49	33.3
25	85	60	35.7
30	88	70	45.7
35	89	79	52.4
40	90	85	57.1
45	91	86.5	61.9
50	92	-	66.7
55	92.5	89	71.4
60	93	89.5	73.3
65	-	-	73.3
75	93.5	-	80.3*
80	94	92	-
90	94.5	-	-
120	-	93	-
145	-	-	82.9
155	-	-	-
160	95	-	-
180	95.5	96.3*	-
215	-	-	84.4
240	96.45*	-	-
250	-	97.2	-
285	-	-	85.5
310	97.1	-	-
320	-	97.9	-
355	-	-	86
380	97.7	-	-
425	-	-	86.7
495	-	-	87.1
565	-	-	87.4
635	-	-	87.8
705	-	-	88.6**
980	-	99.7**	-
1040	99.1**	-	-
1365	-	-	89.1
1640	-	100	-
1700	100	-	-
2025		-	89.9
2685	-	-	90
3345	-	-	90.4
4005	-	-	90.9

TABLE A-1. (CONTINUED)

Cumulative Time	Percent of Total Drained Activated Carbon (F-300)	Activated Carbon (F-400)	Ion-Exchange Bead Resin
4665	-	-	91.5
5325	-	-	91.8
5985	-	-	92.9

*Begin 10 seconds of vacuum at one-minute intervals.
**Begin 60 seconds of vacuum at ten-minute intervals.

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Rev.	**Rev Date**	Prepared by	Director Engineering	QA Manager			
0	12-1-82	E. Cholan	FOR C. MALLORY				TSR-82-479

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Summary Report of Powdered Resin
Dewatering in a RADLOK Container
STD-R-03-005

I. INTRODUCTION

Powdered ion exchange resins are widely used throughout the nuclear industry to remove chemical and radioactive ions from water.

The life of the resin will either be dictated by chemical depletion or by the retention of suspended solids. The suspended solids buildup in a bed of powdered resin can reach a point where the pressure drop across the unit increases so that further operation is not practical.

Powdered resins are not chemically regenerated or ultrasonically cleaned. When expended either by depletion or by blinding with solids, the resins are replaced with new and the old resins are processed for disposal. At most nuclear power plants, the resins are dewatered by various means or solidified with cement in preparation for transportation and burial.

With the advent of the high integrity container, powdered and bead resins may be dewatered to less than one percent drainable liquid and disposed of in the dewatered state in lieu of solidification.

This report summarizes the work done at HITTMAN regarding the dewatering of powdered resins in RADLOK containers to meet the burial site criteria.

II. INITIAL TESTING PERFORMED AT HITTMAN

A. Test 1 - March, 1982

The initial test was done to characterize the flow rate of water through a three foot length of porous plastic pipe capped on one end. The material used for this laboratory scale test was a polyethylene porous pipe rated at 60 micron. However, the measured porosity by General Polymetric revealed the openings to be 60 to 120 microns from outside to inside the tubes. The pipe had an O.D. of 3/4 inches and an I.D. of 1/2 inches.

The porous pipe was submerged vertically in a 55 gallon drum of water at 100°F. Vacuum was applied and the amount of water pulled through the pipe was measured as a function of time.

The data show that when a starting vacuum of 18-19 inches of Hg is used, the flow rate averaged 1.035 gpm per linear foot of pipe.

The data are shown in Table II-1.

TABLE II-1
Flow Rate of Porous Plastic Pipe (60 micron)

Time, sec.	Volume of Water, ml	Vacuum, in. Hg	Temp., °F	Flow Rate gpm per Linear Foot
2.0	1325	18 dropped to 15*	100	1.00
2.4	485	18 dropped to 12	100	1.07
3.4	660	18 dropped to 12	100	1.03
3.4	670	18 dropped to 13	100	1.04

*The vacuum reading dropped after the flow was initiated.

B. Test 2 (March, 1982)

The second test was designed to determine the flow rate characteristics of water through a multilegged underdrain system.

The underdrain system consisted of a four inch diameter PVC hub having eight legs evenly spaced along the circumference. Each leg was made up of 60 micron pipe 32 inches in length with an I.D. of 1/2 inch and on O.D. of 7/8 inches. Each leg was threaded on one end to fit the hub and the other end was sealed with a PVC cap. The PVC hub had a one inch diameter opening in the top center to accommodate a hose to the dewatering pump.

Five inches of water were added to the HIC and the dewatering pump was put into the recirculation mode to keep the water level constant. The hub was positioned in the HIC at the low point in the center. The hub was weighted to keep it at the bottom. The tests were run with the pump regulator set at 60-70 psig and the throttling valve fully open.

The flow rate through the underdrain system was measured with the hub having 0, 2, 4, 6, and 8 legs connected. With the exception of the test where the hub was used alone, the openings having no attached legs were plugged with rubber stoppers. As expected, the flow rates were directly proportional to the number of legs fastened to the hub but did not reach the flow rate of the hub alone. The data are shown in Table II-2 below.

Table II-2

Flow Rate versus Number of Fritware Pipes

Number of Pipes	Flow Rate (gpm)	Vacuum (In. of Hg)
0	34	2.5 - 3
2	20	14.5 - 15.5
4	25	15.5
6	28	15.5
8	30	15.5

C. Test 3 (April, 1983)

The purpose of this test was to determine if the 60 micron porous pipe is capable of dewatering powdered resin yielding an effluent which is free of particulate matter.

The test was done using a large plastic container, 7 feet in diameter having a straight wall height of 40 inches. The container was positioned on blocks so that the center of the container sagged two inches. The materials and configuration of the porous pipe underdrain were the same as used in Test 2 described above. A Warren Rupp pump was used to dewater. The pump regulator was set at 60-70 psig and the throttling valve was fully opened.

The porous pipe underdrain was placed in the center of the container and weighted to prevent it from lifting off the bottom. Two drums of powdered resin were sluiced into the container with no suction applied to the underdrain. At the end of the sluicing operation, the container was approximately 2/3 full of slurry.

The powdered resin was allowed to settle one hour then the Warren Rupp pump was put into operation in the recirculation mode. The effluent was allowed to recirculate 30 minutes. After the flowrate was established (approximately 2 minutes into the recirc mode) sampling of the effluent was started. Samples were taken every 5 minutes thereafter. The first sample was very slightly turbid; however, the remaining samples were crystal clear. The maximum flowrate obtained was 10-12 gpm at 21 inches of Hg during the recirculation operation. At the end of the 30 minute recirculation period, the flow rate was 7-8 gpm at 24 inches of Hg.

The effluent was then discharged and sampling was continued at 30 minute intervals. The Powdex was dewatered within 2½ hours and every sample taken was crystal clear. The flow rate at the end of the test was 5 gpm at 25-26 inches of Hg. The dewatered powdered resin layer measured 4 inches in depth.

The results of this test showed that the 60 micron porous plastic pipe underdrain is capable of yielding a clear effluent with no powdered resin breakthrough.

D. Test 4 (April, 1982)

The object of this test was to determine the dewatering flow rate as a function of powdered resin depth. This test was performed using a RADLOK-100 container. The RADLOK was positioned on a stand so that the bottom sagged thereby establishing a low point. The materials and configuration of the porous pipe underdrain were the same as used in Test 2 above. The regulator of the dewatering pump was set at 60-70 psig and the throttling valve was fully open for this test.

This test required nine transfers of 14 dry weight percent powdered resin slurry. The resin from each transfer was dewatered and the powdered resin depth measured. The pump vacuum and dewatering flow rate was measured during each transfer. The resin slurry was allowed to settle for 15 minutes after the first transfer was completed before activating the dewatering pump. The data are shown in Table III-3.

Table II-3
Dewatering Flow Rate versus Powdered Resin Depth

	Time (min)	Flow Rate (gpm)	Vacuum (in. Hg)	Height Dewatered Powdered Resin (in.)
Transfer 1	0	8.0	24	
	9	6.0	26	
	19	6.0	27	
	24	4.0	27	
	109	4.0	27	
	119		lost suction	4.5
Transfer 2	0	2.75	16	
	12	3.0	18	
	21	3.5	26	
	31	4.0	25	
	48		lost suction	8.0
Transfer 3	0	2.1	17	
	5	2.3	18	
	10	2.5	21	
	60	3.0	27	
	75		lost suction	12.0
Transfer 4	0	2.1	20	

Table II-3 (Continued)

	Time (min)	Flow Rate (gpm)	Vacuum (in. Hg)	Height Dewatered Powdered Resin (in.)
Transfer 4 (continued)	18	2.1	20	
	60	2.1	21	
	65		lost suction	17
Transfer 5	0	2.75	20	
	30	2.25	21	
	75	2.25	21	
	90		lost suction	20
Transfer 6	0	2.25	18	
	20	2.50	25	
	40		lost suction	23.25
Transfer 7	0	2.2	20	
	37	2.0	20	
	52		lost suction	27.0
Transfer 8	0	2.0	17	
	20	2.0	20	
	33	2.0	21	
	52		lost suction	30.0
Transfer 9	0	2.0	20	
	35	2.0	21	
	80		lost suction	34.0

The data show that although the dewatering flow rate was affected up to 12 inches of resin depth; there was no appreciable differences in flow rate from 12 to 34 inches of resin depth.

There was no evidence of resin breakthrough throughout the test period.

E. Test 5 (May, 1982)

This test was performed to study the effects of a three layered porous pipe dewatering system. The test used a RADLOK-100 container. Each dewatering layer consisted of 12 porous polypropylene pipe laterals 28¼ inches long rated at 30 microns. One dewatering layer was positioned on the bottom of the container and the others were positioned so that there were 20 inches between each layer. The middle and top dewatering layers were suspended by the dewatering hoses. Each dewatering layer was operated by a separate dewatering pump. As in the previous tests, the regulators on the pumps were set at 60-70 psig and operated with the throttling valves fully open.

The powdered resin slurry (17-18 dry weight percent) was prepared in a mix tank. Due to limited tank capacity the resin transfer was done in five increments. Each resin slurry increment consisted of three drums of powdered resin diluted with enough water to fill the mixing tank to within 12 inches from the top with the mixer turning. The resin slurry was transferred at approximately 27 gpm.

The dewatering process was started by drawing vacuum on the bottom underdrain after it was covered with 15 inches of slurry. The dewatering process from the middle and top underdrain was initiated as each layer was covered with slurry. It was necessary to stop the dewatering process each time a transfer was completed so that suction was not lost while another batch of slurry was being prepared.

The experimental design after the transfer was completed was to stop pumping from each underdrain layer as it lost suction. However, due to crack formation in the powdered resin cake, all three underdrain layers lost suction at approximately the same time. This loss of suction occurred after 80 minutes of dewatering. The dewatering was continued for 40 minutes after the loss of suction. Samples from the top of the resin cake were taken for percent solids determination 10 and 40 minutes after the loss of suction. The dry weight percent solids of these samples was 29.7 and 36.3 respectively.

The 5/8 inch gravity drain in the bottom of the container at the low point was opened. No water was collected in one hour of draining. The container was allowed to stand undisturbed for 16 hours.

The resin cake was then pumped down from all three underdrain layers for one hour each day and vacuum drained one hour each day for seven nonconsecutive days (the sixth day of pumping was performed on the seventh day due to the weekend). The water was collected and measured. Samples were taken from the top of the resin cake for percent solids determination after the second and third day of pumping.

The data are shown in Table II-4.

Table II-4

Dewatering Data After Loss of Suction

Pump Time, min.	Vacuum Time, min.	Water Collected, gallons	Percent Solids of Resin Cake[a]
Pump Period 1			
60	-	39.75	-
-	60	1.04	-
Pump Period 2			
60	-	34.25	37.9
-	60	0.74	
Pump Period 3			
60	-	26.0	41.0
-	60	0.48	
Pump Period 4			
60	-	22.8	-
-	60	0.40	

Table II-4 (Continued)

Pump Time, min.	Vacuum Time, min.	Water Collected, gallons	Percent Solids of Resin Cake[a]
Pump Period 5			
60	-	16.5	-
-	-	-	
Pump Period 6[b]			
60	-	12.5	-
-	-	-	-

[a] The samples were taken from the top of the resin cake.
[b] Let stand an extra day between Pump Period 5 and Pump Period 6.

A plot of the pumping period time versus the total number of gallons removed is liniar. Even when a pumping period was delayed 24 hours there is no interruption in the curve. The curve is shown in Figure II-1. The data indicate that the dewatering of the resin after loss of suction is a function of pumping time and not necessarily just of total time (stand plus pumping time).

