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OCT 03 1994
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ENGINEERING DATA TRANSMITTAL

Page 1 of 1

1. EDT 608383

2. To: (Receiving Organization)	3. From: (Originating Organization)	4. Related EDT No.:
Special Projects, 7E620	Special Projects, 7E620	N/A
5. Proj./Prog./Dept./Div.:	**6. Cog. Engr.:**	**7. Purchase Order No.:**
Tank 241-C-103 Organic Removal	R.J. Parazin	N/A
8. Originator Remarks:		**9. Equip./Component No.:**
ETN-94-0129 Attached is a Restart Plan to be released entitled "Removal of Floating Organic in Hanford Waste Tank 241-C-103		N/A
		10. System/Bldg./Facility: Tank 241-C-103
11. Receiver Remarks:		**12. Major Assm. Dwg. No.:** N/A
		13. Permit/Permit Application No.: N/A
		14. Required Response Date: N/A

15. DATA TRANSMITTED

(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	(F) Impact Level	(G) Reason for Transmittal	(H) Originator Disposition	(I) Receiver Disposition
1	WHC-SD-WM-PLN-092		0	Restart plan for the 241-C-103 Organic Removal	N/A	1/2	1	1

16. KEY

Impact Level (F)	Reason for Transmittal (G)	Disposition (H) & (I)
1, 2, 3, or 4 (see MRP 5.43)	1. Approval 4. Review 2. Release 5. Post-Review 3. Information 6. Dist. (Receipt Acknow. Required)	1. Approved 4. Reviewed no/comment 2. Approved w/comment 5. Reviewed w/comment 3. Disapproved w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION (See Impact Level for required signatures)

(G) Reason	(H) Disp.	(J) Name (K) Signature (L) Date (M) MSIN	(J) Name (K) Signature (L) Date (M) MSIN	(G) Reason	(H) Disp.
1/2	1	Cog.Eng.:T.R. Wilson 9/30/94 H5-09	← w/o ATTACHMENTS		
1/2	1	Cog. Mgr.:C.E. Hanson 9/30/94 H5-09			
		Central Files (2) 28-04	P. Ba		
		OSTI (2) 28-07			

18.	19.	20.	21. DOE APPROVAL (if required)
Thomas R. Wilson 9/30/94 Signature of EDT Originator Date	Carl E. Hanson 9/30/94 Authorized Representative for Receiving Organization Date	Carl E. Hanson 9/30/94 Cognizant/Project Engineer's Manager Date	Ltr. No. ☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments

BD-7400-172-2 (07/91) GEF097

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Document Number:	WHC-SD-WM-PLN-092, REV. 0
Document Title:	Removal of Floating Organic in Hanford Waste Tank 241-C-103 Restart Plan
Release Date:	10/03/94

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SUPPORTING DOCUMENT

1. Total Pages 552

2. Title	3. Number	4. Rev No.
Removal of Floating Organic in Hanford Waste Tank 241-C-103 Restart Plan	WHC-SD-WM-PLN-092	0

5. Key Words	6. Author
Organic Removal 241-C-103 APPROVED FOR PUBLIC RELEASE 10/3/94 D. Vold	Name: Thomas R. Wilson Signature Organization/Charge Code 7E620/N2E32

7. Abstract

The decision whether or not to remove the organic layer from Waste Tank 241-C-103 was deferred until May, 1995. The following restart plan was prepared for removal of the organic if the decision is to remove the organic from the waste tank 241-C-103.

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9. Impact Level N/A

10. RELEASE STAMP

OFFICIAL RELEASE
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DATE OCT 03 1994
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WHC-SD-WM-PLN-092
REV. 0

REMOVAL OF FLOATING ORGANIC IN HANFORD WASTE TANK 241-C-103 RESTART PLAN

Prepared by

Carl Hanson, Manager
Special Projects

MASTER

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Table of Contents

1.0 INTRODUCTION 3

1.1 BACKGROUND 4
1.2 SCOPE 6
1.3 ASSUMPTIONS 7
1.4 COMPONENT DESCRIPTIONS 7

2.0 WORK DESCRIPTION 8

2.1 IN-TANK EQUIPMENT 9

2.1.1 History 9
2.1.2 Current Status 10
2.1.3 Restart 11

2.2 ABOVE GROUND EQUIPMENT 15

2.2.1 History 15
2.2.2 Current Status 16
2.2.3 Restart 18

2.3 REGULATORY 23

2.3.1 History 23
2.3.2 Current Status 23
2.3.3 Restart 23

2.4 SOLID WASTE DISPOSAL 23

2.4.1 History 24
2.4.2 Current Status 24
2.4.3 Restart 24

2.5 SAFETY ANALYSIS/QUALITY ASSURANCE 24

2.5.1 History 24
2.5.2 Current Status 26
2.5.3 Restart 27

2.6 DESIGN 27

2.6.1 History 27
2.6.2 Current Status 28
2.6.3 Restart 28

TABLE OF CONTENTS
(continued)

2.7 ENGINEERING SUPPORT 29

2.7.1 History 29
2.7.2 Current Status 31
2.7.3 Restart 31

2.8 ATTACHMENTS 32

REMOVAL OF FLOATING ORGANIC IN HANFORD WASTE TANK 241-C-103 RESTART PLAN

1.0 INTRODUCTION

For reasons explained in the follow section, the mission to remove floating organic from C-103 was deferred until March 1995 at which time a decision will be made to either continue or terminate the mission. When deferral was decided in August of 1994, the mission team was working toward a March, 1995 Tri-Party Agreement (TPA) milestone. Definitive design was near completion, regulatory strategies were finalized, safety documentation was well underway as was integrated component testing. As a result of the mission deferral, the Waste Tank Safety Program Office developed a strategy to wind down on-going activities in a logical manner by September 30, document the achievements and progress to date and establish a plan to resume the work should the decision be made to proceed. The results of that strategy are reflected in this Organic Removal Restart Plan.

The plan is divided into the major mission elements with a history, current status and the restart requirements identified for each element. All related documentation is described in an attachment section which correlates to each mission element. In addition, the plan presents detailed descriptions of all essential tasks. Technical requirements are provided including those which describe design configuration control and verification methodologies, quality assurance, safety, regulatory requirements, and assumptions.

It should be noted that the plan assumes no changes are made to the strategy considered when the mission was suspended. Provisions are made within the plan, however, to accommodate some measure of expected change. But the degree of impact brought about by any changes derived from the March decision can only be assessed at that time. For this reason and the uncertainties related to program priorities, funding and manpower (should the decision be made to proceed), the plan <u>does not</u> identify restart budget. The plan <u>does</u> provide, however, an overall completion schedule for restart.

In summary, in conjunction with the Engineering Task Plan/Developmental Control document, this plan defines how the removal of the floating organic layer in tank 241-C-103 shall be achieved if the decision is made to proceed with the program in March 1995. Equipment procured in fiscal year 1994 for this program is identified by type and location in Attachment G-1.

1.1 BACKGROUND

Since November of 1987, the U.S. Environmental Protection Agency (EPA) authorized the Washington State Department of Ecology (WDOE) to regulate mixed waste within the state. Under this authorization, the WDOE establishes the operational requirements for the hazardous waste Treatment, Storage and Disposal (TSD) units of which the Single Shell Tanks (SSTs) are a part. In addition, the WDOE delineates the requirements for obtaining permits for these TSD units. The permitting process requires that the operator specify the requirements for operations, closure and post-closure care for the TSDs. The SSTs have been collected into six TSD operable units.

A TSD may be granted interim status under the permit process to allow continued operations until a final permit decision is reached. Interim status for these units has been granted to U.S. Department Of Energy (DOE) through a Part A permit. All interim status activities for continued operations under the Part A permit are regulated under WDOE Dangerous Waste Regulations, Washington Administrative Code (WAC) 173-303 for hazardous chemical constituents in addition to applicable DOE and NRC regulations for radioactive constituents. Authorized under this permit are activities which range from characterization to stabilization and include other activities to mitigate safety concerns (such as limited retrieval) and/or to address unreviewed safety questions (USQ).

In July 1987, noxious vapors emitting from tank 241-C-103 caused illness and observatory hospitalization for two Westinghouse Hanford Company (WHC) workers. The detection of these combustible organic vapors in the headspace of the tank, and the subsequent verification of a second liquid organic phase in the tank, resulted in placing tank 241-C-103 on the Watch List of waste tanks containing high organic content. A USQ was declared for single-shell tank 241-C-103 on September 21, 1992, due to the presence of the floating organic layer on the waste surface. The safety issue related to the potential for ignition of the organic material, resulting in an increase in temperature and pressure within the tank, and consequential release of radioactivity to the environment. Consequently, the removal of the floating organic layer became a Hanford Federal Facility Agreement and Consent Order milestone (TPA) scheduled for completion in June 1995.

WAC 173-303-395 describes the precautions for dealing with ignitable, reactive or incompatible hazardous waste. The TSD operable unit, 200-PO-3 includes tank 241-C-103. This tank contains an immiscible layer of hazardous organic waste which is both ignitable and incompatible with other tank wastes. This regulation requires the separation of the waste. It also provides a listing of prohibitions to be followed when dealing with such materials. The organic layer is believed to be composed of 30 volume percent normal paraffin hydrocarbon and 70 volume percent tributyl phosphate. The organic layer is

estimated to be approximately 2 inches in depth, representing about 5,000 gallons of material in the 75 foot diameter tank.

Removal of the organic from the tank will eliminate the environmental and regulatory concerns and was to allow the safety issue to be closed. A commitment had been made to the DOE to complete the removal of the organic by March 31, 1995. No commitment was made for the disposal of the organic.

The mission was conceived to remedy toxic vapor and flammability concerns related to the 5,000 gallon layer of floating organic in C-103. The mission was initiated with the preparation of a study which developed a suite of options for the retrieval, handling, treatment and disposal of the organic. The study, WHC-SD-WE-ES-293, identified preferred options in each area. This study and follow-on work was performed by Science Applications International Corporation (SAIC).

Drawing upon the study's findings and other programmatic input, two important parallel steps were then taken. A testing program was initiated to screen and validate the preferred technology options identified. Also, a Preliminary Design Report (PDR) was commissioned to more specifically describe the removal, organic/aqueous separations and storage systems to be used for the mission. It was determined through continued investigation and laboratory work that organic treatment and disposal could not be accomplished within a reasonable time and though desirable, was not required to satisfy mission goal. Thus, the scope of the PDR was narrowed to the removal and storage of the organic.

The PDR was issued as a draft and described the removal, separations and storage system to be used as the basis for definitive design and cost/schedule estimates. Preliminary safety analyses were performed parallel with the PDR to support preliminary determination of safety class, hazard classification and hazard category associated with the proposed systems designs. Preliminary design performed by ICF-KH. Major system design drawings have been completed including a construction specification. Fabrication work was to be performed by ICF-KH 200 Area Shops under a development control work plan. This was to allow the results of systems testing to be rapidly integrated into the design control, fabrication and as-building process. This approach was prompted by the aggressive schedule of the mission.

Two key findings came to light during preparation of the PDR which prompted the reassessment of the mission and its possible deferral.

- Objective, quantified data became available which significantly reduced concerns related to the toxic vapor and flammability issues originally raised by the presence of the floating organic.

- Once removed from the tank and stored, disposal of the organic could not reasonably be expected to be achieved for up to five years. This would require on-site storage of the organic for a comparable period.