F. Test 6 (May, 1982)

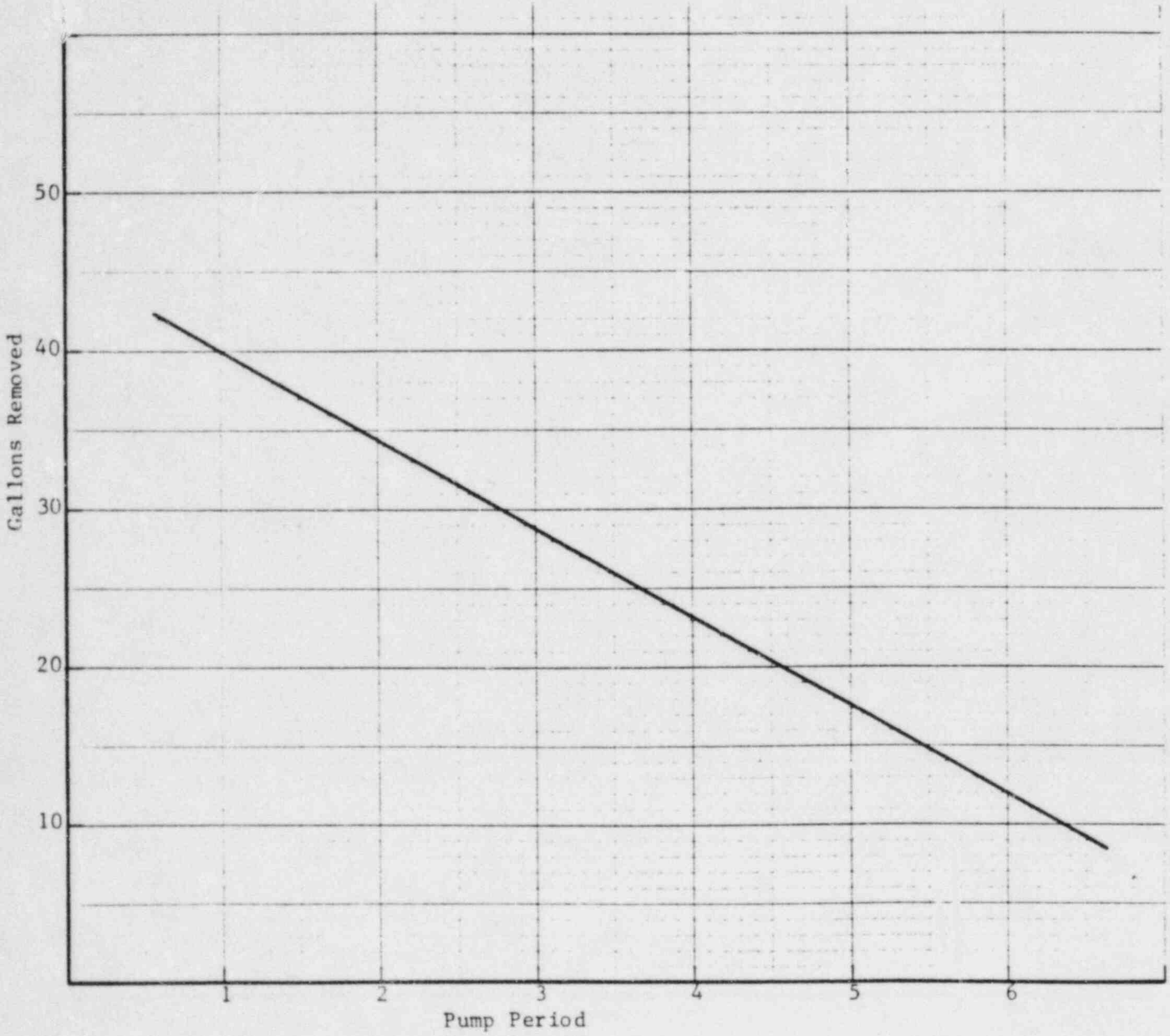
The test was performed to verify that the dewatering rate is a function of pumping time and not of standing time.

The dewatered material from Test 5 was rewet with 227 gallons of water by adding the water through the bottom underdrain. The calculated dry weight percent of the resin slurry after the water addition was 29.5. The resin was allowed to soak overnight to fully hydrate it.

The dewatering was begun using the three layers of porous pipe underdrain. After 15 minutes of dewatering, large cracks appeared in the resin cake and suction was lost. The amount of water removed at this point totaled 78.2 gallons and the calculated dry weight percent solids was 32.4.

Figure II-1

Pump Period versus Gallons Removed



The dewatering was continued from the three layers of underdrains for 13.75 hours after loss of suction. The total amount of water collected totaled 211.5 gallons. The container was allowed to stand nine hours then dewatering was continued for an additional eight hours. The amount of water collected during the eight hour pumping period totaled 18 gallons bringing the calculated dry weight percent solids to 40.2.

A core sample of the powdered resin cake was removed for percent solids determination. The average percent solids was 38. The dewatering data are shown in Table II-5.

Table II-5
Dewatering Data Test 6

Volume Dewatered Powdex (Cu. Ft.)	117.60
Density Dewater Powdex (lb./Cu. Ft.)	45.00
Dry Weight % Dewatered Powdex	40.00
Volume Water Added to Powdex (Gal)	227.00
Weight % @ Time 0	29.46

Hours	Gallon	GPM	GPH	Calc. Wt. % Sol.	Average Wt. % Sol.
0	0	0	0	29.46	
.25	78.2	5.21	312.80	32.40 *	
1	139	2.32	139.00	35.13	
2	151	.20	12.00	35.72	
3	158.5	.13	7.50	36.10	
4	166	.13	7.50	36.49	
5	173.5	.13	7.50	36.89	
6	178.5	.08	5.00	37.16	
7	184.5	.10	6.00	37.49	
8	190	.09	5.50	37.80	
9	194	.07	4.00	38.02	
10	198	.07	4.00	38.25	
11	201.5	.06	3.50	38.45	
12	205	.06	3.50	38.66	
13	208.5	.06	3.50	38.87	
14	211.5	.05	3.00	39.05 **	
15	215.5	.07	4.00	39.29	
16	219	.06	3.50	39.50	
17	221.25	.04	2.25	39.64	
18	222.5	.02	1.25	39.72	
19	225	.04	2.50	39.87	

Table II-5 (Continued)

Hours	Gallon	GPM	GPH	Calc. Wt. % Sol.	Average Wt. % Sol.
20	226.5	.03	1.50	39.97	
21	227.5	.02	1.00	40.03	
22	229.5	.03	2.00	40.16	38.00

*Loss of suction. Appearance of cracks.
**Process stopped for 9 hours.

When the results of this test are compared to Test 5, a plot of Dry Weight Percent of Slurry in Hours of Pumping show that more water is removed per pumping hour when the powdered resin is allowed to stand 24 hours between pumping periods. This relationship is shown in Figure II-2. However, more water can be removed in less time if pumping is constant. Since a limited number of core samples can be taken during one test and to keep the parameters constant the curves were constructed using calculated dry weight percent values.

G. Test 7 (May, 1982)

The object of this test was to repeat Test 6 without the interruption in pumping time and to compare the results.

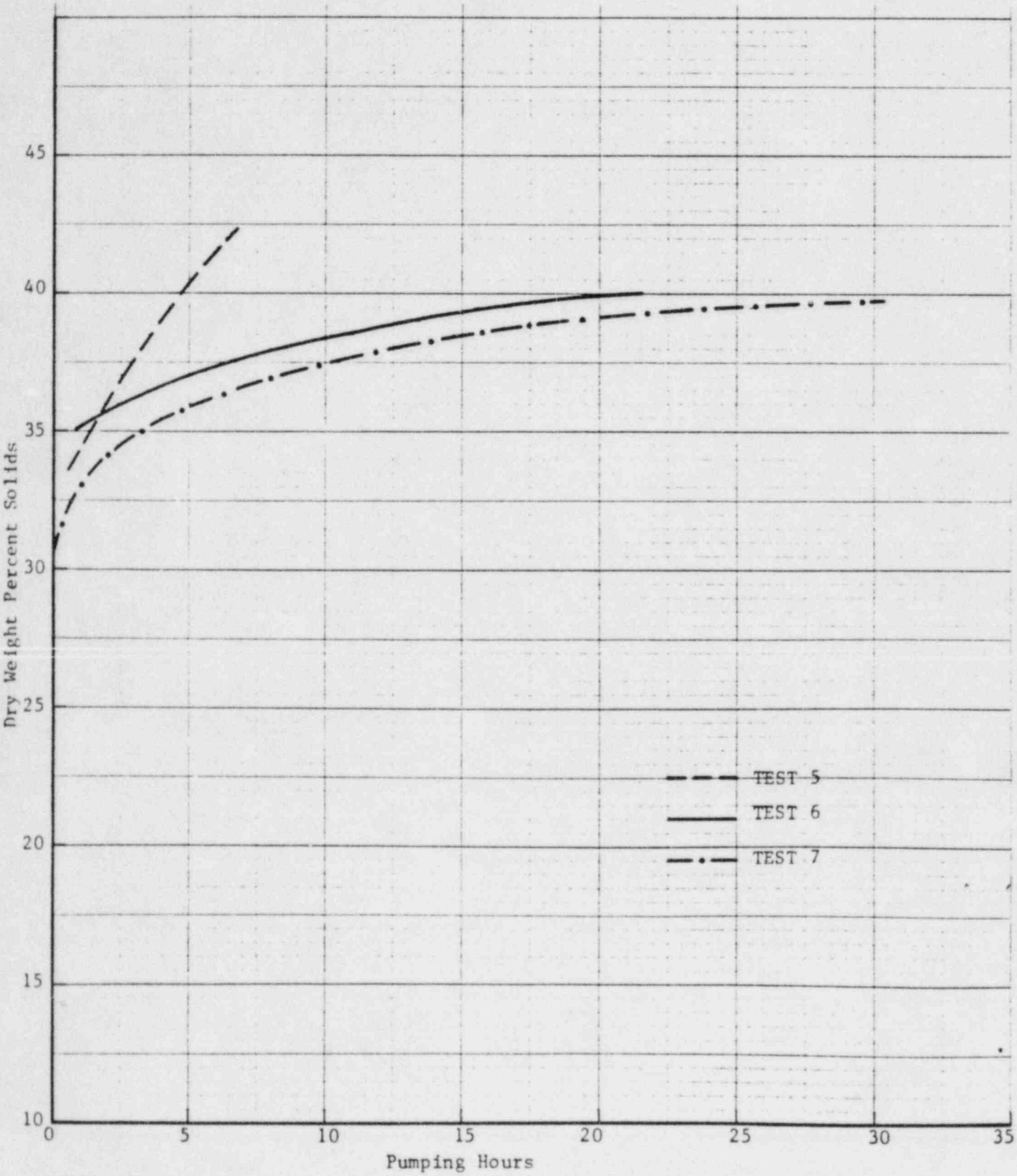
The dewatered resin, having an average dry weight percent solids of 38, from Test 6 was soaked overnight in 210 gallons of water to hydrate. The water was added through the bottom underdrain layer.

The dewatering was started through all three underdrain layers and as in Test 6, suction was lost in 15 minutes. However, in this test, 95 gallons of water had been removed at loss of suction. The calculated dry weight percent at loss of suction was 32.4 which agrees with the value at loss of suction in Test 6.

The resin cake was pumped down through all three underdrain layers for 24 continuous hours. Towards the end of the 24 hour period less than 2 gph were being removed. Core samples were taken for dry

Figure II-2

Dry Weight Percent Solids of Powdered Resin
Versus Pumping Hours



weight percent solids determinations after 13 and 24 hours from loss of suction. The average dry weight percent solids of the resin was 37.76 and 38.55 respectively. The container was allowed to stand 28 hours then pumping was resumed to see if the dewatering flow rate would be increased due to the stand time. During the first hour the dewatering flow rate increased by approximately 0.5 gph; however, the flow rate dropped steadily until no water was removed between the sixth and seventh hour. A core sample was taken at this point and the average dry weight percent solids was 40.4. The data are shown in Table II-6.

Table II-6

Dewatering Data Test 7

Volume Dewatered Powdex (Cu. Ft.)	117.60
Density Dewater Powdex (lb./Cu. Ft.)	47.37
Dry Weight % Dewatered Powdex	38.00 (Average)
Volume Water Added to Powdex (Gal)	210.00
Weight % @ Time 0	28.91

Hours	Gallon	GPM	GPH	Calc. Wt. % Sol.	Average Wt. % Sol.
0	0	0	0	28.91	
.08	50	10.42	625.00	30.66	
.167	76.65	5.11	306.32	31.68	
.25	95	3.68	221.08	32.42 *	
1.25	122	.45	27.00	33.58	
2.25	138.5	.28	16.50	34.33	
3.25	152	.23	13.50	34.96	
3.67	155.5	.14	8.33	35.13	
4.25	161	.16	9.48	35.40	
5.25	170.5	.16	9.50	35.88	
6.25	178	.13	7.50	36.26	
7.25	184.5	.11	6.50	36.60	
8.25	190.5	.10	6.00	36.92	
9.25	196	.09	5.50	37.22	
10.25	200.5	.08	4.50	37.47	
11.25	204.25	.06	3.75	37.68	
12.25	208	.06	3.75	37.89	
13.25	210.5	.04	2.50	38.03	37.76
14.25	214	.06	3.50	38.23	
15.25	216.75	.05	2.75	38.39	
16.25	220	.05	3.25	38.58	
17.25	223	.05	3.00	38.75	
18.25	225.5	.04	2.50	38.90	
19.25	228	.04	2.50	39.05	

Table II-6 (Continued)

Hours	Gallon	GPM	GPH	Calc. Wt. % Sol.		Average Wt. % Sol.
20.25	230	.03	2.00	39.17		
21.25	231.75	.03	1.75	39.28		
22.25	233.1	.02	1.35	39.36		
23.25	234.7	.03	1.60	39.46		
24.25	236.05	.02	1.35	39.54	**	38.55
25.25	237.85	.03	1.80	39.65		
26.25	238.85	.02	1.00	39.72		
27.25	239.65	.01	.80	39.77		
28.25	240.4	.01	.75	39.81		
29.25	240.9	.01	.50	39.84		
30.25	241.19	.00	.29	39.86		40.4

*Loss of suction. Appearance of cracks.
**Process stopped for 28 hours.

The container was allowed to stand 24 hours to see if any water would migrate to the bottom. Vacuum was applied for one hour and 50 ml of water was collected in that time.

Powdered resin in the dewatered state can be a water absorber. In order to see at what dry weight percent solids the powdered resin is no longer a water absorber but contains free water, a simple test was run. A weighed sample of dewatered resin was taken from the bottom of the container and water was added dropwise until there was free water present. The wetted sample was then dried and the dry weight percent solids calculated. The test showed that at 28.6 dry weight percent, the powdered resin becomes a slurry with free water present. The data from Tests 5, 6 and 7 show that the point where the powdered resin is a water absorber is reached somewhere before loss of suction since the calculated dry weight percent of the powdered resin at loss of suction in all three cases was above 32.

This dewatering data is also plotted in Figure II-2 and the curve shows the same effect as was shown in Test 6.

H. Test 8 (June, 1982) Prototype Testing

This full scale test was conducted to demonstrate that powered resins can be dewatered in HITTMAN RADLOK-100 containers using the Prototype System to meet Regulatory requirements. A combination of laboratory and full-scale dewatering procedures were tested to determine the technique necessary to dewater powdered resins to the point where there is no free-standing liquid or drainable liquid.

Preliminary laboratory scale tests were done to determine the minimum dry weight percent of the powdered resin at which no free standing liquid is obtained.

In the first method, dry powdered resin was loaded to a filter funnel and water was added slowly until the resin became saturated. Additional water was added slowly while jiggling the funnel until liquid could be seen coming from the funnel. The dry weight percent of the saturated powdered resin was then determined to be 33.0

In the second test, a powdered resin slurry of low weight percent was added to a filter funnel and at the point where no water was seen coming from the funnel while jiggling it; the dry weight percent of the powdered resin was determined to be 33.3

On the basis of these laboratory tests, the dewatering goal for the full scale dewatering of powdered resin using the Prototype System was to achieve a dry weight percent of 33.0.

The Prototype System consisted of the following equipment:

- RADLOK-100 container - the container was placed on a 12 inch stand so that the bottom center sagged 3-4 inches. A 5/8 inch drain plug was installed at the low point of the container.

- Three layers of porous piping - Each layer consisted of 12 lengths of pipe 30 inches long. The openings in the pipe are rated at 30 microns which is small enough to retain the powdered resin particles. One end of each pipe was closed with a porous plug also having openings rated at 30 microns. The other end of each pipe was threaded so that it could be attached to a 6 inch diameter PVC hub. The pipes were equally spaced along the circumference of the hub to ensure complete coverage of the RADLOK-100 cross sectional area. One layer of the porous piping system was laid on the bottom of the container and the others were positioned so that there were 20 inches between each layer. The middle and top underdrain layers were suspended by the dewatering hoses.

- Vacuum-Receiver Tank - The tank has a 30 gallon capacity and is equipped with a drain valve located at the bottom and an internal stand pipe is positioned so that the internal opening is 1-1/2 inches from the bottom of the tank. The top of the tank has three inlet pipes equipped with valves. Each inlet pipe was attached to a separate porous piping layer. Each porous piping underdrain can be isolated from the system by means of the inlet pipe valves. The means to isolate an underdrain is necessary to prevent loss of system vacuum and inertia. The top of the tank also has a vacuum gauge and a means of breaking the vacuum. The tank is also equipped with low, intermediate and high level probes to indicate the water level inside the tank.

- Diaphram Pump - The pump was attached to the stand pipe in the vacuum-receiver tank. The purpose of this pump was to establish system vacuum and to empty the vacuum-receiver tank when necessary.

- Vacuum Pump - The vacuum pump was used as an additional source of vacuum for the vacuum-receiver tank.

- o Water Reservoir - A 1,000 gallon container was used to serve as a water reservoir to receive water from the resin dewatering process. This water would then be pumped to the mixing tank so that powdered resin slurry was available for transfer on a continuous basis.
- o Powdered Resin - 104 cubic feet of resin at 40 dry weight percent.
- o Mixing Tank - The mixing tank was used to prepare a 6-7 dry weight percent powdered resin slurry.

OPERATING DETAILS & RESULTS (Prototype Test)

The water reservoir was filled with 925 gallons of water which was pumped to the mixing tank at 35 gpm. The powdered resin was added to the mixing tank at a rate of one drum every 6.5 minutes to prepare a 6-7 weight percent slurry.

Each individual underdrain layer was connected to the vacuum-receiver tank used to collect the water. A diaphragm pump capable of delivering 34 gpm was used to establish vacuum and to empty the vacuum receiver tank. An auxilliary vacuum pump rated at 1.3 SCFM at 0 inches of Hg was used to maintain vacuum so that a continuous flow was achieved to the vacuum receiver.

All valves to the vacuum-receiver tank were closed and a vacuum of 15 inches of Hg was established in the tank using the diaphram pump. The pumps were then turned off.

The powdered resin slurry transfer was started at 35 gpm and as each layer of porous piping was covered with 1-2 inches of liquid, the inlet valves to the vacuum-receiver were opened to initiate dewatering. The vacuum pump was activated at the start of dewatering. The diaphram pump was also put into operation at this time to pump the collected water from the vacuum-receiver into the water reservoir. Water from the reservoir was pumped to the mixing tank to prepare additional slurry.

The rate of dewatering was greater than the rate of water transfer from the vacuum-receiver to the water reservoir. Therefore, whenever the intermediate level probe was activated by the water level in the vacuum-receiver, the vacuum was decreased in the tank so that the diaphram pump could pump more efficiently. When the low level probe in the vacuum-receiver was deactivated, indicating that the water level in the tank was reduced, the vacuum was readjusted to 15 inches of Hg. This process was continued until the transfer was completed. The details of the transfer and the pump down are shown in Table II-7.

Table II-7
Transfer Dewatering Data

Time	Vacuum, in. Hg	Flow Rate, gpm	Comments
11:36	12	26	First layer covered. Inlet valve to vacuum-receiver tank opened.
11:51	17	29	Second layer covered. Inlet valve to vacuum-receiver tank opened.
11:55	20	20	
11:58	19	26	
12:01	23	18	
12:03	28	19	Top layer covered. Inlet valve to vacuum-receiver tank opened.
12:12	24	15	
12:20	26	16	Stopped transfer - container full of slurry.
12:25			Restarted transfer.
12:32	15	24	Added 25 gallons water to the system.
12:38			Stopped transfer - container full of slurry
12:46	19	28	Restarted transfer

Table II-7 (Continued)

Time	Vacuum, in. Hg	Flow Rate, gpm	Comments
12:50	22	20	
12:52	19	26	
12:58	22	28	
1:13	25	14	
1:50	24	~8 (avg)	Transfer completed.
2:11	--	--	Lost suction top layer; inlet valve to vacuum-receiver turned off
2:14	--	--	Lost suction to middle layer; inlet valve to vacuum-receiver turned off
2:30	--	--	Lost suction to bottom layer; stopped process and took core sample
3:00			Restarted pumping to remove 60-65 gallons of water
7:00	--	--	63.5-64 additional gallons of water removed. Core sample taken. The powdered resin is 14.5 inches from the bottom of the neck threads.

As the RADLOK-100 container was dewatered, suction was lost to the porous piping layers. The inlet valves to the vacuum-receiver were shut off as each layer of porous piping lost suction so that the vacuum in the tank was not lost. When suction was lost from the bottom layer, the RADLOK container was isolated from the system and all pumping was stopped. The drain plug was removed to observe if any drainable liquid could be collected from the container. A core sample was also taken from the resin bed so that the dry weight percent of resin at each layer of porous piping could be determined. There was no drainable liquid and the three core samples averaged 34.7 percent solids which is higher than the 33 minimum dry weight percent determined in the laboratory.

Since a safety factor is desirable, the vacuum pump was reactivated to establish a vacuum of 15 inches of Hg in the vacuum receiver tank. The inlet valve connected to the bottom layer of porous piping was opened to remove another 60-65 gallons of water. Four hours were necessary to remove that quantity of water. Another core sample of the resin was taken at that point. The removal of 60 to 65 gallons of water raised the average dry weight percent of the resin from 34.7 to 36.2.

After standing 24 hours, the drain plug was removed and no water was collected in one hour.

A vibration test was then instituted to study the effects of transportation vibrations on the dewatered material.

The vibration test was conducted by attaching two pneumatic reciprocating vibrators to the stand the container was sitting on for the dewatering test. The stand was vibrated causing vibrations within the container itself.

The vibrators were put into operation for one hour every day excluding weekends. The drain plug in the bottom of the RADLOK container was removed for one hour after each vibrating period. Liquid did not flow through the drain hole in the bottom of the container at any time during the testing.

After seven hours of vibrating, a core sample of the liner was taken and the dry weight percent determined to see if there were any changes in the water distribution throughout the resin bed.

The dry weight percent solids determinations of the core sample did not show any migration of water. The average dry weight percent of the core sample changed by only a small amount, well within experimental error.

The core sampling data are shown in Table II-8.

Table II-8

Dry Weight Percent Solids of Core Samples

	Bottom Layer	Middle Layer	Top Layer	Avg.
At Loss of Suction	34.3%	33.7%	36.0%	34.7
After 4 Hour Pump Down	34.8%	34.0%	39.9%	36.2
After 7 Hours of Vibrating	34.2%	34.8%	40.7%	36.6

III. CONCLUSIONS

The major conclusions resulting from this test program are summarized as follows:

1. The initial laboratory scale hydraulic testing of porous plastic pipe rated at 60 microns had a flow rate capability of 1.035 gpm per linear foot at 18-12 in. Hg. When the same type pipe was tested on a large scale (8 legs each, 32 inches long) the flow rate increased to 1.406 gpm per linear foot. However, the flow rate under actual use drops depending on powdered resin bed depth.

2. Each 60 micron rated porous plastic pipe dewatering layer (8 legs) is capable of dewatering powdered resin up to at least 34 inches in depth. There is a reduction in dewatering flow rate from 0 to 12 inches of bed depth (8.0 to 3 gpm), however from 12 to 34 inches of resin bed depth, the reduction in dewatering flow rate is small (average of 2.3 gpm to 2.0 gpm from 12 to 34 inches of bed depth).

3. The 60 micron rated porous plastic pipe is capable of dewatering powdered resin slurries at reasonable flow rates with no solids breakthrough. The dewatering should not be initiated until the pipe is covered with slurry solids.

4. A greater quantity of water can be removed per pumping hour when the resin bed is allowed to stand 24 hours between pumping periods. However more water can be removed from the resin bed in less time if pumping is constant. For example, 36 dry weight percent solids of powdered resin can be achieved in four hours of continuous pumping. It would take at least one 24 hour standing period to reach that level with intermittent pumping.

5. The minimum dry weight percent of powdered resin, where no drainable liquid is present, can be obtained in the laboratory. The tests at HITTMAN show that the mininmum dry weight percent of 33 obtained in the laboratory, was exceeded at loss of suction during full scale testing of the prototype system. At loss of suction during the prototype testing, the dry weight percent solids of the resin was 34.7, as determined from a core sample. An additional four hours of pumping after loss of suction increased the dry weight percent of the resin to 36.2. Based on the prototype testing, powdered resin can be transferred and dewatered to 36.2 dry weight percent within an eight hour shift.

6. The effects of vibration do not cause migration of the waste bound to the resin particles. The average dry weight percent solids after the four hour pump down was 36.2, and after seven hours of vibrating, was 36.6 as determined by core sampling.

HITTMAN NUCLEAR & DEVELOPMENT CORPORATION	Document Number: STD-R-03-006	Rev: 0	Rev Date: 1-10-83
	Title: POWDERED RESIN DEWATERING IN A FLAT BOTTOM CONTAINER USING THE HITTMAN LAYERED UNDERDRAIN SYSTEM		

Rev.	Rev Date	Prepared by	Director Engineering	Director Operations	Director Marketing	QA Manager	
0	1-10-83	E. Cloren					EWR 82-770
			40				

Powdered Resin Dewatering In
A Flat Bottom Container Using
The HITTMAN Layered Underdrain System

I. PURPOSE

These tasks were performed to demonstrate that powdered resins can be dewatered in flat bottom container (either RADLOK or HITTMAN steel) to meet Regulatory requirements. The tests conducted were a combination of laboratory and large scale dewatering procedures to show that the HITTMAN layered underdrain system is capable of dewatering powdered resins to the point where there is no drainable liquid.