These findings led to the commissioning of a risk/benefit study of the removal mission to reaffirm its justification. This study has been completed and concludes that, precluding tank stabilization, there appears to be no further benefit in removing the organic as planned, rather than waiting until disposal capabilities are available.

To further focus on the justification of the removal mission, a number of issues are currently being explored. The flammability implications and consequences of floating organic contacting and adsorbing into the sludge through tank stabilization actions, are under investigation. Further sludge sampling will be required to support this investigation. In addition, a study has been commissioned to evaluate the consequences and implications of handling the floating organic through the DST and waste processing systems.

The results of these efforts coupled with an appropriate safety assessment of their findings will lead to a decision to be made by March of 1995 regarding the ultimate disposition of the organic layer. If the decision is made to proceed with the implementation as described in the PDR, this plan has been prepared to describe what will be required for mission completion. If the decision involves any redirection of the mission, i.e. removal to the DST system, etc., appropriate revision of the restart plan would be necessary.

1.2 SCOPE

The information contained herein will describe the position of all major program activities at the end of fiscal year 1994. In addition, this plan will identify all current and outstanding issues that require resolution upon the restart of the floating organic layer removal program. Attention to the details and topics discussed will serve as a comprehensive basis upon which to successfully complete the C-103 organic removal program.

This goal can be broken down into three steps or functions; retrieval, separation and storage. Retrieval constitutes the removal of the organic layer from the tank and its transfer to downstream functions. Separation addresses the task which is required to concentrate the organic and whatever aqueous liquid is carried or mixed with organic into separate process streams. Storage addresses the need to safely contain and store the organic process stream in the course of the engaging the other functions.

1.3 ASSUMPTIONS

The assumptions used in the development of this plan are:

- All identified current technology will be employed, following the successful demonstration of the integrated system.
- Ultimate waste disposal by a licensed commercial operator will be addressed at a later date and is not considered a part of this effort.
- Current personnel involved in this program will be unavailable after fiscal year 1994.
- All current design bases for the organic removal concept and system remain unchanged.
- The decision to remove the floating organic layer will occur in May, 1995.
- All activities described in this plan will remain viable in regards to the program scope.
- Successful restart based on the current strategy of retrieval, separation and storage.
- All fabrication will be completed by the 200E Area fabrication shops.
- ICF KH to complete all remaining design work.
- Identified storage container transportation is available in May, 1995.
- Shielding requirements remain consistent with the current design bases.

1.4 COMPONENT DESCRIPTIONS

RETRIEVAL

The organic layer will be pumped from the tank, undergo separation, and with minimal entrained aqueous be transferred to a storage container. The container will be sited in close proximity to the tank.

The pump is of positive displacement design capable of transferring organic through a double walled pipe system. The pump will operate at low

flows; typically less than 2 gpm. It will be deployable through an existing riser with minimum facility modifications required. Equipment removal from existing risers and pits will be kept to a minimum. The pumping control system will include master pump controls integrated with, pressure and flow indication, multiple and redundant radiation level indication. Diversion capabilities will also be integrated with the control system such that off spec product is returned to the tank.

The pump system will selectively remove the organic phase with minimal aqueous entrainment or mixing. However, the pumped product will undergo separation locally, within the separations enclosure, prior to transfer to the storage container because of the likelihood of carry over, particularly during operations with a thin organic layer remaining.

Retrieval will be a one step process whereby the pumping activity will be sufficient to achieve an acceptable residual thickness of the organic layer.

SEPARATION

Separation of the mixed product stream will be performed by a passive system, specifically a coalesecer. Separation will be performed prior to transfer to the storage container. The activity within the separated organic stream will be within limits suitable for on-site transport using existing packaging and handling practices. The separated aqueous stream will be returned directly to the tank's aqueous layer without treatment.

STORAGE

Temporary storage of the container will be integrated with the treatment strategy. Provisions will be made to acceptably store the container and its organic inventory as required. This will employ the development of temporary storage site(s) to satisfy regulatory requirements. Following treatment, sufficient bulk storage capability for the organic will be available for integration with the off-site disposal strategy. Existing storage facilities (i.e. tank farms) with minor modification are currently satisfactory.

2.0 WORK DESCRIPTION

This section identifies the tasks necessary to perform the organic disposal mission. Requirements for all related design and fabrication of equipment will be per the Engineering Task Plan/Developmental Control document [Attachment E-1]. The following sections summarize each task and its relationship to the mission.

The strategy of the plan is such that the technologies employed are commercially and industrially proven, and adapted as directly as possible to field use. Existing facilities and balance of plant infrastructure will be used as much as possible. Testing has been performed primarily to select and validate concepts and verify performance in our application. These efforts are not to be construed as a development program. It is a plan focused to achieve the timely removal of the floating organic in a manner which is fully integrated with a treatment and disposal strategy.

The work breakdown structure is composed of seven primary components: 1) In-tank equipment, 2) Above ground equipment, 3) Regulatory requirements, 4) Decontamination, 5) Safety, 6) Quality and 7) Design. Each category is further reduced and described accordingly in terms of history, current status and restart.

2.1 IN-TANK EQUIPMENT

Contact: Kimberly L. Morris, WHC Upgrades Program, 376-6878.

The equipment procured for the 241-C-103 organic removal is identified and located in the Attachment G-1 of this document.

2.1.1 History

The in-tank equipment consists of the riser shielding, mast, hydraulic drive unit and motor, the Waukesha pump, the Douglas Engineering skimmer (modified) and organic layer measuring probe. A discovery process fed the choice of most of these components. The following text is a description of how and why these were chosen.

SKIMMER

The skimmer was chosen based on preliminary testing of the most promising technologies available off-the-shelf. The two most promising techniques were based on Ensearch research provided to WHC. The skimmer and another type of skimmer, the density skimmer were purchased and tested with TBP/NPH in the Chemical Engineering Laboratory. Two density-type skimmers from different vendors were recommended. The density skimmer, a plastic buoy with a depressed top, was supposed to float at the surface and just allow the organic to come over its "weir." It was combined with a hydrophobic filter at the weir. Our aqueous was not held out by the hydrophobic filter with either density skimmer. Aqueous could flow freely into the process system so these technologies were discarded. Meanwhile, the Douglas Engineering skimmer did work, being a mechanical weir not dependent on the filter technology.

MAST

The rigid mast concept was not the only option investigated. We also investigated a flexible hose to deploy the system but it quickly became apparent that almost all flexible hoses besides Teflon were not compatible with the TBP/NPH. Metallic hoses were contamination traps. Besides that, the stability was questionable in a hose-deployed system.

PUMP

The Waukesha pump was chosen after a search based on parameters determined to be necessary for successful organic removal.

DRIVE UNIT

The drive unit was originally to be an explosion-proof electric motor. The decision whether the atmosphere was explosive or not was long in coming and changed a few times. Due to concerns from Kaiser engineering, a hydraulic drive unit was chosen. This brought control issues, such as how to determine dead head shut off, up that were not a concern with the electrical motor.

ORGANIC LAYER MEASURING PROBE

The organic layer measurement system was chosen after research into several different types of interface measurement systems. These systems included Ultrasonic Test (UT), time domain reflectometer, buoyancy, and microwave-type gauges. For various reasons (low accuracy for some and high cost for others) most of the devices were undesirable. A UT gauge developed at the Hanford site was chosen after it performed well in a simulant test in the Chemical Engineering Laboratory in March 1994. Another test in the summer of 1994 showed that a calibration device should be added to the probe (a wire set at a known distance from the probe). This was done that summer.

OTHER

Savannah River contacted WHC about the plans for organic removal in C-103. They, too, are removing organic from a tank and are interested in the WHC design and research.

2.1.2 Current Status

The in-tank equipment consists of the following components:

- hydraulic motor and drive
- pump head
- skimmer

In addition, two important issues are pertinent to the in-tank equipment selection:

- materials investigation
- radiation analysis

HYDRAULIC MOTOR AND DRIVE

The skimmer has been tested with water and a test report created. Full-system testing, including the skimmer, pump and hydraulic unit was performed by the Chemical Engineering Laboratory.

The following key accomplishments have taken place during fiscal year 1994:

- Preliminary design complete for the removal system: skimmer, pump riser installation and piping.
- All removal equipment on-site, including the skimmer, pump and hydraulic drive unit.
- Equipment testing complete for the deployment and system concepts.
- Remotely operated flow control valve specified for hydraulic system.
- UT liquid level measurement work package in progress.
- Safety and hazards class designators resolved.

ORGANIC LAYER MEASURING PROBE

The UT test in 241-C-103 was scheduled for late summer of 1994. The Engineering Surveillance Testing group, Dave Smet, Manager, owns and runs the UT probe. Robert Steele is the lead engineer for the UT probe system. Kyle Hein of Tank Farms Test Engineering worked on getting the test performed on 241-C-103. Schedule permitting, the organic measurement system was also to be tested with the complete system in the Chemical Engineering Laboratory.

2.1.3 Restart

The following items, necessary to successfully optimize the retrieval system, are outlined and described below:

- Finalize skimmer flap material selection.
- Incorporate test findings into detailed design. Includes the optimization of the deployment method from baseline.
- Determine pump hose/process lines manufacturing method and configuration.
- Miscellaneous Issues

SKIMMER FLAP

The skimmer requires a flap. The Kalrez flap is adequate, but still has two drawbacks: it doesn't float and it tears easily. An alternate Goretex material has been selected and has undergone preliminary testing with our skimmer in the simulant. All indications are that it should work well (e.g. not shrink) since Douglas Engineering tested a piece of it in our fluid simulant. Clearly, the limiting factor is to determine how long the equipment must withstand the tank radiation field.

To facilitate this investigation, the design life for the skimmer must be resolved. Preliminary radiation analysis showed that the skimmer could potentially be exposed to 250,000 rads during a four-month stint in the tank. This was a very rough calculation done by Pete Owczarski of PNL, based on the samples taken from C-103. A more thorough radiation analysis should be performed upon restart. The analysis may increase the dose for a four month period, since it would include sludge contribution to the dose rate. Many of the issues surrounding skimmer equipment life can be resolved if the mission is limited to four months or less.

This high dose rate is not a problem for most plastics and elastomers. However, Goretex, being made of Teflon, is one of the few that is very radiation sensitive. Some factors to consider in dealing with this issue are:

1) The Goretex works very well as the skimmer flap.
2) The larger skimmer (10.5" weir) will shorten the time required to remove the organic layer.
3) Further analysis may reveal a more accurate dose rate on which to base a decision.
4) Extensive testing at restart to ensure material compatibility for the skimmer flap and the organic.

SKIMMER DEPLOYMENT

The skimmer deployment is currently performed by a lanyard arrangement. The lanyard for the test is not load-tested or verified in any way. It was made from local hardware stock cable and electrical eye fittings to fit the screws on the skimmer top. A quote was received from a lanyard manufacturer to make load-rated lanyards (to at least 100 lbs). The lanyards attached to the skimmer are 18 inches long with an eye connector at each end. The lanyard attached to the pump and the skimmer lanyard is 18 inches long with a loop at each end. Ten of these assemblies, made at the factory, would cost approximately $70 and could be delivered in 4-6 weeks. The crimp fittings are rated to 80% of the maximum line load.