II. SUMMARY

The laboratory tests determined the minimum dry weight percent of the powdered resin at which no free-standing liquid is obtained.

The results show that the dewatering system used by HITTMAN in a flat bottom container is capable of removing enough water from a powdered resin slurry so that no drainable liquid is present.

Core samples of the dewatered powdered resin taken at loss of suction and after a four hour vacuum pump down showed that the dry weight percent of the dewatered material in the container is above the minimum value determined in the laboratory. Removal of the drain plug in the bottom of the container at loss of suction, after the four hour vacuum pump down and after standing seven days showed no drainable liquid was present.

These results form the basis for HITTMAN's conclusion that the procedure for dewatering powdered resins in a flat bottom container using the layered dewatering system meets all requirements.

III. EQUIPMENT USED AND METHOD OF TESTING

The powdered resin used for the test program was nonradioactive waste resin supplied by a power plant. The laboratory tests used to determine the minimum dry weight percent solids where no free-standing liquid was observed were done using two methods.

In the first method, dry powdered resin was loaded into a filter funnel and water was added slowly until the resin became saturated. Additional water was added slowly until liquid could be seen coming from the funnel. The dry weight percent of the saturated powdered resin was then determined.

In the second test, powdered resin slurry of low weight percent was added to a filter funnel and at the point where no water was seen coming from the funnel, the dry weight percent of powdered resin was determined.

The large scale dewatering test was performed in a RADLOK-100 container positioned directly on the floor so that the bottom remained flat. The flat bottom configuration of the RADLOK simulates any flat bottom container regardless of its structural material. The RADLOK container had a 5/8 inch hole drilled through the bottom at the center to act as a drain. The hole was plugged with a machine bolt during the testing. Periodically the bolt was removed to examine for drainable liquid at various times during the test.

The powdered resin depth within the container was 29 inches (60 cu. ft.). Only the bottom underdrain layer was used for dewatering since the resin depth was shallow. The prototype system is designed so that the underdrain layers are horizontally spaced 20 inches apart; however, it was decided to use the 29 inch layer of powdered resin and one underdrain layer as a worst case condition.

The underdrain was connected to a vacuum receiver tank used to collect the water. A diaphragm pump capable of delivering 34 gpm was used to establish vacuum and to empty the vacuum receiver tank. An auxilliary vacuum pump rated at 1.35 SCFM at 0 inches of Hg was used to maintain vacuum so that a continuous flow was achieved to the vacuum receiver.

The vacuum receiver tank was also equipped with a vacuum gauge, an air inlet valve to control the vacuum within the tank and level probes to determine the height of water within the tank. A schematic drawing of the system is shown in Sketch SK-82-016 (attached).

The powdered resin was dewatered using the above described system and at loss of suction, pumping was stopped. A core sample of the resin was taken to determine the dry weight percent solids. The container was also raised to remove the drain plug to determine if drainable liquid was present.

The container was repositioned on the floor and pumping was continued for another four hours as a safety factor. A second core sample was removed at this point to verify that the additional dewatering increases the dry weight percent of the liner contents therefore making the presence of drainable liquid even less likely. The container was again raised to remove the drain plug to observe for drainable liquid. The container was then repositioned on the floor and allowed to stand seven days then raised to remove the drain plug to observe for drainable liquid.

IV. DESCRIPTION OF TESTS AND RESULTS

This section discusses the laboratory and large scale test along with their results. The laboratory tests have been described in

Section III. Both laboratory tests show that the minimum dry weight percent where no drainable liquid is observed occurs at 33 percent.

For the large scale test enough water was added through the underdrain to saturate the resin. Approximately 1/2 inch of water covered the resin as it hydrated overnight.

Vacuum was established in the vacuum receiver tank using the diaphragm and vacuum pumps. When the vacuum reached 15 inches of mercury in the tank, the operation of the diaphragm pump was stopped. The inlet valve to the bottom underdrain was opened to start the dewatering process. When the middle level probe was activated in the vacuum receiver tank by the incoming water, the vacuum was reduced in the tank to approximately 10 inches of mercury by opening the vent valve to the tank. The reduction in vacuum is necessary so that the diaphragm can easily empty the vacuum receiver tank. The diaphragm pump was used only to empty the vacuum receiver tank and did not contribute to maintaining the vacuum in the system. When the low level indicator showed the vacuum receiver tank was nearly emptied, the air inlet valve was closed, and the diaphragm pump turned off. The vacuum pump then reestablished a vacuum of 15 to 20 inches of mercury in the system. The powdered resin was dewatered in this manner to loss of suction in 45 minutes.

At loss of suction, as indicated by a loss of vacuum, all pumping was stopped and the container was raised from the floor to examine for drainable liquid by opening the drain plug. No drainable liquid was observed. The drain hole was also probed to remove a small amount of resin which was in a semidry state, containing no free water.

A core sample of the resin was obtained to determine the percent solids. The dry weight percent solids of the bottom 1 to 2 inches of the resin cake was 34.8 which exceeds the minimum dry weight percent as determined in the laboratory.

The air inlet valve to the vacuum receiver tank was closed and a vacuum of 15 inches of mercury was reestablished in the system with the vacuum pump. When the system vacuum reached 15 inches of mercury, the inlet valve to the underdrain was opened to perform the 4 hour pump down. The tank vacuum dropped to 3 to 4 inches of mercury due to air being pulled through the underdrain. The amount of water removed from the resin during the four hour pump down totaled 6 to 7 gallons.

The container was raised again to observe for free liquid and no drainable liquid was observed. A core sample was taken and the bottom 1 to 2 inches of the resin cake had a dry weight percent of 35.4.

The container was examined for drainable liquid after standing seven days and found to contain no free water.

The results show that there is no drainable liquid present after loss of suction, after the four hour pump down or after standing one week.

The dry weight percent of the bottom 1 to 2 inches of dewatered material are shown below.

Time of Sampling	Dry Weight Percent Solids Flat Bottom Container
Loss of Suction	34.8
After 4 hour pump down	35.4

V. CONCLUSIONS

The results of the HITTMAN dewatering test in a flat bottom container show that when the bottom dewatering element has lost suction, there is no drainable liquid. The four hours of additional pumping increases the dry weight percent solids further.

The affects of a standing period of seven days after the four hour pump down are not conducive to the migration of the water bound to the powdered resin and no drainable liquid is present.

The minimum dry weight percent value determined in the laboratory will either correspond or be less than the dry weight percent solids at which suction will be lost during the dewatering operation (i.e., discharge becomes predominantly air with periodic slugs of water).

At the loss of suction, the resin adjacent to the dewatering elements will contain no drainable water. However, the resin between the dewatering elements may still have drainable liquid.

Following the loss of suction, vacuum will be applied to the bottom layer of dewatering elements. The vacuum will continue to remove water from the resin adjacent to the dewatering element to become an absorber of water. It will also cause any free water in the resins between the dewatering elements to move to the dewatering elements and be removed from the container.

Vacuum dewatering of the container following the loss of suction shall be continued to assure that the resin will contain no drainable liquid. This condition will be attained when any liquid that may remain in the resin between the dewatering elements is less than the liquid that can be absorbed by the resin adjacent to the dewatering elements. The resin adjacent to the dewatering elements will have been dewatered to a condition where liquid will be absorbed rather than drained.

The large scale test has shown that the resin contained in a large container contains no drainable liquid, when the amount of additional liquid removed from the resin after loss of suction increases the dry weight percent of the dewatered resin by at least one percentage point on a dry basis.

To assure that no drainable liquid will exist in the container when shipped, it is recommended that the amount of liquid removed from the container following dewatering be sufficient to increase the dry weight percent by two percentage points.

Tests have shown that for removal of every 18 gallons of water per 120 cu. ft. of waste after loss of suction there will be an increase in the dry weight percent solids of the waste by one percentage point. This relationship is virtually linear and may be proportionally applied to any volume of dewatered powdered resin.

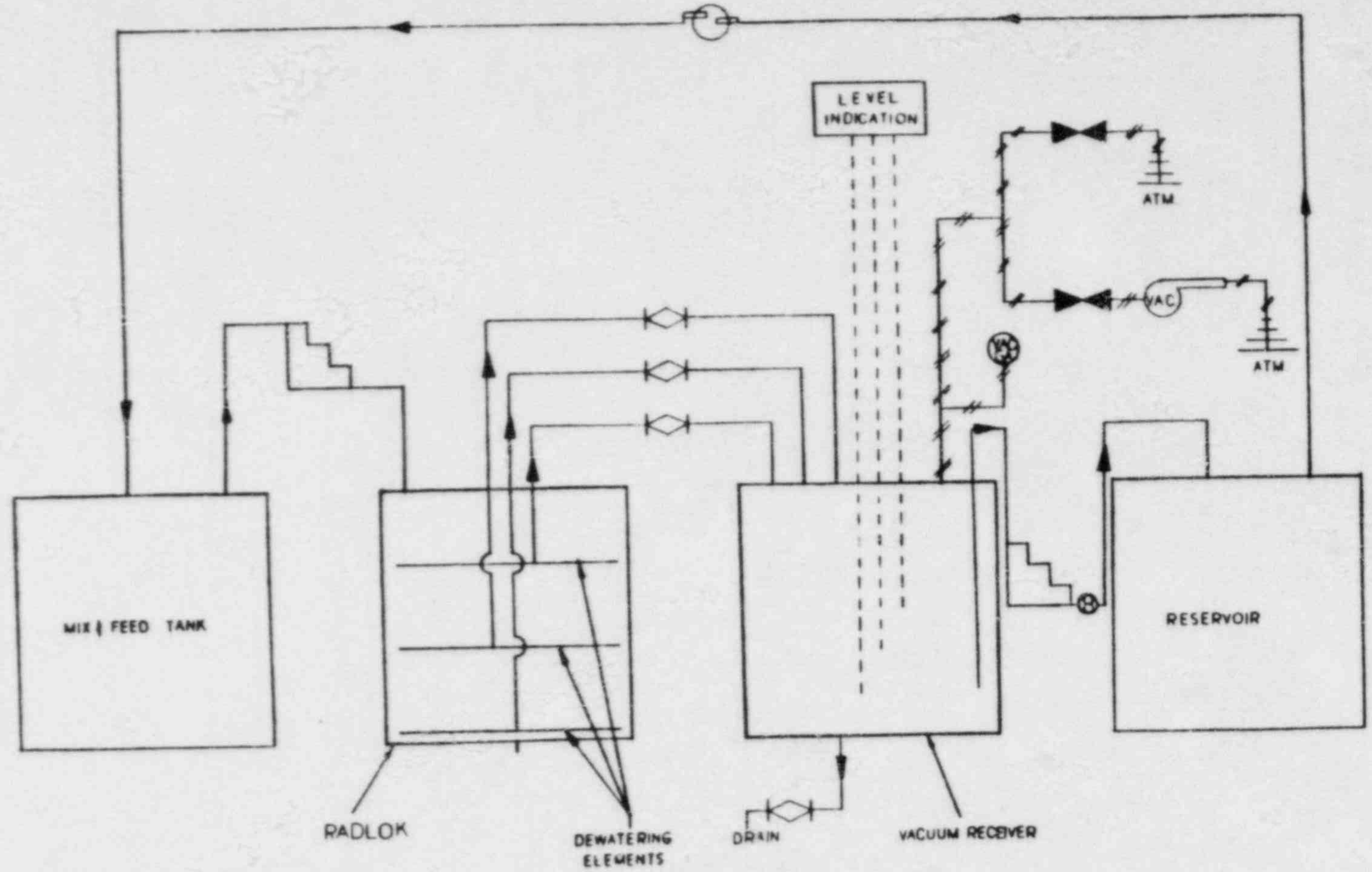
The desired increase in the solids content of the dewatered resin can be attained by measuring the amount of liquid removed during the vacuum dewatering following the loss of suction. The time it takes to remove the desired amount of water should also be measured so that in subsequent dewatering operations on the same type of waste, only the time and not the quantity of water removed will need to be measured.

The following table shows the amount of liquid that should be removed after loss of suction for various quantities of dewatered powdered resin. These amounts are for each increase of one percentage point in the dry weight percent solids of the waste.

Dewatered Waste Volume, cu. ft.	Quantity of Liquid to Remove for Each Percentage Point Increase in Solids Content, gallons
60	9
120	18
150	22.5

Further vacuum dewatering to verify that the powdered resin does not contain drainable liquid at the time of shipment is not required. Tests have shown that the continued application of vacuum will remove liquid from the matrix of the resin which is not drainable. Further, the amount of liquid which can be removed by vacuum will generally be greater than the allowable quantity of free water and could be unknowingly interpreted as noncompliance.