PUMP/PROCESS LINES

The connection between the skimmer and pump can be made of Kynar pipe: molded flexible coil and regular Kynar fittings. The rotational joint arrangement has not been tested as planned. The joints were ordered and found to be very stiff. However, another joint from the 305 building stock was very loose and would have worked mechanically. The benefit to this joint arrangement is the simplicity. Not only does the joint provide an adjustable process line to skimmer, it also is the deployment mechanism.

Two drawbacks, then, are associated with using rotational joints. The first is that all joints found to date had sealant compatibility problems. Should the other process line become too difficult to work with, a more exhaustive search should be conducted on rotational joints. This search would have to include determining if the manufacturers could provide special sealants, such as Kynar and Kalrez. Currently, the sealants are usually urethanes, teflon (acceptable but may not last in the radiation field), or others incompatible with the environment. Hytrel was one, but it hasn't been determined whether Hytrel will withstand the TBP/NPH. Samples of Hytrel were received and stored in the design files for the in-tank equipment.

The second drawback is hinted at in the paragraph describing the joints' use. It is difficult to determine from manufacturer's specifications just how loose the joints will be. The joints that were stiff were ordered because manufacturers specification sheets indicated they were low-torque at low pressure. Several different types of joints would have to be made with the special sealants and tested for the torque required to rotate them.

HYDRAULIC SYSTEM

A small issue requires resolution for the hydraulic lines. They require a clean-out plan for removal. A good option is just to remove them with the fluid inside and coil them as they come out of the tank. If a decision is made to cut the apparatus as it comes out, then the coils would have to be moved out of the way of the cut, of course.

Coupled with this issue is how to empty the hydraulic motor. In speaking with Jerry Johnson, he indicated that the small amount of hydraulic fluid in the system (approximately 2 gallons in the lines and motor) would not affect the tank contents (even the 20 gallons in the reservoir would not do harm). The letter requesting a waiver to fluid addition ceiling would probably cover this if flushing to the tank were necessary. Therefore, flushing the contents to the tank is an option. Still, there is no mechanism in the system to do this right now and I feel it would be unnecessary and wasteful.

A final, perhaps overriding issue to resolve involves the use of the hydraulic motor for this application. Initially, the pump was to be driven by an electric motor. Safety concerns were raised, however, due to the lack of chemical/fire knowledge about the organic. This prompted a switch to the hydraulic drive and motor to eliminate any sparking potential. Throughout the fiscal year new information was gathered, raising many questions concerning the relevant safety classification of the fluid and tank environment. As a result, it may be possible to re-designate the safety class of this system, if an adequate and sound technical basis is shown to exist. If this is the case, an electric motor, in retrospect, will not only be compatible with the removal program, but would eliminate many disadvantages of the hydraulic system (e.g. hydraulic line cleanout procedure and motor fluid removal). It is stressed that upon restart, an electric motor is seriously reconsidered.

MISCELLANEOUS ISSUES

ORGANIC LAYER MEASUREMENT

The organic layer measurement device was demonstrated in the Chemical Engineering Laboratory earlier this year. The device needed some modification to provide a standard distance off of which to calibrate the system when in the fluid. This has been done, but not tested in the simulant. A conflict between measuring the interface in C-103 and accompanying system testing may preclude one of these activities occurring. If so, the missed activity should be taken up upon restart.

Installation of the device was originally planned together with the C-103 video camera. However, this will not be done. The device will be installed as soon as possible following the decision to restart the mission. Precise measurement of the organic layer's thickness is considered necessary to optimize the design of the organic storage system and its installation would become a priority.

MATERIAL COMPATIBILITY

The material compatibility research has not been exhaustive nor totally documented. Mike Britton provided a short report on material changes over time on several plastics and elastomers immersed in the simulant. The preferred materials from this search and tests are:

Chemical and Radiation Resistant
Kynar (hard plastic)
Kalrez (elastomer)
Halar (hard plastic - is used as coating)

Chemical Resistant
Teflon (semi-hard plastic)

Goretex (flexible Teflon)

Another possible candidate for investigation is Hytrel, a hard plastic found, in our case, as a rotational joint sealant.

2.2 ABOVE GROUND EQUIPMENT

Contact: Thomas R. Wilson, WHC Special Projects, 376-5308 for Piping/Separations Enclosure/Storage Container

Contact: Larry A. DellaRocco, WHC Special Projects, 373-4928 for Instrumentation/Electrical/Radiation Monitors/Control Trailer

Equipment procured for the 241-C-103 organic removal program is identified and located in Attachment G-1 of this document.

2.2.1 History

The above ground equipment consists of the overground transfer lines, separations enclosure, storage container, instrumentation/ controls, radiation monitors and the control trailer.

OVERGROUND TRANSFER LINES (OGT)

The overground transfer lines provide the method to transfer the waste streams from the tank riser to the separations enclosure. After processing, the OGT directs the organic waste stream to the storage container and the separated aqueous back to the tank.

Originally, the OGT was to be designed per **WHC-SD-WM-SAR-034, Rev. 0-A "Overground Transfer Line Addendum to the Single Shell Tank Safety Analysis Report"**. However, upon evaluating the criteria, the overall design and questioning those who authored the SAR, it became clear that the document could not be used for the organic removal mission. The SAR consists of a primary pipe inside a secondary containment. The primary pipe is a 1" diameter, ethylene propylene diene monomer (EPDM) lined, stainless steel wrapped, flexible hose. The secondary containment is a stainless steel, welded pipe. Unfortunately, no known vendors currently manufacture piping of this kind. As a result, the SAR specification has been discarded.

SEPARATIONS ENCLOSURE

The separations enclosure is to provide a method of separating any aqueous entrained in the organic waste stream. The separations enclosure also safeguards against in-tank equipment failure or malfunction and ensures that the storage container does become excessively radioactive.

Mechanically, the first concept to be developed included multiple pumps, aqueous and organic accumulation tanks, the coalescer and various instrumentation. By analyzing the hydraulics within the enclosure, the goal was to make the system functional without the need for excessive valving, instrumentation and control switches. This "one on/off switch" approach was discarded for a variety of factors including a requirement that all of the pumps be positive displacement and capable of running dry.

Structurally, the first concept involved mounting all equipment to a removable top. With a crane in place, the separations enclosure equipment could be lifted out of the "box" and worked on. Under the assumption of no maintenance, this would be an acceptable alternative. However, it was decided that if the project were to fail, it would be due to major component error, not insignificant equipment. Therefore, the separations enclosure was to be partially accessible to allow maintenance of all valves, the primary pump and other relatively low activity equipment.

STORAGE CONTAINER

The storage container must receive all of the processed and transferred organic waste from the separations enclosure. Once all the organic has been transferred, the container must be capable of storing the contents for an extended period of time, up to and including 5 years. Further, the container must also be transportable from tank 241-C-103 to the interim storage site to await final disposal. Finally, the container must provide shielding to prevent personnel exposure, during operation, transportation and storage.

During the early stages of conceptualization, a tanker truck (e.g. gasoline truck), was believed to be the ideal container. A system of this type would provide an easily transportable container, Department of Transportation qualified. In addition, much of the hardware for the organic transfer such as pumps, relief valves and flanges would be already present. This concept was discarded however due to the long term storage aspects of the removal program. It was not economically feasible to allow a tanker truck of this type to sit idle during storage. But more importantly, shielding the tanker truck became exceedingly complex, given the geometry of the tank itself. As a result, the current design has changed considerably from the original configuration.

2.2.2 Current Status

In brief, the following major accomplishments have been completed in fiscal year 1994:

ABOVE GROUND EQUIPMENT

- Preliminary design complete on separations and storage system: coalescer, related piping, storage container and transportation.
- Some equipment on site, including valves and transport trailer.
- Radiation exposure analysis completed.
- Completed Packaging Design Criteria (PDC) for storage container.
- Prepared Statement of Work (SOW) for container design/procurement.
- Safety and hazards class designators resolved.

INSTRUMENTATION/ELECTRICAL

- Preliminary design for instrumentation and electrical completed.
- Gamma monitors and associated instrumentation purchased (see Appendix G-1).
- Calibration sources and source holders for Gamma monitors designed and partially fabricated see Appendix G-1).
- Obtained an excess control trailer, at a considerable cost savings, from the Nevada Test Site. The trailer will be used to house the instrument control systems and the operations control room.

OVERGROUND TRANSFER LINES (OGT)

The OGT has been specified as a double shell pipe, the outer shell of stainless steel and the inner tube composed of EPDM, a flexible material. The piping will be simply supported in critical areas by stands. This configuration has undergone radiation analysis to determine appropriate shielding requirements. Shielding for the post-enclosure organic leg does not appear to be required. However, additional shielding is required for the sections containing significant amounts of aqueous.

SEPARATIONS ENCLOSURE

The separations enclosure is a two part structure which contains all of the equipment to separate aqueous from the organic waste stream. Specifically, the enclosure consists of: 1) the outer shell, 2) the shielding wall, 3) active chamber and 4) "inactive" chamber.

The outer shell varies in thickness according to expected radiation activity. For example, the access ports are relatively thin 3/8" steel, with the backside approximately 2" thick.

The shielding wall, 3" thick, was required to reduce potential exposure to maintenance workers replacing a pump or valve. The shielding wall separates the active chamber from the "inactive" chamber.

The active chamber contains all of the equipment which is expected to have high activity. This equipment is not expected to be maintained and is only accessible by lifting, with a crane, out of the enclosure. The "inactive" chamber contains the equipment expected to receive maintenance or be at risk of failure.

STORAGE CONTAINER

The decision has been made to proceed with a storage container, mounted atop a flatbed or lo-boy trailer. A lo-boy trailer was located at the 1171 building, used intermittently by the Hanford Fire Department. Use of this 60 ton, 13.5' wide trailer was granted, with the agreement that the trailer would be replaced (Contact: Ray Roberts, 376-9502). The container would be surrounded by concrete walls of a thickness to ensure proper shielding. The entire package would be taken to the interim storage site to await disposal. The storage container, per the Washington Administrative Code, would be visually inspected at least weekly via a unique remote video system (mobile mast mounted). The video 'stick' would be used in concert with removable concrete "ports" at the four corners of the shielding enclosure.

To conform with site transportation requirements and determine the cost of a system of this type, WHC Transportation and Packaging was consulted. A packaging design criteria document and a statement of work is the culmination of their efforts [See Attachment B-1]. However, the statement of work contains estimates to be used for a concept which differs significantly from the original configuration.

2.2.3 Restart

In brief, the following major issues must be addressed to successful restart the 241-C-103 organic removal program:

- Incorporate filter optimization into detailed design.
- Incorporate shielding analyses findings into detailed design
- Optimization of piping, hydraulics and organic storage/transportation configuration.
- Complete fabrication of calibration sources and source holders.
- Calibrate Gamma monitors.
- Test Gamma monitors and associated instruments in an actual control loop configuration. Establish the high radiation alarm set points and the high radiation system shutdown set points. Verify the high radiation alarms and the high radiation system shut down perform as designed.
- Geoliner. The geoliner material chosen should be tested on contract to relevant government standard testing regimen (e.g. Test # M-3090). Several labs can provide the test which would take 120 days and cost approximately $4000 including a joint test.

OVERGROUND TRANSFER LINES

No significant considerations required for restart.

SEPARATIONS ENCLOSURE

Upon restart, major consideration should be given to the separations enclosure for optimization. Specifically, two areas are worthy of investigation: 1) Pre-filter bank and 2) removal of the aqueous accumulation tank.

The creation of a pre-filter bank will accomplish three major objectives: reduce potential personnel exposure, facilitate particulate removal and reduce the probability of exceeding filter capacity. Currently, the pre-filters are shown as a bank of three parallel Pall Corporation filters. The design ensures that when the differential pressure across a filter is unacceptable, due to particulate buildup, it is valved out to bring another on line. Unfortunately, due to the uncertainties surrounding particle size, three filters may not have enough total capacity. As a result, Ensearch Environmental was given the assignment of determining different pre-filter options. It is strongly recommended at restart that the current filter system be removed from the separations enclosure and replaced with an exterior filter enclosure. This will also require that the piping/valving and radiation calculations be re-evaluated, but the resulting system is expected to be significantly enhanced.

The removal of the aqueous accumulation tank, in another effort to reduce personnel exposure and required shielding, should be considered at restart. The accumulation tank, a concept carried from the original system design with multiple pumps, may be eliminated. It is recommended that hydraulic and pipe routing factors are used when making any decisions regarding accumulation tank removal.

COALESCER

The coalescer that has been specified for the organic layer removal is:

- OSMO Model TSCTB-01-316L-CDE-ALC Coalescer, constructed of carbon steel, built to ASME Code, Section VIII standards and code-stamped. Coalescer includes:
  - Teflon gaskets
  - Unbonded depth coalescing element (36 inches) made of borosilicate glass with steel core and knife-edge seal.
  - Hydrophilic (heavy phase) and Hydrophobic (light phase) Surface Coalescing Elements made of borosilicate glass. Reference # 941320-R2

Vendor: Attn: Michael P. McDonald
Osmonics, Inc.
5951 Clearwater Drive
Minnetonka, MN 55343 612-933-2277

STORAGE CONTAINER

The original schematic of a lo-boy trailer and container is included with the SOW produced by Transportation and Packaging for reference. As mentioned previously, the container was to be placed on a lo-boy trailer to receive the organic waste stream. Once the retrieval mission was complete, the entire system would be moved to an interim storage site. The SOW received from Packaging Engineering describes and estimates a system significantly different from the baseline concept. It must be stressed that the SOW may not be the most viable solution for the storage containment system. At restart, serious consideration and re-evaluation must be performed on the overall container and interim storage equipment. The construction of a semi-permanent concrete storage building and the strategy to lift the container off of the trailer is not recommended.

CONTROL TRAILER - GENERAL

Excess trailer # 9137 was acquired from the Las Vegas Test Site. This trailer will be transferred to the Hanford site and will be modified for use as a control trailer for the 241-C-103 Organic Removal Project. The control trailer will be stored in the 2101M storage area, 200 East area. The modifications to the control trailer will be performed at the 272E building, 200 East area.

Presently there are no heat, ventilation or air conditioning (HVAC) systems installed in the control trailer. The requirements for the control trailer HVAC and associated electrical control systems need to be determined before restart. A wall mounted heat pump should be sufficient for the HVAC requirements. The HVAC unit will need procured.

CONTROL TRAILER - ELECTRICAL

- Upgrades to the control trailer's electrical systems are required.
- Upgrades shall be per drawings H-2-823456, Rev. 0, Sheet 1, One and Three Line Diagrams 241-C-103 and H-2-823457, Rev. 0, Sheet 1, Control Trailer Lighting and Equipment Layout 241-C-103. The existing control trailer 208V to 120/240, 3-15 KVA transformer needs to be replaced with a 480-120/208V, 3 phase, 30 KVA transformer. This Transformer needs to be procured.

Note: Upgrades to the Control Center 271-CR-503-1 (See Below **) were suspended for budgetary reasons. If the upgrades are reactivated prior to the restart of this mission the Engineering Change Notice will be to the new installation drawings. Contact Allen Alstad, 241-C-103 Electrical Cog. Engineer at 373-5639 for upgrade status and directions prior to performing this task.

** Power for the control trailer will be taken from the Control Center 271-CR-503-1 cubicle labeled Air Comp, 271-CR, 25HP. An Engineering Change Notice will be required to drawings H-2-41251 Sheet 1, Rev. A, Electrical Conduit and Grounding Plan, Control Center 271-CR-503-1 and H-2-40262 Sheet 1, Rev. A, Electrical One Line Diagram Waste Metal Removal Facilities 241-CL Area to reflect this change. Note that at the time of restart, other options for power may be available in the proximity of C-103. These options would be assessed at that time.

The drawout unit ("bucket") located in the Control Center 271-CR-503-1 cubicle for the control trailer power needs to be replaced with a 100 ampere breaker. Refer to drawing H-2-40262 Sheet 1, Rev. A, Electrical One Line Diagram Waste Metal Removal Facilities 241-CL Area for details.

The control trailer will be located in the C-Tank Farm. Refer to drawing H-2-823456, Rev. 0, Sheet 2, Civil Site Plan 241-C-103.

Note: Before routing the cable (See Below **) from the control center to the control trailer contact the engineer(s) for the Vapor Treatment System for 241-C-103 Robert (Bruce) Conrad at 376-7299 or Steven Sutey at 373-0532 . This system requires power routed to the C - Tank Farm. Discussion were held on a joint effort to route the power for both systems in a shared permanent installation.

** Route the cable from the control center ** to the control trailer and the control trailer to the separation enclosure per drawing H-2-823455, Rev. 0, Sheet 1, Electrical Site Plan 241-C-103.

The cable from the control center to the control trailer and the control trailer to the separation enclosure shall be run in a protective device consisting of an inverted channel bolted to a one inch thick piece of plywood. Fabricate the protective device per drawing H-2-823458, Rev. 0,Sheet 1, Misc. Details and Distribution panel schedules, 241-C-103.

CONTROL TRAILER - INSTRUMENTS

Installation of the Programmable Logic Controller (PLC) control panel enclosure and the PLC monitor in the control trailer is required. Refer to drawing H-2-823457, Rev. 0, Sheet 1, Control Trailer Lighting and equipment Layout 241-C-103 for installation details.

Modify the PLC enclosure per drawing H-2-823462, Rev. 0, Sheet 1. Instrumentation PLC Enclosure Control Panel Assembly. Install the PLC and the associated instrumentation in the PLC control panel enclosure per drawing H-2-823462, Rev. 0, Sheet 1, Instrumentation PLC Enclosure Control Panel Assembly. Connect the PLC enclosure instrumentation per drawing H-2-823463, Rev. 0, Sheet 1. Instrumentation PLC Enclosure Interconnection Diagram.

SEPARATION ENCLOSURE

Connection of the Separation Enclosure instrumentation, the Separation Enclosure DC T-Box and the PLC Enclosure are required. Refer to drawings H-2-823463, Rev. 0, Sheet 2, Instrumentation Separation Enclosure DC T-Box interconnection diagram and H-2-823463, Rev. 0, Sheet 3, Instrumentation Separation Enclosure AC T-Box interconnection diagram for details.

RADIATION MONITORS

Storage for the radiation monitors has been tentatively located at 272AW. Contact Lee Livesey, Health Physics, at 373-3500 to verify location. The associated radiation monitor's instrumentation, cable, mounting racks will be stored in the control trailer.

The calibration source holders were fabricated per drawing H-2-824277, Rev. 0, Sheet 1, Sample Holder Assembly & Details. The sample holders will be stored in the control trailer. On restart the sample holders will be taken to the 222S Standards Laboratory. The 222S Standards Laboratory will use these holders to fabricate the calibration sources for the radiation monitors. Contact Robert Ford, Cog. Engineer Radiation Monitors, at 376-8585 and/or Wayne Sant, Standards Laboratory, at 373-3991.

The storage containers for the sources need to be designed and fabricated. Contact Kenneth (Dick) Dunn, Site Source Custodian, at 373-0570 for requirements. A radiological control area needs to be obtained for storing the sources after they are fabricated. Contact Lee Livesey, Health Physics, at 373-3500 for location.

The radiation monitors need to be calibrated and tested. Contact Robert Ford, Cog. Engineer Radiation Monitors, at 376-8585 to arrange for calibration and testing.

GENERAL-INSTRUMENTATION

All instrumentation (except the radiation monitors and associated equipment) and the Programmable Logic Controller needs to be procured. PLC software and operator interface software (WonderWare) must be written and validated.

The control ladder logic drawing for the pumps is: H-2-823461, Rev. 0, Sheets 1, Instrumentation Pump Control Logic Diagrams.

The ladder logic drawing for the totalizers and the annunciators is: H-2-823461, Rev. 0, Sheets 2, Instrumentation Totalize and Annunciate Logic Diagrams.

2.3 REGULATORY

Contact: Douglas W. Hendrickson, WHC Engineered Process Applications, 373-7540.

2.3.1 History

On August 8, 1994, the "Notice of Construction For Organic Removal From Tank 241-C-103," was transmitted from DOE-RL to the Washington Department of Health and to the EPA with respect to Washington Administrative Code 246-247 and 40 CFR 61 Subpart H controls of radionuclide emissions. This transmittal provided the technical bases for emission estimates and dose consequence estimates from this activity.

2.3.2 Current Status

A RCRA Part A revision has been prepared for the SST Farms to include container storage areas within the C- and B-farms and the treatment (separation) of the organic layer material from 241-C-103. Submission had been held pending other SST revisions with regard to diversion boxes. Within Unit Manager meetings, the Washington Department of Ecology indicated waiver of notice of intent requirements would be relieved from this activity thereby reducing the lead time requirements for permitting activities prior to the remediation.

2.3.3 Restart

Revision of the SST Farm Part A, may be submitted with an expectation of approval within less than two months.

2.4 SOLID WASTE DISPOSAL

Contact: Mike Ostrom, WHC Tank Waste Remediation System (TWRS) Engineering Support, 376-2478.

2.4.1 History

Typically, during the conceptual, and detailed design phase of a program, the method for accommodating the removal, decontamination, and disposal, of all of the necessary components is worked on, in parallel. It has been a policy at WHC, and particularly within TWRS, that if a piece of equipment, or hardware is installed into a waste tank, or other application, where the component will come into contact with a hazardous, mixed waste, this disposal process must be ready **prior** to the installation phase.

2.4.2 Current Status

The current status of the Waste Handling Plan for the organic removal equipment proposed for tank 241-C-103, is contained in Attachment C-1. This draft proposal outlines a strategy for handling the solid waste, that will be generated if this program is pursued. The proposal was drafted with input from TWRS Operations and TWRS Engineering. At the time the decision was made to delay this program, the attached agreement had not been agreed upon, and signed by the affected parties. This approval will be one of the parts of the restart procedure, if needed.

2.4.3 Restart

Upon receiving a decision to re-start this program to remove the floating organic layer, the agreement contained in Attachment C-1 must be revisited, updated, and approved. This proposal contains a listing of the suggested steps to take, at the time re-start is initiated.

2.5 SAFETY ANALYSIS/QUALITY ASSURANCE

Contacts: Richard Brewster, WHC Safety Analysis, 37372-1061
Yogi Ananda, WHC Quality Assurance, 373-5091
Larry Thomas, WHC Tank Farm Safety, 372-2402
Bill Anderson, WHC Fire Safety, 372-3941
Gary Moist, WHC Project QA, 372-2090

2.5.1 History

Early coordination with TWRS WHC SAR Applications lead to the preparation a preliminary USQ Screening/Evaluation and Safety Classification Analysis. This document in part was used to support the preliminary design work being performed by KEH and the preparation of the Preliminary Design Report. To further support safety classification analysis, SAIC under Purchase Order M315924, Task Order 36, was commissioned to prepare a series of probablistic assessments of specific system elements.