REVISIONS				
LTR	DESCRIPTION	DFTG	APP'D	DATE
O	ENG RLSE	CTN	EC	6/[illegible]



QTY	ITEM	PART NO	DESCRIPTION	MATERIAL / VENDOR

LIST OF MATERIALS

DRAWN BY A BALAGULA
DATE 6 28 82
CHECKED BY C T JENNING
DATE 6/28/82
RESP ENGR K K McDaniel
DATE 6/28/82
PROJ ENGR E CLOEREN
DATE 6/28/82
CONTRACT NO ~

HITTMAN NUCLEAR & DEVELOPMENT
CORPORATION
COLUMBIA, MARYLAND 21045

TITLE
RADLOK
DEWATERING SYSTEM

SIZE C
CODE IDENT ~
DWG NO SK-82-016
REV O
SCALE ~
WEIGHT ~
SHEET 1 OF 1

NEXT ASSY
USED ON
APPLICATION

Joe WALDEN

WESTINGHOUSE HITTMAN NUCLEAR INCORPORATED	Document Number: STD-R-05-007	Rev: 0	Rev Date: 5-22-84
	Title: Topical Report Cement Solidified Waste To Meet The Stability Requirements Of 10CFR61 Revision 0 (SUPERSEDES STD-R-05-005)		

Rev.	Rev Date	Director Engr.	Project Manager	QA Manager			
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WESTINGHOUSE HITTMAN NUCLEAR INCORPORATED

TOPICAL REPORT

CEMENT SOLIDIFIED WASTES TO MEET THE STABILITY REQUIREMENTS OF 10CFR61

Revision 0

STD-R-05-007

April 1984

Prepared by:

Westinghouse Hittman Nuclear Incorporated
9151 Rumsey Road
Columbia, Maryland 21045

TABLE OF CONTENTS

I. INTRODUCTION

This Topical Report, prepared by Westinghouse Hittman Nuclear Incorporated, presents the results of testing performed on simulated low-level radioactive waste to demonstrate compliance with the stability requirements of 10CFR61.56 Waste Qualification, and the Branch Technical Position on Waste Forms. This report represents the culmination of several years of experimentation and testing of Portland Type I Cement for the solidification of LWR wastes.

The program conducted by Hittman included seventeen wastes commonly found in U.S. light water reactors in addition to a "blank" and a "grout" for encapsulation of filters and other scrap material. This compendium of wastes is the most comprehensive program of its kind currently being pursued today.

Hittman is currently under contract to supply mobile solidification services to 23 power plants throughout the country. The first mobile cement solidification system went into service over seven years ago and since that time has always produced acceptable products using Portland Type I or Type II cement. In 1983 alone, over 1,000 large liners were solidified and shipped for burial.

The formulations used to produce the samples tested for the program were made using Portland Type I cement as the major component in the solidification process. The exact formulations of waste to cement and additives are provided as Proprietary Data in Attachment A.

Section VII, Test Results provides specific data on the samples put through the various tests required to show product stability. The final leach testing of one waste type is still in progress. A supplement to this report will be provided when this data is available.

In addition, three of the long-term immersion tests performed as part of the Scale Up Testing, Section VIII, and on the grout formulation, are still in progress. This data will also be supplied with the supplemental information.

The last of the aforementioned tests will be completed on June 13, 1984. The supplement will be submitted, to complete the entire document, by June 22, 1984.

II. BACKGROUND

On December 27, 1982, the U.S. Nuclear Regulatory Commission issued, in the Federal Register, a new paragraph 311, Transfer for disposal and manifests, to 10CFR20, Standards for Protection Against Radiation. Section (d)(1) of 20.311 requires that a licensee shall "prepare all wastes so that the waste is classified according to paragraph 61.55 and meets the waste characteristics requirements in paragraph 61.56 of this chapter." The referenced paragraphs, contained in 10CFR61, Licensing Requirements for Land Disposal of Radioactive Wastes, are, paragraph 61.55, Waste Classification and paragraph 61.56, Waste Characterization.

Under the definitions presented in paragraph 61.55 certain wastes, classified as Class B and Class C wastes must meet certain "rigorous requirements on waste form to ensure stability after disposal." These rigorous requirements are defined in paragraph 61.56 with further guidance being provided by the NRC in the Branch Technical Position on Waste Forms issued in May 1983.

In response to these regulations, Westinghouse Hittman Nuclear Incorporated instituted a program to qualify specific solidification formulations, to the requirements of a stable waste form per paragraph 61.56.

The formulations are all based on Portland Type I cement with additives. Specific additives are a function of the waste stream and its chemistry. While many of these additives are commonly known to be used in the solidification of specific wastes certain other additives are proprietary.

In developing the qualification program certain alternate test methods were identified which differed slightly from the test methods specified in the Branch Technical Position on Waste Forms. These alternate test methods were discussed with the NRC staff prior to incorporation in this program. This program was submitted to the NRC for review. A subsequent letter from the NRC stated that the test program was "acceptable for demonstrating compliance with the waste stability requirements of 10CFR Part 61".

The program undertaken involved the testing of nine separate waste types, a blank and a grout. Some of these waste types were then combined at various combinations of concentrations to yield an additional six waste types. Liquid concentrates were also tested at two separate concentrations for a total of nineteen waste types. A complete listing of the waste types tested is shown at the beginning of Section IV. As can be seen, these waste types cover all of the waste streams commonly found in most PWRs and BWRs and thus comprises the most extensive and comprehensive test program undertaken to date for the qualification of solidified wastes to these criteria.

III. SUMMARY AND CONCLUSION

Based on the analyses performed on the waste types listed in Tables 1 and 2, the formulations tested possess superb structural stability far exceeding the requirements specified in the BTP on Waste Forms. Table 1 gives the compressive strength of the sample(s) after each of the stability tests were completed. Table 2 gives the leachability index after the completion of the 90-day leach test.

Two blank formulations, i.e., samples made using Portland Cement with different additives and no waste, were tested as control samples for the biodegradation test, leach tests, thermal cycling test, and long-term immersion in water. These test results verify the stability of this formulation for use in encapsulating Class B or C filters. Results of these tests are also in Tables 1 and 2.

The scale-up testing conclusively demonstrates that the product quality of wastes solidified in the Hittman mobile solidification system can be extrapolated from laboratory size samples. The tests performed on the core drilled samples has also shown that the product strength throughout the solidified liner is homogeneous. Visual inspections of the liners has shown that there are no voids or other areas where complete mixing does not occur.

Table 1

Compressive Strength After Testing, psi

Waste Type	Initial Strength	90-Day Immersion	90-Day Non-Immersion	Thermal Cycling	Biodegradation		Irradiation
					Bacteria	Fungus	
Bead Resin	1,500	1,960	1,340	300	1,570	1,860	670
Powdered Resin	700	670	1,040	880	1,010	770	600
Diatomaceous Earth	1,000	1,140	1,200	1,300	[3]	[3]	1,400
Filter Sludge	710	1,240	1,290	1,100	[3]	[3]	670
8% Boric Acid	130	400	290	270	470	340	140
20% Boric Acid	130	330	230	400	[3]	[3]	140
10% Sodium Sulfate	530	540	1,170	1,470	[3]	[3]	630
20% Sodium Sulfate	830	1,050	910	1,400	[3]	[3]	1,540
Oil	140	340	190	210	230	200	290
Grit	280	500	210	360	[3]	[3]	340

Table 1 - (Cont'd.)

Compressive Strength After Testing, psi

Waste Type	Initial Strength	90-Day Immersion	90-Day Non-Immersion	Thermal Cycling	Biodegradation		Irradiation
					Bacteria	Fungus	
5% Boric Acid - 30% Bead Resin	140	490	140	130	[3]	[3]	160
16% Boric Acid - 30% Bead Resin	170	280	120	280[5]	[3]	[3]	110
16% Boric Acid - 62% Bead Resin	260	370	120	300	[3]	[3]	210
5% Sodium Sulfate - 30% Mixed Solids	850	1,040	1,490	1,720	[3]	[3]	1,400
20% Sodium Sulfate - 30% Mixed Solids	1,120	460	1,340	1,850	[3]	[3]	890

Table 1 - (Cont'd.)

Compressive Strength After Testing, psi

Waste Type	Initial Strength	90-Day Immersion	90-Day Non-Immersion	Thermal Cycling	Biodegradation		Irradiation
					Bacteria	Fungus	
20% Sodium Sulfate - 62% Mixed Solids	660	1,210	1,600	1,070	1,610	1,310	1,070
Blank	300	480	590	240	530	730	[3]
Decon Solution	340	460	230	200	200	200	200
Grout	1,540	1,290[1]	[2]	[3]	[3]	[3]	[3]
Acceptance Criteria	>50	>50	[4]	>50	>50	>50	>50

[1] Interim Strength - testing not complete
[2] In progress
[3] Not tested
[4] Not required
[5] Inadvertently crushed 5 days early

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Table 2

Leach Test Summary

Average Leachability Index

	Sample 1				Sample 2			
Waste Type	Co-60	Cs-137	Sr-89	Ce-144	Co-60	Cs-137	Sr-89	Ce-144
Bead Resin	12.9	7.5	8.9	>11.6	13.0	7.5	8.9	>11.6
Powdered Resin	12.4	7.0	8.9	>11.4	12.3	7.0	8.5	>11.5
Diatomaceous Earth	13.2	6.5	8.4	>12.7	13.1	6.5	8.4	>12.7
Filter Sludge	11.8	6.5	7.8	>11.3	12.2	6.5	7.9	>11.3
8% Boric Acid	10.8	6.3	8.9	>12.6	10.7	6.3	8.9	>12.6
20% Boric Acid	11.1	6.6	9.3	>12.7	10.8	6.5	9.2	>12.7
10% Sodium Sulfate	13.6	6.6	8.7	>11.3	13.6	6.7	8.9	>11.3
20% Sodium Sulfate	13.2	6.6	8.7	>11.4	13.5	6.6	8.7	>11.3
Oil	10.8	7.3	10.0	>12.7	10.5	6.7	9.2	>12.5
Grit	11.1	6.9	8.6	>12.6	11.3	6.8	8.6	>12.5
Decon Solution[1]	10.7	5.9	7.9	>12.3	10.8	5.9	7.9	>12.5

Table 2 - (Cont'd.)

Leach Test Summary

Average Leachability Index

	Sample 1				Sample 2			
Waste Type	Co-60	Cs-137	Sr-89	Ce-144	Co-60	Cs-137	Sr-89	Ce-144
5% Boric Acid w/ 30% Bead Resin	11.6	6.8	8.9	>12.2	11.4	6.6	9.0	>12.1
16% Boric Acid w/ 30% Bead Resin	12.1	7.5	9.7	>12.8	12.1	6.9	9.6	>12.7
16% Boric Acid w/ 62% Bead Resin	12.5	7.1	9.8	>11.4	12.4	7.1	9.8	>11.5
5% Sodium Sulfate w/ 30% Mixed Solids	12.9	6.8	8.8	>11.2	13.2	6.8	8.8	>11.3
20% Sodium Sulfate w/ 30% Mixed Solids	13.6	6.7	9.0	>11.4	13.2	6.6	8.8	>11.3
20% Sodium Sulfate w/ 62% Mixed Solids	11.3	6.5	8.2	>11.5	11.4	6.3	8.1	>11.3
Blank	10.9	6.4	8.3	>12.3	11.1	6.4	8.2	>12.5
Acceptance Criteria	>6.0	>6.0	>6.0	>6.0	>6.0	>6.0	>6.0	>6.0

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[1] Subsequent testing with a proprietary additive has resulted in Cs-137 leach indices of 6.91 and 6.93 for two new samples after 8 leach intervals.

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IV. WASTE QUALIFICATION PROGRAM DESCRIPTION

Scope

The program undertaken by Hittman covered eight basic types of liquid and solid wastes typically found in a nuclear power plant. These are:

- Mixed Bed Bead Ion-Exchange Resin
- Mixed Powdered Ion-Exchange Resin
- Diatomaceous Earth (DE)
- Filter Sludge (a mixture of powdered resin, DE, iron oxide and dirt).
- Oil
- Boric Acid (8% and 20%)
- Sodium Sulfate (10% and 20%)
- Grit (from abrasive decontamination processes)

As indicated two concentrations of both boric acid and sodium sulfate were tested to demonstrate the ability to produce qualified products over a range of concentrations. Additionally, three combinations of boric acid and bead resin and three combinations of sodium sulfate and a mixture of bead resin, powdered resin and diatomaceous earth were tested. Figures 1 and 2 give a graphical presentation of the relative concentrations tested.

The shaded areas in both figures represents the combinations of liquid chemical wastes and wet solids that can be solidified to the stability requirements of the BTP on Waste Forms as demonstrated by the test data in this report.

The last two samples tested contained no physical wastes but were cement slurries each using one of the two major additives used with the basic waste forms. One of these is identified as the "Blank" and the other as "Grout". The latter can be used as a pumpable grout slurry for encapsulation of cartridge filters. Both formulations also provide a data point for the extrapolation of formulations for wastes at zero concentration. For example, the Blank waste, using the same additives as boric acid can be used to develop solidification parameters below eight weight percent.