Also early in the mission's development, a Quality Assurance Program Plan was prepared under the direction of Larry Salsbury, Projects Quality Assurance by Gary Moist.

An NFPA Hazards Location Classification was also performed to support the preliminary design effort. This work was performed under the direction of R. A. Huckfeldt, WHC Fire Safety by W. B. Anderson and documented in a series of DSIs.

A Hazards Category and Classification Analysis was also performed by WHC Criticality and Radiological Analyses under the direction of J.W. Daughtry by Chester Huang

With respect to a Safety Evaluation and how it interfaced with the Interim Safety Basis and the Unreviewed Safety Question evaluation, a plan was prepared by TWRS SAR Applications, Greg Henson and issued June 29, 1994. The plan was subsequently approved, funded and implemented. During the course of the safety evaluation process, the lead engineer separated from WHC and the assignment was given to Richard Brewster.

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2.5.2 Current Status

The following is a listing of documents developed in support of the Organic Removal effort in tank 241-C-103:

Date Issued	Document No.	Title
Mar 23,1994.....	USQ TF-94-0119	Evaluation of Proposed Activities in 241 C-103
Apr 12,1994.....	USQ TF-94-0186	Video and Ultrasonic Organic Layer Monitor in Tank C-103
May 27,1994.....	LVN-81D150-94-008	Dose Consequence Calculations in Support of Safety Analysis From Tank 241-C-103
May 31,1994.....	CHH-8D150-94-003	Preliminary Hazard Category For the Tank 241-C-103 Organic Retrieval in the C-Farm
Jun 30,1994.....	CHH-8D150-094	Hazard Category and Classification for an Organic Waste Transfer Container
Aug 15,1994.....	N/A	Hazard and Operability Study For the 241-C-103 Organic Removal Task (draft)
September 30, 1994....	N/A	Hazard Evaluation (draft)
September 30, 1994....	N/A	Consequence Analysis (draft)
September 30, 1994....	N/A	Safety Evaluation (draft)

SAFETY EVALUATION

A draft Hazard and Operability Study (Haz Op) has been issued, commented upon and revised. The Hazard Evaluation, Consequence Analysis and Safety Evaluation have been developed by the safety analysis/risk assessment group. A peer review will not be performed at this time and the documents will be issued as drafts.

2.5.3 Restart

Upon restart, the draft Safety Evaluation must undergo a peer review. It will then be edited and issued for functional and team review, comments resolved and the document issued. Following completion, a USQ evaluation must be performed based upon the Evaluation's findings.

If, following the decision to restart involve changes to the mission, all applicable quality and safety documentation will be reviewed and revised as required.

2.6 DESIGN

Contact: Mark Manderbach, ICF KH, 373-2198

2.6.1 History

ICF Kaiser Hanford (ICF KH) was tasked in March, 1994, to provide support to SAIC in the development of the PDR. ICF KH specific area of responsibility was drawing preparation and text input for support systems description, constructability assessment, design estimate and integrated design and construction schedule, and design uncertainties. Direction to ICF KH was provided through a series of LOIs and approval/revisions to the task's Technical Data Sheet. WHC submitted a waiver request to DOE to selected requirements of DOE Order 6430.1a. ICF KH was directed to proceed with preliminary design under the assumption that the waiver would be approved.

In June, 1994, ICF KH began work on the definitive design for the organic removal system described in the draft PDR. The deliverables were divided into five design packages, divided as follows:

1. Separations enclosure.
2. Instrument enclosure and cabinets.
3. Pump/riser shielding enclosure.
4. Organic storage container modifications.
5. Site work, piping, electrical and piping and instrument drawings.

The design proceeded, including on-going changes as discussed in other sections of this plan.

In August, 1994, package number 4 (organic storage container modifications) was removed from ICF KH scope of work and assigned to WHC by LOI #4. LOI #4 also delineated design modifications required to (1) change the safety classification of the design from 2 to 3 and (2) further reduce personnel exposure. These changes were estimated but not implemented into the design due to the decision to defer the mission.

2.6.2 Current Status

The drawings and construction specification have been completed thru 90% which includes discipline check and comments incorporated. Additionally, WHC has performed a preliminary review of the design packages with comments incorporated. All that is remaining for the final release of the design packages, without any design changes, is the ICF-KH interdiscipline review and a formal WHC design review. The WHC requested waivers to 6430.1a remain pending at this time.

All calculations have been completed in draft form and checked. A file of vendor information that the design was based on has been accumulated and can be found in the project file being retained by Carl Hanson, Mgr. WHC Special Projects. All other related design information will be available in the project file as well. This includes the following:

- Hard copies of all prepared drawings
- Electronic media copy of all prepared drawings
- Draft Construction Specification
- Design Analysis
- Draft Restart Statement of Work
- Miscellaneous design media, vendor data sheets, illustrations, etc.

In addition, Attachment D-2 contains a listing of all project drawings.

2.6.3 Restart

The following is a list of items that will need to be performed by ICF KH to restart to project:

1. Re-mobilize engineering staff (note: current C-103 staff is now dedicated to project W-211).
2. Review and prepare a more detailed SOW and estimate based on requirements at time of restart.
3. Revise existing 90% drawings and/or produce new drawings based on design requirements at time of restart.
4. Conduct 90% check and comment incorporation.
5. Have fabrication shops perform constructability review of the drawings and construction specification.
6. Deliver drawings and construction specification to shops for fabrication.
7. Follow design through fabrication using developmental control procedure.
8. Upon completion of shop fabrication, incorporate all red-line changes into the drawings and complete the formal drawing review

and sign-off to release the drawings prior to commencement of field work.

The following items will be required to be provided by WHC at time of restart:

1. Approved PDR.
2. Copy of all approved waivers to DOE 6430.1A.
3. Approved developmental control procedure.
4. Any new design requirements.
5. Review and approval of ICF KH Technical Data Checklist.
6. Funding to complete the design
7. Shielding requirements for riser, tank and transfer piping.
8. Receiver tank size.
9. Compatibility test results for the storage pad liner.

2.7 ENGINEERING SUPPORT

Contacts:	SAIC -	Mickey M Beary	943-2235
		Pete Owczarski	943-3133
	Enserch -	Russ Treat	372-5812
		Phil Bartley	372-58-5

2.7.1 History

Supplemental engineering support was initiated under the Tank Farm Staff Augmentation Contract MBG-SSV-319149 under which a proposal was prepared for an engineering study of the options to remove the floating organic layer from C-103. This proposal was approved and funded under contract MJK-SVV-315924, call the Regulatory Blanket Order Agreement (BOA). The Regulatory BOA provided the services of SAIC and Enserch Environmental Corporation (formerly Ebasco Environmental) with SAIC serving as the lead organization.All subsequent work was funded through this BOA.

The following is a listing of the Task Orders and Sub Tasks approved under this BOA and the deliverables provided. Attachment H provides a listing of these deliverables as well. Only the Engineering Study prepared under Task Order No 11 was issued through the WHC document control system. All other documents are available from the project file held by Carl Hanson, WHC Manager, Special Projects.

Task Order No.	Deliverables Description
11	Engineering Study investigated a suite of options for the removal, separation, treatment and disposal of the floating organic layer. It including a ranking of the preferred options and regulatory/permitting strategy, cost and schedule for the preferred option.
11 (mod)	A test report covering the vendor test of aqueous organic separation using simulants. The report completed a task which included contacting with the vendor, preparation of the test plan, directing and coordinating the test at the vendor's plant.
24 Sub Task 1	The Preliminary Design Report(PDR) provided the functions and requirements, preliminary engineering and conceptual design necessary for the preparation of definitive design. An NFPA hazards analysis of the above ground removal operation was performed and resulted in a Flammability Hazard Requirements document. This was used in follow-on safety analysis work and preparation of the PDR.
24 Sub Task 2	A Technical Report was prepared under this task provided a technical assessment of Ion Exchange for radionuclide separation of the organic stream. The report included the input of Russian specialists contracted through SAIC. The report was revised to include treatment cost as a function of ion exchange DF, Russian Laboratory test results.
24 Sub Task 3	Provided the technical expertise of Dr. Peter C Owczarski, SAIC, to the WHC team conducting testing with simulants and a coalescer purchased exclusively for testing.
36 Sub Task 1	A Risk/Benefit Analysis was performed to determine the consequences of deferring removal of the organic until a viable disposal option was available.

36 Sub Task 2	This sub-task was to be for the preparation of procedures, data packages and information required for work packages used in mission implementation including document preparation for a readiness review. No work was performed under this sub-task.
36 Sub Task 3	Three Probablistic Risk Assessments were performed covering in-tank, separations, and container transfer and handling operations. These assessments were used in finalizing safety class equipment designations. A Letter Report was also issued finalizing the dispersion analysis to document the consequences to the public and the co-located worker of the organic fire described in the Preliminary Design Report.
36 Sub Task 4	A Technical Report is issued which assessed technologies which could be used to prevent potential interfacial or floating solids from entering the coalescer. The report provided a general over-view of available systems listing attributes and ranked them.

2.7.2 Current Status

Only one task order related to Organic Retrieval remains active under the Regulatory BOA, Task Order 43. This task order is to identify the safety, operational, regulatory and environmental limitations, restrictions and impediments to the transfer and storage of C-103 organic to the 200 E double shell tank farm system. Also to be investigated are the implications the handling of the organic bearing DST product through the evaporator and Effluent Treatment Facility in 2 East.

2.7.3 Restart

Not applicable: this section intentionally left blank.

2.8 ATTACHMENTS

ATTACHMENT A: IN-TANK EQUIPMENT
- ATTACHMENT A-1: SKIMMER TEST REPORT, 305 BUILDING
- ATTACHMENT A-2: CHEMICAL ENGINEERING LABORATORY TEST REPORTS

ATTACHMENT B: ABOVE GROUND EQUIPMENT
- ATTACHMENT B-1: PACKAGING DESIGN CRITERIA
- ATTACHMENT B-2: STATEMENT OF WORK FOR STORAGE CONTAINER
- ATTACHMENT B-3: RADIATION AND SHIELDING ANALYSIS

ATTACHMENT C: SOLID WASTE DISPOSAL
- ATTACHMENT C-1: PRELIMINARY WASTE HANDLING PLAN

ATTACHMENT D: ICF KAISER HANFORD
- ATTACHMENT D-1: RESTART STATEMENT OF WORK
- ATTACHMENT D-2: PRELIMINARY DRAWINGS

ATTACHMENT E: DESIGN/SAFETY DOCUMENTATION
- ATTACHMENT E-1: ENGINEERING TASK PLAN
- ATTACHMENT E-2: PRELIMINARY DESIGN REPORT
- ATTACHMENT E-3: SAFETY EVALUATION

ATTACHMENT F: SCHEDULING
- ATTACHMENT F-1: RESTART SCHEDULE

ATTACHMENT G: RESTART
- ATTACHMENT G-1: PROCURED EQUIPMENT AND LOCATION

ATTACHMENT H: DOCUMENTATION
- ATTACHMENT H-1: ENGINEERING SUPPORT DOCUMENTATION

ATTACHMENT
A-1

Skimmer Assembly for the 241-C-103 Organic Removal Program

A. S. Lee, Testing Engineer
T. R. Wilson, Cognizant Engineer
C. E. Hanson, Cognizant Manager
Mechanical Equipment

September 2, 1994

TABLE OF CONTENTS

	Page
1.0 INTRODUCTION	1
1.1 BACKGROUND	1
1.2 TEST PLAN	1
1.2.1 Floatation Testing of Skimmer	1
1.2.2 Hose Connection Testing	2
1.2.3 Rotational Joint Connection Testing	2
1.2.4 Skimmer Deployment Method Testing	2
1.3 CONSTRAINTS	2
1.3.1 Deployment through 30.5 cm (12") Riser	2
1.3.2 Free Floatation	2
1.3.3 Material Compatibility	2
1.3.4 Weir Angle	3
2.0 TEST METHOD AND TEST EQUIPMENT	3
2.1 FLOATATION TEST OF SKIMMER	3
2.1.1 Skimmer Floatation Without Fittings	3
2.1.2 Skimmer Floatation With Fittings	3
2.1.3 General Comments on Floatation of Skimmer	3
2.2 HOSE CONNECTION TEST	4
2.2.1 Hose Composition Test	4
2.2.2 Kynar Coil Test	4
2.2.3 Drawdown/Level Test with Kynar Coil	4
2.2.4 Kynar Coil Spring Constant Test	4
2.3 ROTATIONAL JOINT CONNECTION TEST	4
2.4 SKIMMER DEPLOYMENT TEST	5
2.4.1 Bracket Fabrication and Attachment	5
2.4.2 Deployment of Skimmer	5
2.4.3 Deployment of Skimmer Through a 30.5 cm (12") Pipe	5
3.0 TEST RESULTS	5
3.1 FLOATATION TEST OF SKIMMER	5
3.1.1 Skimmer Floatation Without Fittings	5
3.1.2 Skimmer Floatation With Fittings	5
3.1.3 General Comments on Floatation of Skimmer	6
3.2 HOSE CONNECTION TEST	6
3.2.1 Hose Composition Test	6
3.2.2 Kynar Coil Test	6
3.2.3 Drawdown/Level Test with Kynar Coil	6
3.2.4 Kynar Coil Spring Constant Test	6

3.3 ROTATIONAL JOINT CONNECTION TEST 6
3.4 SKIMMER DEPLOYMENT TEST 7
3.4.1 Bracket Fabrication and Attachment 7
3.4.2 Deployment of Skimmer 7
3.4.3 Deployment of Skimmer Through a 30.5 cm (12") Pipe . . 7

4.0 CONCLUSIONS AND RECOMMENDATIONS 8
4.1 FLOATATION TEST OF SKIMMER 8
4.2 HOSE CONNECTION TEST 8
4.3 ROTATIONAL JOINT CONNECTION TEST 8
4.4 SKIMMER DEPLOYMENT TEST 9

1.0 INTRODUCTION

1.1 BACKGROUND

Tank 241-C-103, a 22.86 m (75 ft) diameter underground single-shell tank, was placed in service in 1946 for the storage of nuclear waste. As additions of waste were made to the tank, a mixture of tributyl phosphate and normal paraffin hydrocarbon (TBP/NPH) was added to the aqueous solutions and sludge already in the tank. The TBP/NPH mixture layer, the top liquid layer of the waste, is about 6.5 cm (2.5 in) thick and represents about 19,000 L (5,000 gallons). This layer of organic waste has a relatively low radioactivity if unmixed with the aqueous content. However, laboratory tests have shown that the organic layer is easily miscible in the high activity aqueous.

If the organic layer mixes with the aqueous content upon removal, a highly radioactive product will be taken to the surface. This potential scenario causes much worker safety and organic processing concerns. One challenge in removing the organic layer is, therefore, to find a removal system that provides flow in the laminar region. Laminar flow of the organic material greatly reduces mixing with the aqueous layer.

There are two other challenges for removal: (1) the removal system must be deployed remotely through a 30.5 cm (12 in) tank riser; and (2) plastics and elastomers that are compatible with the organic mixture must be used. Tributyl phosphate and normal paraffin hydrocarbon are solvents and are incompatible with many materials. Also, the radiation level of the contents reduces the material candidates even further.

The removal system that has been chosen and scheduled for testing is made up essentially of three parts: the skimmer; the pump; and the connection between the skimmer and pump.

The skimmer will float on the waste, feeding a sanitary pump. The skimmer is a stainless steel rectangular float with a central sump. Fluid enters the sump through a floating weir that is hinged to the body of the skimmer. In front of the weir is an elastomer flap. This flap provides the liquid-tight seal to the aqueous solution below the organic. A port located at the center of the back side of the skimmer connects to a flexible hose or rotational joint which, in turn, connects to the pump inlet.

1.2 TEST PLAN

The following are the testing plans of the skimmer for the C-103 organic layer removal program.

1.2.1 Floatation Testing of Skimmer

Observations and measurements will be made on the skimmer. Floatation behaviors of the skimmer will be noted.

1.2.2 Hose Connection Testing

Appropriate composition hoses and various hose configurations will be tested. Effects of these hose compositions and configurations on the skimmer's floatation behavior and function will be noted.

1.2.3 Rotational Joint Connection Testing

Appropriate rotational joint and piping configurations will be tested. Effects of these configurations on the skimmer's floatation behavior and function will be noted.

1.2.4 Skimmer Deployment Method Testing

Various methods for the skimmer deployment will be tested. These methods will take into consideration the constraints of the deployment environment. Appropriate hose compositions and configurations will be incorporated with the deployment methods. Observations and measurements will be made on the deployment methods and improvements will be made accordingly.

1.3 CONSTRAINTS

1.3.1 Deployment through 30.5 cm (12") Riser

The skimmer and the associated connection between it and the pump must fit in a 3.05 m x 0.305 m (10' x 12") schedule 40 pipe.

1.3.2 Free Floatation

The skimmer must be allowed to free-float on the organic/aqueous fluid. The skimmer is composed of a weir arrangement that allows only the top portion of the liquid on which it floats to enter the sump. By this method, it "skims" the undesirable liquid (e.g., a gasoline spill) off of the water. As the skimmer operates, it reduces the overall fluid level in the tank and hence must follow that reducing level. The organic layer in C-103 is believed to be 5 to 6.4 cm (2 to 2.5") deep, so the skimmer must freely float with a vertical range of motion of at least 6.4 cm (2.5"), preferably 7.6 to 8.9 cm (3 to 3.5"). Several deployment scenarios have been conceptualized and must be tested.

1.3.3 Material Compatibility

The organic material in the tank is a solvent for many plastics and elastomers. Teflon, one of the few plastics compatible with the organic material, cannot withstand the radiation levels in the tank for the prescribed three months. Three others have merit: Kynar, Kalrez and Santoprene. Kalrez is a special order and is very costly. Therefore, Kynar (polyvinyledene fluoride; PVDF) and Santoprene will be the first to be tested. Since Teflon is similar to Kynar in rigidity and because information was urgently needed, initial tests were done with Teflon. Kynar was then purchased for testing.

1.3.4 Weir Angle

The skimmer weir must be parallel lengthwise with the plane of the fluid. It will not function properly if the skimmer floats at a side-to-side angle (although temporary upsets can be tolerated). The skimmer has a higher tolerance for floating at a front-to-back angle (see Figs. 1, 2). According to the vendor, the skimmer can be nose down (weir side) as much as 20°, and nose up as much as 10°.

2.0 TEST METHOD AND TEST EQUIPMENT

2.1 FLOATATION TEST OF SKIMMER

Equipment list:

skimmer (model SHX 650, serial # 2357)
water tank, plexi glass
Kynar fittings, 1/2"
high pressure fittings, 1/2"
laboratory scale, Mettler PK 36 (max capacity 30,000 g, WHC calib exp 9/11/94, Prop # WA 49517, Code # 347-06-01-004)
protractor (angles & lengths)

Note: All hose and fitting sizes are intentionally left in English units, the units used in the catalogues.

2.1.1 Skimmer Floatation Without Fittings

The skimmer was allowed to float freely in the water tank without the fittings attached. Floatation behaviors were noted. Measurements were taken of the front and back heights of the skimmer's top edge from the water surface (see Fig. 1).

2.1.2 Skimmer Floatation With Fittings

The proper weight allowance of the fittings was determined to allow for the skimmer to float level with the surface of the water. The proper fittings were attached to the skimmer. The skimmer was then allowed to float freely in the water tank. Floatation behaviors were noted. A measurement was taken of the height of the skimmer's top from the water surface (see Fig. 2).

2.1.3 General Comments on Floatation of Skimmer

Some general observations on the skimmer's floatation behaviors were made. Irregular floatation tendencies were noted.

2.2 HOSE CONNECTION TEST

Equipment list:

Santoprene hose (1/2" I.D. 73 Durometer)
Teflon hose (3/8" I.D. 1/2" O.D.)
Kynar hose (1/2" I.D. 5/8" O.D.)
oven
peristaltic pump, Cole-Parmer Masterflex (model 7549-39, serial # 429493)
pulley assembly

2.2.1 Hose Composition Test

Santoprene, Teflon, and Kynar hoses were tested for applicability. Negative pressure tests were performed on the different composition hoses. The best material, Kynar, was chosen of the three hoses.

2.2.2 Kynar Coil Test

The Kynar hose was manipulated into a coil configuration by softening the material with heat (~150°C). Two coils of different pitches were fabricated. The two coils were tested with the skimmer for stability and the better of the two was chosen for continued testing.

2.2.3 Drawdown/Level Test with Kynar Coil

The Kynar coil was attached to the fittings on the skimmer and the entire assembly allowed to float in the water tank. Water was pumped through the coil allowing the skimmer to follow the water level and skim 5 cm (2") of water while the top of the coil remained stationary (see Fig. 3). This was done with various flow rates and measurements of the front and back heights of the skimmer from the water surface were taken. A relationship was determined between the flow rate, the amount of drawdown of water, and the front-to-back leveling of the skimmer.

2.2.4 Kynar Coil Spring Constant Test

The spring constant, k, of the Kynar coil was determined for both a dry coil and one filled with 45°C water. The coil was secured to the weighing surface of the lab scale by means of anchoring using a heavy weight. A small rope was attached to the upper end of the coil which ran up to a pulley assembly above the coil. The rope was pulled to stretch the coil (see Fig. 4). The distances of stretch and the corresponding forces applied were collected. Using this data, the forces v. distances was graphed and the two spring constants were determined.

2.3 ROTATIONAL JOINT CONNECTION TEST

(Test not completed due to scheduling conflicts in the full-system testing at the Chemical Engineering Laboratory.)

2.4 SKIMMER DEPLOYMENT TEST

Equipment list:

sheet metal
eye-bolts
light cable
PVC pipe, ~30.5 cm (~12") I.D.

2.4.1 Bracket Fabrication and Attachment

A bracket was made from thin sheet metal and fastened to the top of one end of the skimmer using the existing acorn nuts on the skimmer. Two eye-bolts were attached to the bracket at the two top corners of the end of the skimmer. The skimmer was suspended by light cable attached to the eye-bolts (see Fig. 5).

2.4.2 Deployment of Skimmer

With the bracket fastened to the skimmer, the assembly was lowered into the water tank using the cable. The skimmer was deployed into the water at different velocities and observations were noted on the final resting position of the skimmer in the water.