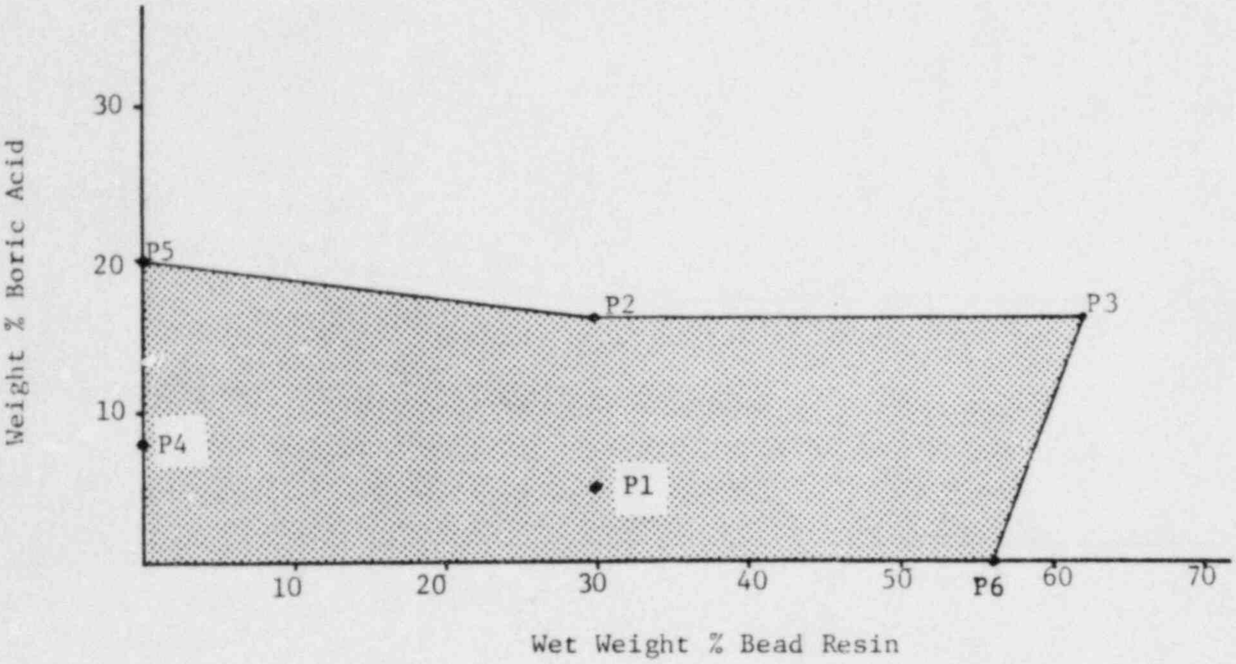

Figure 1
Bead Resin with Boric Acid

- Points P1, P2 and P3 in Figure 1 are the mixed boric acid and bead resin where:
- P1 is 30% bead resin and the liquid is a 5% boric acid solution;
- P2 is also 30% bead resin but the liquid is a 16% boric acid solution;
- P3 is 62% bead resin with again a 16% boric acid solution;
- Points P4 and P5 are the pure boric acid samples at 8% and 20% concentrations respectively.
- Point P6 is a plain bead resin sample at 57.6 wet weight percent solids and no boric acid.

Figure 2 is similar to Figure 1 with slightly modified concentrations.

- Points S1, S2 and S3 in Figure 2, are the mixed sodium sulfate and mixed solids (powdered resin, bead resin, and diatomaceous earth) where:
- S1 is 30% mixed solids and 5% sodium sulfate;
- S2 is 30% mixed solids and 20% sodium sulfate;
- S3 is 62% mixed solids with, again, 20% sodium sulfate;
- Points S4 and S5 are the pure sodium sulfate concentrations of 10% and 20% respectively;
- Point S6 represents plain mixed solids at 66 wet weight percent solids.

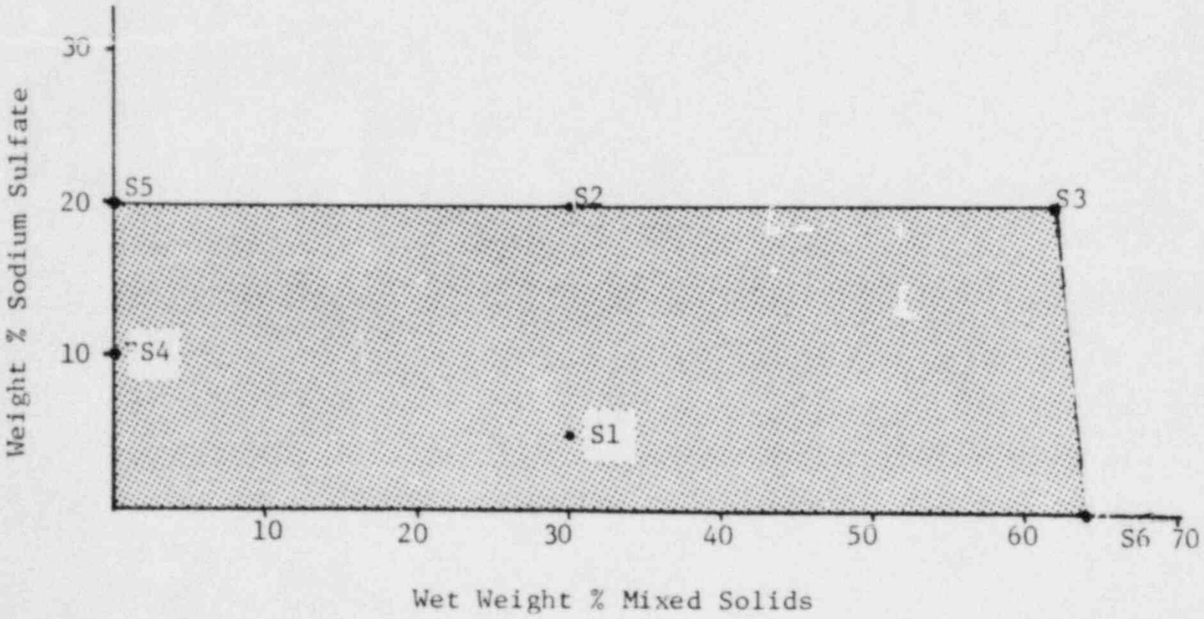

Figure 2
Mixed Solids with Sodium Sulfate

V. SAMPLE PRODUCTION

Individual samples for initial testing were prepared in 1,000 ml plastic beakers using a standard laboratory mixer with a three inch diameter mixing blade. These blades are made specifically for this purpose and are shaped in the same configuration as the full scale in-container mixing system. As specific mixes were identified for complete testing a large scale laboratory mix was prepared. Each of these large scale lab mixes was formulated to produce a sufficient batch of waste to fill sixteen three (3) inch diameter by six (6) inch high molds. These mixes were prepared in a five gallon can using a mixer blade shaped to recreate the same basic mixing action as a full scale in-container mixing system. The motor used was a variable speed motor which permitted adjusting the speed to hold a tip speed on the mixing blade at the same tip speed experienced with the Hittman in-container mixing system.

As soon as the samples were molded they were placed in sealed plastic bags, one sample per bag, to prevent moisture loss due to evaporation. All of the samples were then placed in an oven at 120°F for twenty-four hours to simulate the elevated curing temperature experienced in full scale operations due to the exothermic reaction as cement cures. After the samples were removed from the oven they were marked and put into storage while they awaited additional testing.

If samples were stored for prolonged periods prior to being used for one of the tests a companion sample from that batch was compressively tested to provide an adjusted base line against which to judge the effects of the test. In those cases where this additional test was performed it is so noted and the compressive strength of the additional sample is listed.

Samples for leach testing were prepared by the Westinghouse R & D Center. These samples were cured for one week in the same manner as the other test samples described above. Leach testing for all the waste types was performed on two identical samples measuring one (1) inch in diameter by two (2) inches long. Samples were produced using water containing Co-60, CS-137, Sr-85 and Ce-144 in concentrations of approximately 1μCi/gm each[1]. Demineralized water was used as the leachate for all samples except bead resin and powdered resin which were leached in synthetic sea water.

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[1] Due to a packaging error by the isotope vendor, approximately half of the samples had Cs-137 concentrations approximately ten times higher than the other isotopes. This has no impact on the leach index as the calculation is based on the fraction leached and not the absolute quantity leached.

VI. TESTS AND TEST METHODS

The tests performed and the methods of testing are given in Attachment A, Waste Qualification Program. This program differs from the program outlined in the BTP for the thermal cycling and the biodegradation testing. These differences are described below.

A. Thermal Cycling:

The ASTM Standard B-355 referenced in the BTP was not used for three reasons. First, the rapid cycling time is not representative of the actual environmental conditions that wastes will be subjected to. Second, the temperature ranges specified are not available in normal laboratory equipment designed for the large number of samples required. Third, unpublished results of tests performed by a national lab indicate that the large temperature difference, -40°C to 60°C, and the rapid cycling prevents the centerline of the samples from ever reaching the requisite temperature extremes.

The method selected used more realistic temperature extremes of -18°C and 48°C (0°F and 120°F respectively). The test chamber was set to alternate between these two temperatures on a 24-hour cycle. During each cycle, the 0°F and 120°F temperatures are maintained for 8 hours each with a 4-hour transition time.

Each sample was tested for a total of 50 cycles, or 50 days.

Following completion of the test, the samples were compressively tested to demonstrate a minimum of 50 psi compressive strength.

B. Biodegradation:

The ASTM Standards G21 and G22 referenced in the BTP were modified slightly as follows. Both tests are designed to use samples approximately one-quarter inch thick and to be incubated in a shallow petri dish. In order to be able to use samples that could be compressively tested upon completion of the test, samples three (3) inches in diameter by six (6) inches high were used. Each sample was placed in a beaker and covered with the non-nutrient salt and injected with the appropriate bacteria and fungus.

Testing for degradation due to fungus growth was modified by replacing penicillium funiculosum with penicillium jenseni. This substitution was made because of the strict sterilization requirements imposed on any item that comes in contact with penicillium funiculosum which is a plant pathogen.

Due to an adverse reaction between the bead resin sample and the agar this test was conducted using the recommended salts dissolved in water without the agar.

Upon completion of the test, the samples were inspected for growth of the fungus or bacteria and then compressively tested to demonstrate a minimum compressive strength of 50 psi.

VII. TEST RESULTS

The results of the testing on individual waste types are as follows:

1. Bead Resin

Samples of solidified bead resin were prepared using chemically depleted mixed bed ion exchange resin. The initial average compressive strength of the lab mixed samples was 1,090 psi while the drum mixed samples had an average strength of 1,500 psi. After 90 days immersion the average strength of two samples tested was over 1,960 psi.

The formulation tested in the irradiation, thermal cycling and leach tests was slightly different from the final reference formulation. By comparison, the original formulation had an average initial compressive strength of 740 psi compared to 1,090 psi for the reference formulation. The difference in these two formulations is in the water to cement ratio while maintaining identical volumetric waste loading. Therefore, the test results for the original formulation are conservative in both strength and leach characteristics compared to the reference formulation and additional, or repeat testing of the reference formulation was not required.

The thermal cycling tests on the original formulation resulted in an average compressive strength of 300 psi. The sample irradiated to the 10^8 Rad had a compressive strength of 670 psi. The average leachability index for each of the four radionuclides tested is given in Table 2 for both samples. The two samples used in the biodegradation tests showed no visible signs of bacteria or fungus growth. The compressive strengths were 1,570 psi and 1,860 psi after exposure to the bacteria and fungus respectively. Table 3 contains the data for the individual bead resin samples tested.

Table 3

Compressive Strength Summary

Bead Resin, psi

	Initial Test	90-Day Immersion	90-Day Non-Imm.	Biodegradation	Thermal Cycling	Irradiation 10^8 Rad
Sample 1	1,260	1,660	1,340	1,570[1]	270	670
Sample 2	1,740	2,260	--	1,860[2]	330	--

[1] Bacterial Attack.

[2] Fungus Attack.

2. Powdered Resin

The initial strength of two powdered resin samples measured 630 psi and 770 psi with little change seen after 90 days immersion in water. The immersed samples had strengths of 630 psi and 700 psi. Over the same time period the non-immersed sample increased in strength to 1,040 psi.

The sample irradiated to 10^8 Rad exhibited a compressive strength of 600 psi after irradiation. The samples tested for biodegradation had strengths of 1,010 psi after bacterial attach and 770 psi after fungus attach. There was no visual growth of bacteria or fungus on either sample. Thermal cycling tests on two samples resulted in compressive strengths of 860 psi and 900 psi.

Leach testing of powdered resin was also conducted using synthetic sea water. The average leachability index for each of the four radionuclides tested is given in Table 2 for both samples.

Table 4

Compressive Strength Summary

Powdered Resin, psi

	Initial Test	90-Day Immersion	90-Day Non-Imm.	Biodegradation	Thermal Cycling	Irradiation 10^8 Rad.
Sample 1	770	630	1,040	1,010[1]	860	600
Sample 2	630	700	--	770[2]	900	--

[1] Bacterial Attack

[2] Fungus Attack

3. Diatomaceous Earth

The initial compressive strength of two samples of solidified diatomaceous earth are 1,300 psi and 970 psi. The 90-day immersion strengths were 1,140 psi for both samples with a non-immersed sample testing at 1,200 psi. The two samples used in the thermal cycling tests had strengths of 1,640 psi and 1,150 psi. The irradiated sample was 1,400 psi. This data is summarized in Table 5.