2.4.3 Deployment of Skimmer Through a 30.5 cm (12") Pipe

With the same bracket and cable assembly attached, the skimmer was deployed through a 30.5 cm (12") PVC pipe, simulating a riser, into the water tank. Observations were noted on the deployment through the pipe and the final resting position of the skimmer in the water.

3.0 TEST RESULTS

3.1 FLOATATION TEST OF SKIMMER

3.1.1 Skimmer Floatation Without Fittings

The free-floating skimmer without fittings floated with the front end submerged considerably under water. The rear end was lifted out of the water approximately 2.5 cm (1") from the water surface (see Fig. 1).

3.1.2 Skimmer Floatation With Fittings

In order for the skimmer to float level on the water, a mass of 720 g placed on the center of the back end was required. Kynar fittings approximating that weight was attached to the skimmer. With the proper fittings attached, the skimmer floated level with a height of 0.6 cm (0.25") from the water surface (see Fig. 2).

3.1.3 General Comments on Floatation of Skimmer

The free-floating skimmer with fittings attached remained afloat at a level position if undisturbed. However, if forced to sink below the water level, the skimmer was not able to correct itself into a proper level position. Also, if the skimmer is placed gently into the water, it had a tendency to float with its front end rising out of the water making water flow into the sump impossible.

3.2 HOSE CONNECTION TEST

3.2.1 Hose Composition Test

Of the three hoses available Santoprene and Kynar were the two best suited for the environmental conditions for which they would be exposed to. The Santoprene hose, having a rather thin and flexible construction, had a tendency to collapse upon application of negative pressure. Therefore, Kynar was chosen as the best composition of the three hose choices.

3.2.2 Kynar Coil Test

Two coils, A and B, were made from the Kynar hose with pitches of 3.2 cm and 7.0 cm (1.25" and ~2.75") respectively. Testing showed that coil B was able to maintain the skimmer at a more stable position and was thus chosen for the coil to be used in the continued testing.

3.2.3 Drawdown/Level Test with Kynar Coil

Coil B from the previous test was used. With different flow rates used for the various trials, the skimmer was maintained at a fairly level position throughout the drawdown process (see Fig. 6). The data obtained was graphed to show the relationship between the flow rate, the amount of drawdown of water, and the front-to-back leveling of the skimmer (see Fig. 7).

3.2.4 Kynar Coil Spring Constant Test

A force v. distance graph was made using the data acquired for both a dry coil and a coil filled with hot water (Fig. 8). A best fit for the two graphs were calculated and the resulting spring constants, k, for the dry and wet coils respectively were 57.0 kg/s^2 and 43.1 kg/s^2.

3.3 ROTATIONAL JOINT CONNECTION TEST

(Test not completed due to scheduling conflicts in the full-system testing at the Chemical Engineering Laboratory.)

3.4 SKIMMER DEPLOYMENT TEST

3.4.1 Bracket Fabrication and Attachment

The sheet metal bracket was attached securely to the skimmer, however the weight of the bracket needed to be reduced for the skimmer to float at its proper level position. This was done, but not tested.

3.4.2 Deployment of Skimmer

Deploying the skimmer at moderate velocities (~0.3 to 0.5 m/s), it had a tendency to float nose-up not allowing for water to flow over the weir resulting in an inoperable skimmer. Better results were obtained when the skimmer was deployed at slower or faster velocities, although at times the skimmer would stabilize in a submerged position also resulting in an inoperable skimmer.

3.4.3 Deployment of Skimmer Through a 30.5 cm (12") Pipe

While deploying the skimmer through the 30.5 cm (12") PVC pipe, the arrangement had just adequate space at the angle with which the skimmer was held. The skimmer was able to be lowered through the pipe although contact of the skimmer to the walls of the pipe was difficult to avoid. Final resting positions of the skimmer upon insertion into the water were identical to the results above.

4.0 CONCLUSIONS AND RECOMMENDATIONS

The testing regimen, while not conclusive, clearly establishes the applicability and likelihood of success for the proposed skimmer system. The results should not be construed as final, however, since the testing was conducted with a single phase liquid. The single phase liquid, among other variables, do not represent the actual conditions in the tank. Further, due to the unavailability of components, the rotational joint connection was not tested.

The Kynar hose connection and skimmer, coupled with the recommendations below, should be capable of removing the floating organic layer in waste tank 241-C-103. An additional suggestion is the use of a real time video system to monitor the critical phase of skimmer deployment.

The major unsolved issue with the skimmer is the gasket material used for the flap. While Kalrez can function properly, it is not ideal given that it does not possess floating capabilities and is also easily torn.

4.1 FLOATATION TEST OF SKIMMER

Two issues were identified which must be taken into account to ensure the successful use of skimmer technology. First, the skimmer was shown to possess very good side to side stability, however front to back floatation is delicate at best. As a result, the skimmer fittings must be positioned to compensate for the tendency to tip too far nose down at deployment.

Second, initial placement in the aqueous solution is critical to floatation. The sump must be allowed to take on fluid, without the skimmer top surface being extensively submerged. Failure to accomplish this position at the initial deployment could result in permanent submergence.

4.2 HOSE CONNECTION TEST

The pump connection is critical to the practical application of the skimmer with the organic removal program. The pump connection must be flexible enough to allow the skimmer to float freely, while possessing the material properties necessary to be compatible with the pumped liquids and radiation environment.

The hose connection was shown to be feasible, with Kynar demonstrating the above characteristics. It is recommended that further work is performed to determine the ideal spring constant for the skimmer system.

An effective method of forming Kynar hose into a coil configuration must be determined on site or contracted from the vendor. If on-site fabrication is chosen, there exist several methods that are simple to apply.

4.3 ROTATIONAL JOINT CONNECTION TEST

(Test not completed due to scheduling conflicts in the full-system testing at the Chemical Engineering Laboratory.)

4.4 SKIMMER DEPLOYMENT TEST

With the use of an additional bracket to facilitate proper deployment, the skimmer can easily pass through the 30.5 cm (12") diameter riser. The bracket tested was to establish the concept only, and as a result was too heavy and affected floatation. Without properly accounting for the additional load on the skimmer, side to side floatation becomes adversely affected. If this event occurs, improper skimmer function will result. A new lanyard arrangement was assembled and did not seem to affect floatation, but this was not officially tested. This new arrangement will be used during the full-system testing at the Chemical Engineering Laboratory.

In addition, the velocity at which the skimmer is placed on the surface of the liquid is critical. As mentioned in previous sections, the skimmer must be deployed fast enough to add liquid to the sump, but not too slow as to be nose up and inoperable.