Average leachability indices for the four radionuclides tested are given in Table 2 for both samples. The leachate for DE was demineralized water.

Table 5

Compressive Strength Summary

Diatomaceous Earth, psi

	Initial Test	90-Day Immersion	90-Day Non-Imm.	Biodegradation	Thermal Cycling	Irradiation 10^8 Rad.
Sample 1	970	1,140	1,200	NT[1]	1,640	1,400
Sample 2	1,030	1,140	--	NT	1,150	--

[1] Not tested

4. Filter Sludge

The initial compressive strengths of the filter sludge solidifed samples were 510 psi and 910 psi. After 90 days of immersion the strengths were 1,200 psi and 1,270 psi with a non-immersed sample having a compressive strength of 1,290 psi. After irradiation to 10^8 rad the compressive strength of a single sample was 670 psi. Thermal cycling tests resulted in compressive strengths of 1,070 psi and 1,140 psi. Biodegradation tests were not conducted on solidified filter sludge. This information is summarized in Table 6.

Table 6

Compressive Strength Summary

Filter Sludge, psi

	Initial Test	90-Day Immersion	90-Day Non-Imm.	Biodegradation	Thermal Cycling	Irradiation 10^8 Rad.
Sample 1	510	1,200	1,290	NT	1,070	670
Sample 2	910	1,270	--	NT	1,140	--

Leach testing of filter sludge were conducted in demineralized water. The average leachability indices for the four radionuclides tested are given in Table 2 for both samples.

5. 8% Boric Acid

The initial compressive strengths of the 8% boric acid samples were 140 psi and 110 psi. Following irradiation to 10^8 rad, the sample still exhibited a strength of 140 psi, while the samples exposed to bacterial and fungus attach had strength of 470 psi and 340 psi respectively. Neither sample showed any visible signs of bacteria or fungus growth. After 90 days immersion the compressive strengths of two samples were 370 psi and 430 psi. Thermal cycling tests resulted in compressive strengths of 270 psi for both samples. This data is summarized in Table 7.

Leach testing of 8% boric acid was conducted using demineralized water. The average leachability indices for the four radionuclides tested are given in Table 2 for both samples.

Table 7

Compressive Strength Summary

8% Boric Acid, psi

	Initial Test	90-Day Immersion[1]	90-Day Non-Imm.	Biodegradation	Thermal Cycling	Irradiation 10^8 Rad.
Sample 1	140	430	130	470[1]	270	130
Sample 2	110	370	--	340[2]	270	--

[1] Bacterial Attack

[2] Fungus Attack

6. 20% Boric Acid

After 90 days immersion, the compressive strength of two samples were 310 psi and 340 psi. Prior to immersion, the compressive strengths were 140 psi and 110 psi, while a non-immersed sample had a compressive strength of 230 psi after 90 days. After exposure to a gamma radiation source to a total centerline dose of 10^8 Rad, the compression strength of a single sample was 140 psi.

Due to an earlier failure of one sample to pass the thermal cycling test, four additional samples were tested. These four samples had strengths following testing of 410 psi, 440 psi, 410 psi and 330 psi. The average of these four samples is shown for Sample 2.

Table 8

Compressive Strength Summary - 20% Boric Acid, psi

	Initial Test	90-Day Immersion	90-Day Non-Imm.	Biodegradation	Thermal Cycling	Irradiation 10^8 Rad.
Sample 1	110	310	230	NT	140	140
Sample 2	140	340	--	NT	400[1]	--

[1] The average of four samples.

Leach testing was conducted using demineralized water. The average leachability index is shown in Table 2 for each of the four radionuclides tested for both samples.

7. 10% Sodium Sulfate

The initial compressive strengths of the 10% sodium sulfate samples were 570 psi and 490 psi. The samples used in the 90-day immersion test had compressive strengths of 690 psi and 390 psi. After exposure of 10^8 Rads, the strength of a single sample was 630 psi. Thermal cycling test resulted in sample strengths of 1,410 psi and 1,530 psi. Since sodium sulfate is a non-nutrient salt it was not considered necessary to test this waste form for biodegradation. These data are summarized in Table 9.

Leach testing of the 10% sodium sulfate samples was conducted using demineralized water. The average leach indices for the four radionuclides tested are given in Table 2 for both samples.

Table 9

Compressive Strength Summary

10% Sodium Sulfate, psi

	Initial Test	90-Day Immersion	90-Day Non-Imm.	Biodegradation	Thermal Cycling	Irradiation 10^8 Rad.
Sample 1	490	690	1,170	NT	1,410	630
Sample 2	570	390	--	NT	1,530	--

8. 20% Sodium Sulfate

The initial compressive strength of both 20% sodium sulfate samples was 830 psi. The samples used in the 90-day immersion test had compressive strengths of 1,000 psi and 1,100 psi. The thermal cycling test resulted in sample strengths of 1,280 psi and 1,530 psi. Following irradiation to 10^8 rads, the strength of a single sample was 1,540 psi. Biodegradation tests are not being performed as stated under 10% sodium sulfate. See Table 10 for a summary of these data.

Leach testing was conducted in demineralized water. The average leach indices for the four radionuclides tested are given in Table 2 for both samples.

Table 10

Compressive Strength Summary

20% Sodium Sulfate, psi

	Initial Test	90-Day Immersion	90-Day Non-Imm.	Biodegradation	Thermal Cycling	Irradiation 10^8 Rad.
Sample 1	830	1,000	910	NT	1,280	1,540
Sample 2	830	1,100	--	NT	1,530	--

9. Oil

Samples solidified contained used motor and turbine lube oil diluted in water and emulsified with a proprietary emulsifier.

The initial compressive strengths after 7 days of cure were 140 psi and 130 psi. After 90 days immersion in water, both samples had compressive strengths of 340 psi. A single non-immersed sample from the same batch exhibited a compressive strengh of 190 psi.

After exposure to a gamma radiation source to a total centerline dose of 10^8 rads, the compressive strength of a single sample was 290 psi. Both samples used in the thermal cycling tests had compressive strengths of 210 psi. The samples tested for biodegradation had strengths of 230 psi after bacterial attack and 200 psi after fungus attack. There was no visual growth of bacteria or fungus on either sample. Table 11 provides a summary of the testing discussed above.

Table 2 contains the leach indices for solidified oil for the four radionuclides tested, for both samples. Demineralized water was used for the leachate.

Table 11

Compressive Strength Summary - Oil, psi

	Initial Test	90-Day Immersion	90-Day Non-Imm.	Biodegradation	Thermal Cycling	Irradiation 10^8 Rad.
Sample 1	140	340	190	230[1]	210	290
Sample 2	130	340	--	200[2]	210	--

[1] Bacterial Attack

[2] Fungus Attack

10. Grit

The grit used in these samples is aluminum oxide; however, due to the inert nature of the material, the results of these tests are considered applicable to other similar materials such as magnetite and steel grits at comparable waste loadings.

Prior to immersion, the average compressive strength was 280 psi. Samples immersed for 90 days had an average compressive strengths of 390 psi and 610 psi while a non-immersed sample of the same age had a compressive strength of 210 psi. Due to the inert nature of the waste, biodegradation testing was not considered necessary.

A single irradiated sample had a compressive strength of 340 psi after irradiation in a gamma field to a centerline dose of 10^8 Rads. The samples used in the thermal cycling test had strengths of 400 psi and 320 psi. This data is summarized in Table 12.

Table 12

Compressive Strength Summary - Grit, psi

	Initial Test	90-Day Immersion	90-Day Non-Imm.	Biodegradation	Thermal Cycling	Irradiation 10^8 Rad.
Sample 1	280	390	210	NT	400	340
Sample 2	270	610	--	NT	320	--

Table 2 shows the leach indices for the solidified grit, for all four radionuclides for both samples. The leachate for this waste type was also demineralized water.

11. 5% Boric Acid and 30% Bead Resin

This waste form consists of a slurry which, if separated by dewatering, would be 30% by weight dewatered resin and the liquid would be a 5% boric acid solution.

Prior to immersion, the compressive strength of both samples was 140 psi. Ninety-one days later, the compressive strength of a non-immersed sample was unchanged, at 140 psi. The compressive strength of the immersed samples at 90 days was 490 psi. Biodegradation testing was not performed since both bead resin and boric acid were tested separately.

Following irradiation to 10^8 Rads, the compressive strength was 160 psi. Samples used in the thermal cycling tests had compressive strengths of 120 psi and 140 psi. Table 13 provides a summary of the testing discussed above.

Table 13

Compressive Strength Summary - 30% Resin, 5% Boric Acid, psi

	Initial Test	90-Day Immersion	90-Day Non-Imm.	Biodegradation	Thermal Cycling	Irradiation 10^8 Rad.
Sample 1	140	490	140	NT	140	160
Sample 2	140	490	--	NT	120	--

Leach testing was performed using demineralized water. The average leachability indices for each of the four radionuclides for both samples are shown in Table 2.

12. 16% Boric Acid with 30% Bead Resin

The initial compressive strength of both samples was 170 psi. After 90 days immersion the two samples tested has compressive strengths of 230 psi and 330 psi. During the same period a non-immersed sample had a strength of 120 psi. Following irradiation to 10^8 rads, the compressive strength of a single sample was 110 psi. Biodegradation testing was not performed since both boric acid and bead resin were tested separately. Thermal cycling tests resulted in compressive strengths of 270 psi and 290 psi. This data is summarized in Table 14.

Table 14

Compressive Strength Summary

16% Boric Acid with 30% Bead Resin, psi

	Initial Test	90-Day Immersion	90-Day Non-Imm.	Biodegradation	Thermal Cycling	Irradiation 10^8 Rad.
Sample 1	170	230	120	NT	270	110
Sample 2	170	330	--	NT	290	--

Leach testing of the 16% boric acid with 30% bead resin samples were conducted in demineralized water. The average leach indices for the four radionuclides tested are given in Table 2 for both samples.

13. 16% Boric Acid with 62% Bead Resin

The initial compressive strengths of both samples tested was 260 psi. After 90 days immersion the two samples tested had strengths of 430 psi and 310 psi. After 90 days the non-immersed sample had a strength of 120 psi. After exposure to 10^8 rad the irradiated sample had a strength of 210 psi. Biodegradation tests are not being performed since both boric acid and bead resin were tested separately. Both of the thermal cycling samples had compressive strengths of 300 psi. These data are summarized in Table 15.

Table 15

Compressive Strength Summary

16% Boric Acid with 62% Bead Resin, psi

	Initial Test	90-Day Immersion	90-Day Non-Imm.	Biodegradation	Thermal Cycling[1]	Irradiation 10^8 Rad.
Sample 1	260	430	120	NT	300	210
Sample 2	260	310	--	NT	300	--

[1] Inadvertently crushed at 45 days.

Leach testing was conducted in demineralized water. The average leach indices for the four radionuclides being tested are given in Table 2 for both samples.

14. 5% Sodium Sulfate with 30% Mixed Solids

The initial compressive strengths for the two samples tested were 700 psi and 1,000 psi. The 90-day immersion test samples had compressive strengths of 660 psi and 1,430 psi. After the same period, a non-immersed sample had a compressive strength of 1,490 psi. The thermal cycling test samples had strengths of 1,730 psi and 1,720 psi. The single sample exposed to 10^8 Rad had a strength of 1,400 psi. Biodegradation tests were performed on the 20% sodium sulfate with 62% mixed solids samples. Table 16 provides a summary of these data.

Leach testing on the 5% sodium sulfate with 30% mixed solids was conducted in demineralized water. The average leach indices for the four radionuclides tested are given in Table 2 for both samples.

Table 16

Compressive Strength Summary

5% Sodium Sulfate with 30% Mixed Solids, psi

	Initial Test	90-Day Immersion	90-Day Non-Imm.	Biodegradation	Thermal Cycling	Irradiation 10^8 Rad.
Sample 1	700	660	1,490	NT	1,730	1,400
Sample 2	1,000	1,430	--	NT	1,720	--

15. 20% Sodium Sulfate with 30% Mixed Solids

The initial compressive strengths for two samples of this waste type were 1,000 psi and 1,230 psi for lab samples and 830 psi and 1,230 psi for samples from the drum mix. The 90-day immersion test on the drum samples resulted in compressive strengths of 660 psi and 960 psi. After 90 days of curing a non-immersed sample had a compressive strength of 1,340 psi. Following irradiation to 10^8 Rads, a single sample had a strength of 890 psi. The thermal cycling test samples had compressive strengths of 1,820 psi and 1,880 psi. Biodegradation tests were performed on the 20% sodium sulfate with 62% mixed solids samples. These data are summarized in Table 17.

Leach testing was conducted using demineralized water. The average leach indices for the four radionuclides tested are given in Table 2 for both samples.

Table 17

Compressive Strength Summary

20% Sodium Sulfate with 30% Mixed Solids, psi

	Initial Test	90-Day Immersion	90-Day Non-Imm.	Biodegradation	Thermal Cycling	Irradiation 10^8 Rad.
Sample 1	830	660	1,340	NT	1,820	890
Sample 2	1,230	960	--	NT	1,880	--

16. 20% Sodium Sulfate with 62% Mixed Solids

The initial compressive strengths of these two samples were 660 psi and 670 psi. After 90 days immersion the strengths of two samples were 1,140 psi and 1,280 psi. A non-immersed sample after the same time interval had a strength of 1,600 psi. After exposure to 10^8 rads, the strength of a single sample was 1,070 psi. The samples subjected to biodegradation testing had compressive strengths of 1,610 psi and 1,310 psi after bacterial attack and fungus attack respectively. There was no visible growth of bacteria or fungus on either sample. The thermal cycling test samples had compressive strengths of 1,060 psi and 1,080 psi. These data are summarized in Table 18.

Leach testing for the 20% sodium sulfate with 62% mixed solids samples was conducted using demineralized water. The average leach indices for the four radionuclides tested are given in Table 2 for both samples.

Table 18

Compressive Strength Summary

20% Sodium Sulfate with 62% Mixed Solids, psi

	Initial Test	90-Day Immersion	90-Day Non-Imm.	Biodegradation	Thermal Cycling	Irradiation 10^8 Rad.
Sample 1	660	1,140	1,600	1,610[1]	1,060	1,070
Sample 2	670	1,280	--	1,310[2]	1,080	--

[1] Bacterial Attack

[2] Fungus Attack

17. Miscellaneous Chemical Wastes

The initial compression strength of the miscellaneous chemical waste samples was 340 psi for both samples. Following 90 days immersion in water, the samples had compressive strengths of 430 psi and 490 psi. A non-immersed sample had a strength of 230 psi after 90 days. The samples used in the thermal cycling test both had strengths of 200 psi, as did the samples used in the radiation test, the bacterial attack test and the fungus attack test. There was no visible growth of bacteria or fungus on either sample. Table 19 provides a summary of this data.

Table 19

Compressive Strength Summary, psi

Miscellaneous Chemical Waste

	Initial Test	90-Day Immersion	90-Day Non-Imm.	Biodegradation	Thermal Cycling	Irradiation 10^8 Rad.
Sample 1	340	430	230	200[1]	200	200
Sample 2	340	490	--	200[2]	200	--

[1] Bacterial Attack

[2] Fungus Attack

Leach tests using demineralized water as the leachate resulted in average leach indices after 90 days of greater than 6.0 for three of the four isotopes as shown in Table 2. The average leachability index for Cs-137 was slightly below 6.0 for both samples. Subsequent retesting using a proprietary additive for Cs retention is presently in progress with a scheduled completion date of June 5, 1984. Through the eighth leach interval, the average cesium leachability indices are 6.91 and 6.93.

18. Blank and Grout

Two blank cement formulations were tested for qualification as a Class B waste form for the encapsulation of cartridge filters or other non-dispersable wastes. The initial strengths were 310 psi and 290 psi for the formulation identified as "Blank". For the "Grout" formulation, the initial strengths were 2,070 psi and 1,000 psi. The blank formulation was used in the biodegradation tests, and the thermal cycling tests. Following thermal cycling tests, the blank samples had compressive strengths of 240 psi and 250 psi. After completion of the bacterial and fungus attack tests, the blank sample strengths were 530 psi and 730 psi, respectively. Following the 90-day immersion tests on the blank formulation, the two samples had compression strengths of 460 psi and 500 psi. The 90-day immersion test on the grout formulation is in progress. After six weeks immersion, a single grout sample had a strength of 1,290 psi. Due to the common use of cement in radiation environments these tests were not considered necessary. Table 20 provides a summary of this data.

Leach testing of this waste form was performed on the blank with the same four radionuclides dispersed throughout the sample as in all the other waste types. Table 2 lists the individual leachability indices for the four radionuclides tested.

Table 20

Compressive Strength Summary

Blank Waste, psi

	Initial Test	90-Day Immersion	90-Day Non-Imm.	Biodegradation	Thermal Cycling	Irradiation 10^8 Rad.
Sample 1	310	460	590	530[1]	240	NT
Sample 2	290	500	--	730[2]	250	NT

[1] Bacterial Attack

[2] Fungus Attack

VIII. SCALE-UP TESTING

A. Solidification Testing and Sample Compression Strength

As recommended by the NRC Branch Technical Position on Waste Forms, additional testing was performed, culminating in a full scale liner solidification, to demonstrate the scale-up of product quality from the lab size samples used for testing to the full size product. Both the Hydraulic Drive and Electric Drive In-Container Solidification systems are proven systems and have been in use for over seven years. In 1983, Hittman solidified over 1,000 large liners, never once failing to produce an acceptable product using Portland Type I or Portland Type II Cement.

In developing the scale-up program, the real impetus was to scale down from the full scale system to lab and drum scale mixes. In performing these calculations, four parameters were analyzed. These were:

- Mixing blade diameter to container diameter. This ratio was held constant, ± 5%, and used to define the mixing blade diameter for the drum and lab scale mixes.
- Horsepower per cubic foot. This ratio was used to define mixer motor horsepower for the drum and lab scale mixes.
- Total BTU input. With the mixer horsepower defined, this was used to determine the interval over which the solidification ingredients would be added and the total mix time.
- Mixing blade tip speed. This was used to determine the appropriate gear reducer for the drum scale mixing system, and the appropriate mixing speeds for the lab scale mixes.

As discussed in Section V, the sample production utilized both individual lab mixed samples and large lab mixes. The individual lab samples were prepared in 1,000 ml containers, preparing sufficient product to fill a 3" diameter by 6" high mold. The large lab mixes were prepared to supply sufficient product to fill up to seventeen of the same molds. These samples were used in the immersion, biodegradation, thermal cycling and irradiation tests.

Following completion of these tests, drum scale tests were performed on four of the mixes. The selected mixes were:

- Bead Resin
- 20% Boric Acid
- 20% Sodium Sulfate

- 30% Mixed Solids with 20% Sodium Sulfate

Each mix was prepared in a 55-gallon drum using an in-drum mixing system specifically designed for these tests. This design was based on the scaling factors outlined above. At the completion of the mix cycle, some of the product was removed from the drum and used to fill several 3" diameter by 6" molds. These samples were then cured in a manner identical to the large lab sample mixes. After the initial cure period, two samples were tested for initial compression strength. Additional samples were immersed in water for duplication of the 90-day immersion tests.

After the samples had been taken from the drums, each drum was sealed with a standard drum lid and bolt-closure ring. Samples and drums were examined at 24 hours to check for final set and free liquid. At this check, all samples and drums were hard and contained no liquid, drainable or otherwise. To complete the scale-up testing, two liners were solidified. The first was an HN-100 LVM (large volume mixer) containing 30 percent mixed solids and a 20 percent sodium sulfate solution. This liner is an upsized standard HN-100 designed to maximize the usable internal volume. The second liner solidification was a standard HN-100 UM (underdrain mixer) containing bead resin.

Both solidifications were performed using a Hittman Hydraulic Drive In-Container Solidification System. The HN-100 LVM was solidifed at the normal mixing speed of a hydraulic drive system. The waste type solidified in this liner is representative of a BWR, and, therefore would be solidified in the field using this system. A reduced mixing speed, representative of the electric drive, was used for the bead resin solidification in the HN-100 UM.

During both solidifications, the hydraulic pressure was monitored. At no time in either solidification did the system pressure exceed 20 percent of the stall pressure. By comparison to an electric drive system this would still be only a fraction of the motor capacity. In this instance, the higher mixing speed of the hydraulic drive system does not appear to have resulted in a stronger product since the initial strength of the liner samples from the HN-100 LVM are very similar to the initial strength of the lab and drum scale samples. It can then be concluded that both waste types tested could also have been solidified with an Electric Drive System with similar results.

Comparisons of the initial sample strengths and the immersed sample strengths are provided in Table 21 for the four waste types tested in the scale-up program. Dipped samples taken at the completion of the mixing cycle were cured in the liners for seven days prior to being removed for testing.

Table 21

Individual Scale-Up Testing Sample Strengths

	Compressive Strength, psi		
	Lab Sample	Drum Sample	Liner Sample
Bead Resin			
Initial Strength	1260, 1740	830, 1660	770, 1430, 860
Immersion Strength	1660, 2260	In Progress	In Progress
30% Mixed Solids With 20% Sodium Sulfate			
Initial Strength	1230, 1000	830, 1230	1200, 700
Immersion Strength	460	660, 960	In Progress
20% Boric Acid			
Initial Strength	110, 140	200, 200	Not Tested
Immersion Strength	310, 340	260, 400	Not Tested
20% Sodium Sulfate			
Initial Strength	830, 830	570, 460	Not Tested
Immersion Strength	1000, 1100	570, 570	Not Tested

A closer examination of the individual sample strengths in Table 21 gives a clearer impression of the curing process:

1. Bead Resin. While the average initial strength of the three bead resin liner samples is lower than the average lab strength, one of the three liner samples falls between the two lab samples. Similarly, for the drum samples, one had a strength close to the stronger of the two lab samples, while the other was close to the two lower strength liner samples.

The range of strengths experienced here is not unexpected. Previous testing, as part of this and other programs has demonstrated a significant distribution of sample strengths for cement solidified wastes. In particular, tests conducted as part of this program showed an average initial compression strength for 16 identical samples, of 960 psi with a standard deviation of 210 psi for the 30% mixed solids with 20% sodium sulfate waste type. While the seven initial bead resin strengths are higher than those in this test, they do follow the same general distribution.

Following the 90-day immersion test, the two bead resin lab samples had compression strength of 1,660 psi and 2,260 psi. Final immersion testing of the drum scale samples and liner samples will be completed in the near future and supplied with the June supplement.

2. 30% Mixed Solids With 20% Sodium Sulfate. Drum scale and full size liner tests were also performed on the 30% mixed solids with 20% sodium sulfate. The data for the samples of this waste type is also shown in Table 21. A comparison of the initial sample strengths from the lab, drum and liner samples with the previously mentioned data on the distribution of sample compressive strength shows good correlation between the two sets of data. Although one of the lab samples was cracked at the end of the 90-day immersion test and was not tested, both drum samples had compression tests well in excess of the minimum 50 psi. Final verification of the liner samples will be available shortly and provided with the supplemental data.

For consistency within the process control program with other combinations of mixed solids and sodium sulfate, the final formulation selected for this particular combination has been increased in cement by approximately 8.5%. To demonstrate that this formulation does not result in a weaker product than the formulation tested, a drum scale test solidification was performed. Dipped samples were taken for testing. The initial sample strengths were 860 psi and 1,430 psi compared to the original drum samples of 830 psi and 1,230 psi. The results of the immersion testing will be reported with the supplemental information.

3. 20% Boric Acid and 20% Sodium Sulfate. Two other waste types, 20% boric acid and 20% sodium sulfate were taken to the drum scale tests. The similarity in strengths for the 20% boric acid samples shows good scale-up from the lab mixes to the drum size mix. For the sodium sulfate samples the strengths of the drum samples, although lower than the lab mixes, are an order of magnitude higher than minimum recommended strength of 50 psi. And, as shown in Table 10, the sample strength can be expected to increase as additional curing occurs.

B. Homogeneity of Liner

In addition to testing samples taken from the two full scale liners prior to setting of the cement product, both liners were core drilled to demonstrate the homogeneity of the product. Two cores were taken from each liner. One core was on a horizontal plane from the outer wall to the center of the liner. The second core was vertical from the top down to the bottom of the liner. Core samples were removed in 9 to 20 inch sections and then cut into six inch segments for compression testing. While these are considered nominal three inch diameter core samples, the actual diameter of the samples was 2.75 inches.

Five samples were cut from the vertical cores and three from the horizontal cores. Each sample was capped and tested for compression strength. These results are shown in Table 22.

Table 22

Compression Strengths of Core Drilled Samples

	Compression Strength, psi	
	Bead Resin Liner	30% Mixed Solids with 20% Sodium Sulfate
Horizontal Core		
Outer Edge	1780	1720
Middle	1630	740
Center	1430	1010
Vertical Core		
Top	2120	1480
Middle Top	2220	840
Middle	1950	1350
Middle Bottom	1110	960
Bottom	2120	1650

As the data demonstrates, the variation in sample strengths is random, following the same pattern of distribution found previously. The mixed solids with sodium sulfate strengths are very similar to those reported in Table 21 for initial strengths. The bead resin strengths are, on the average, higher than the initial liner strength. While this too may also be a function of the normal distribution of strength, it may also be an indication that the solidified product continued to cure and strengthen beyond the initial seven-day period used for the initial strength testing. This theory is supported by the fact that after the seven-day curing, the internal temperature of the liner was still at 100°F having peaked at 180°F at 24 hours. The temperature of the waste prior to solidification was approximately 65°F.

Visual examinations of the liners has also confirmed complete mixing within the liners. Two removable plates along the bottom of the HN-100 UM were removed subsequent to the core drilling. Examination of the corner formed by the liner wall and the underdrain found a complete homogeneous mix of waste and cement with no unmixed solids.

These examinations and tests conclusively demonstrate that the product quality throughout the liners is completed homogeneous with no voids or other areas of unmixed wastes.