FIGURES

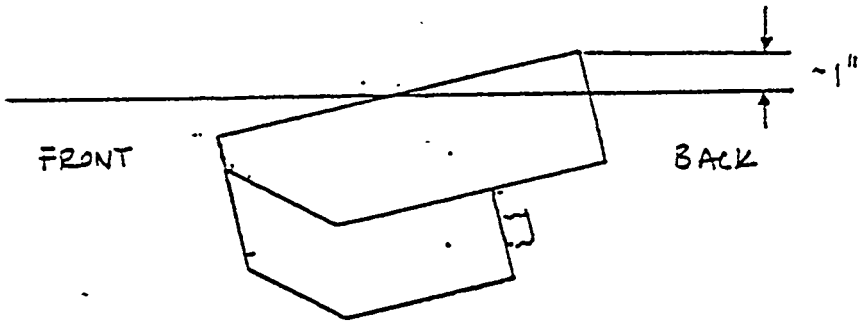


Fig. 1 Skimmer Floatation without Fittings

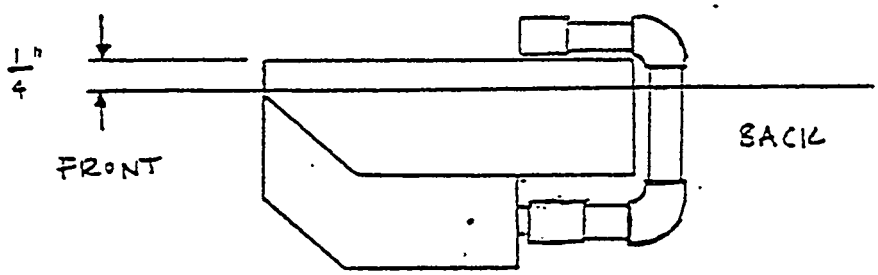


Fig. 2 Skimmer Floatation with Fittings

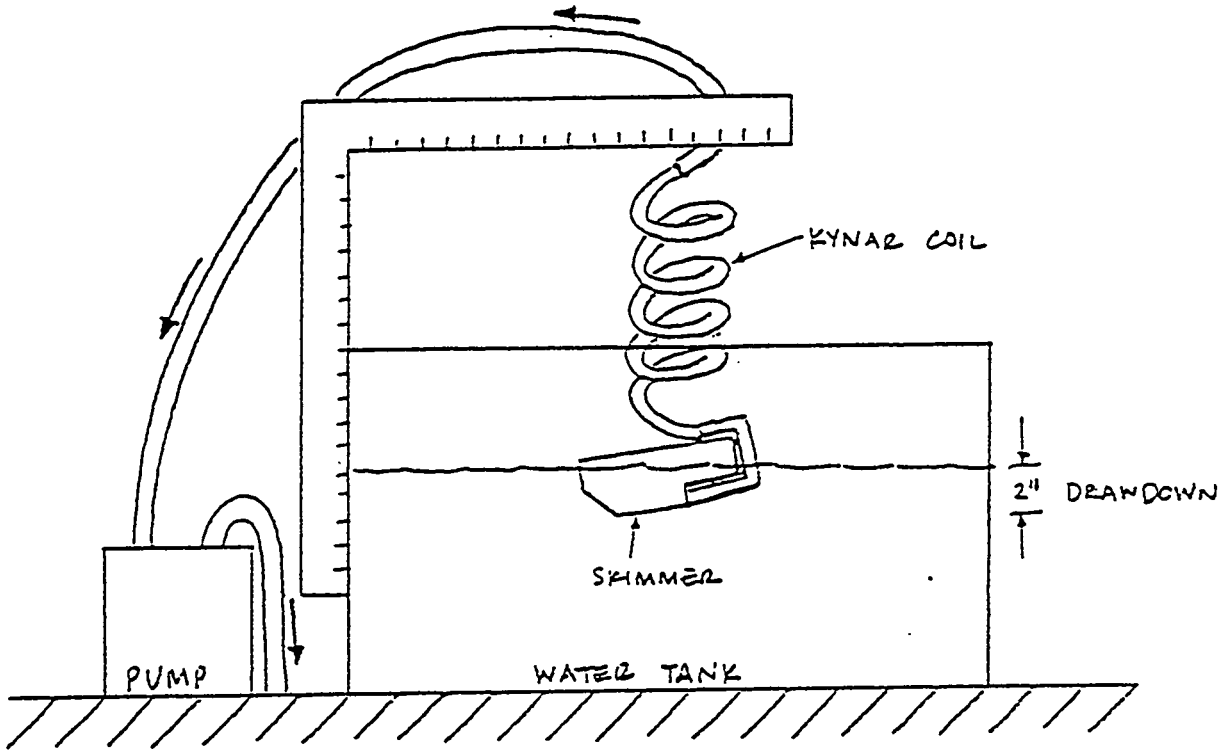


Fig. 3 Drawdown/Level Test

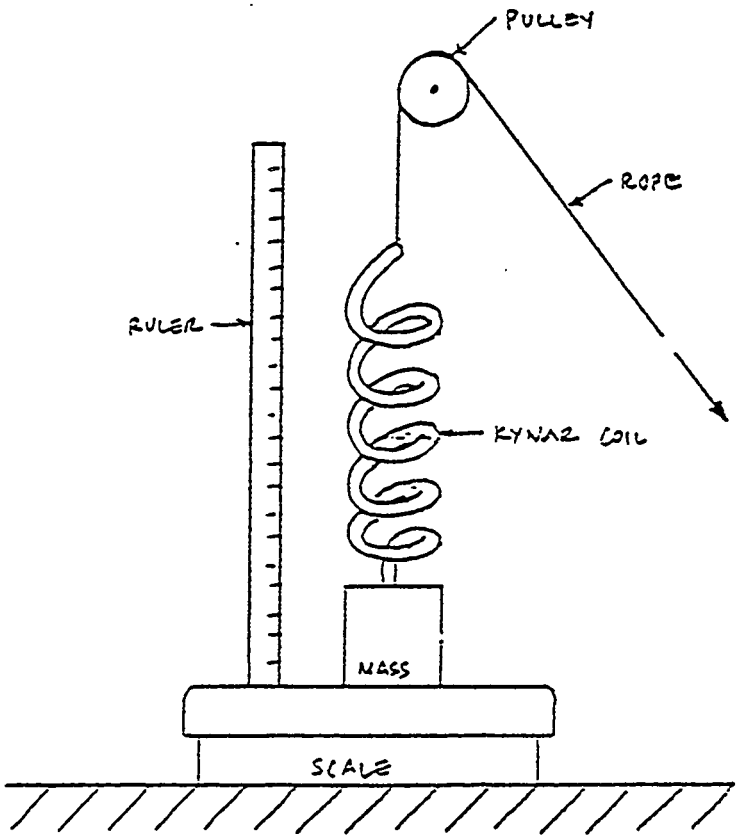


Fig. 4 Kynar Coil Spring Constant Test

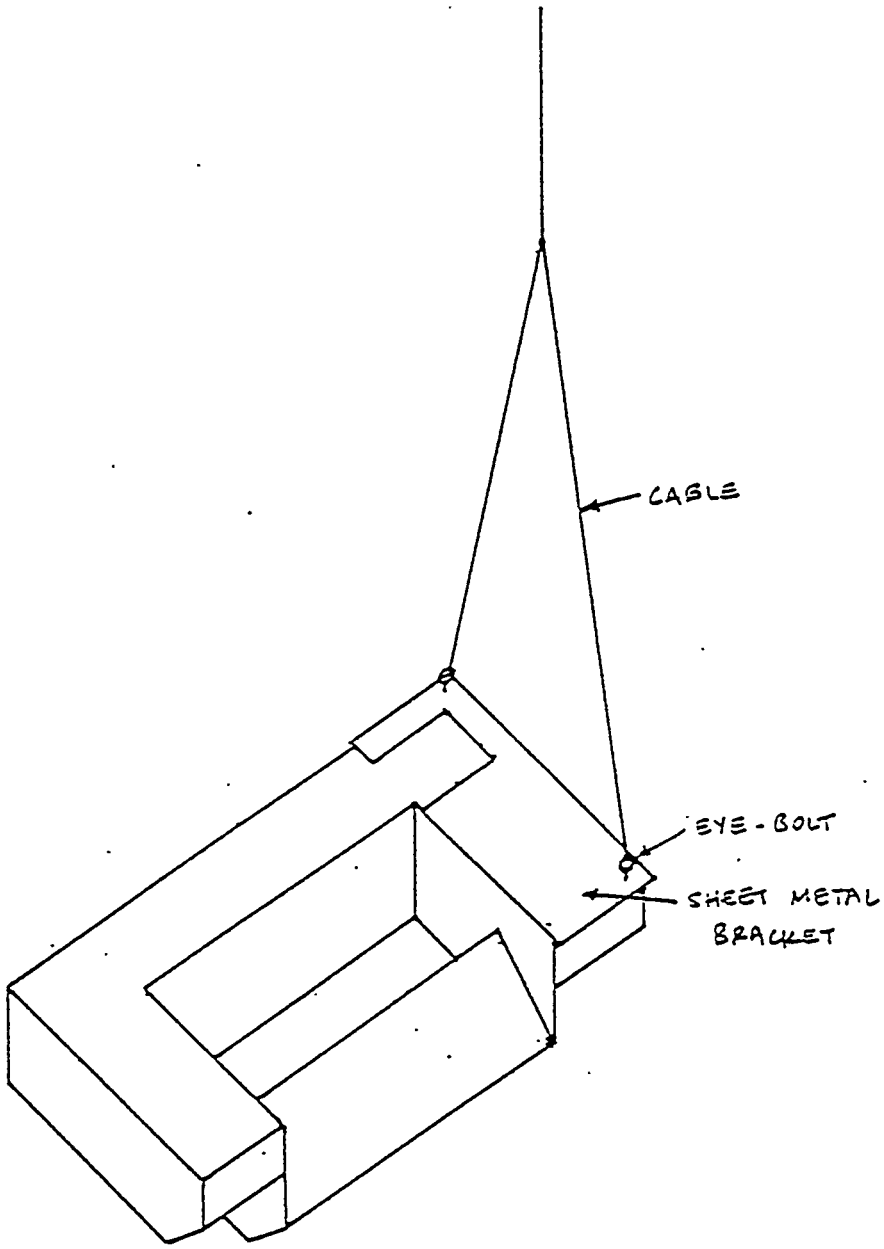


Fig. 5 Skimmer Bracket Attachment

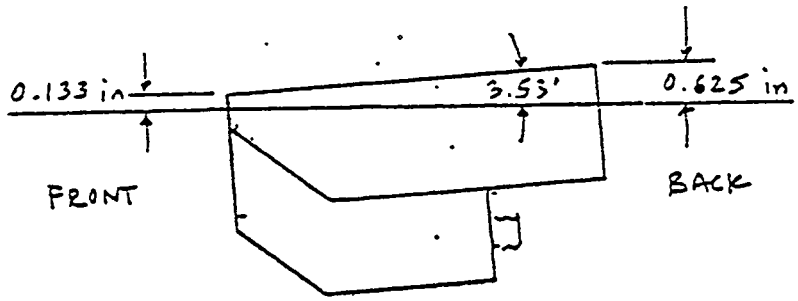


Fig. 6-A Skimmer's Average Initial Floatation Position

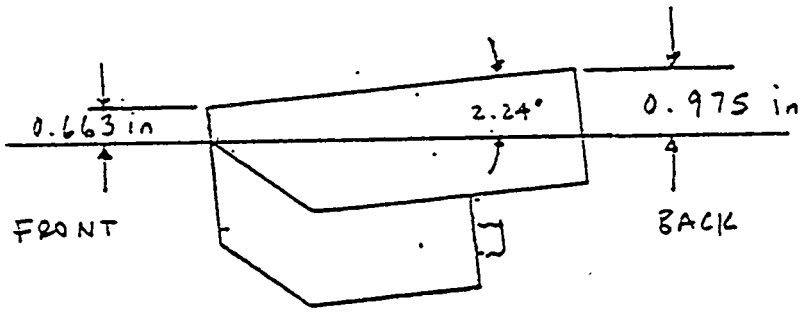


Fig. 6-B Skimmer's Average Final Floatation Position

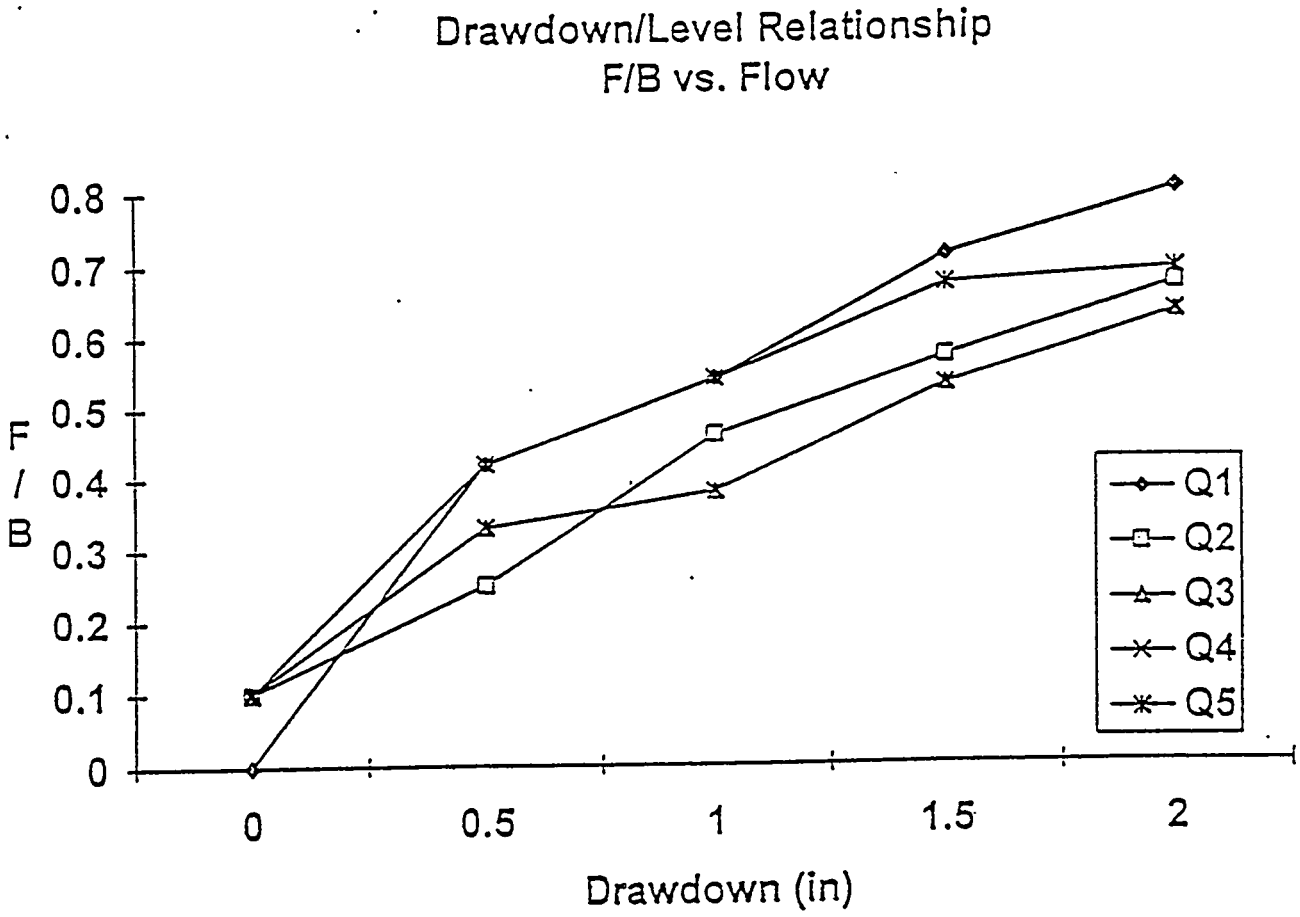


Fig. 7 Drawdown/Level Relationship

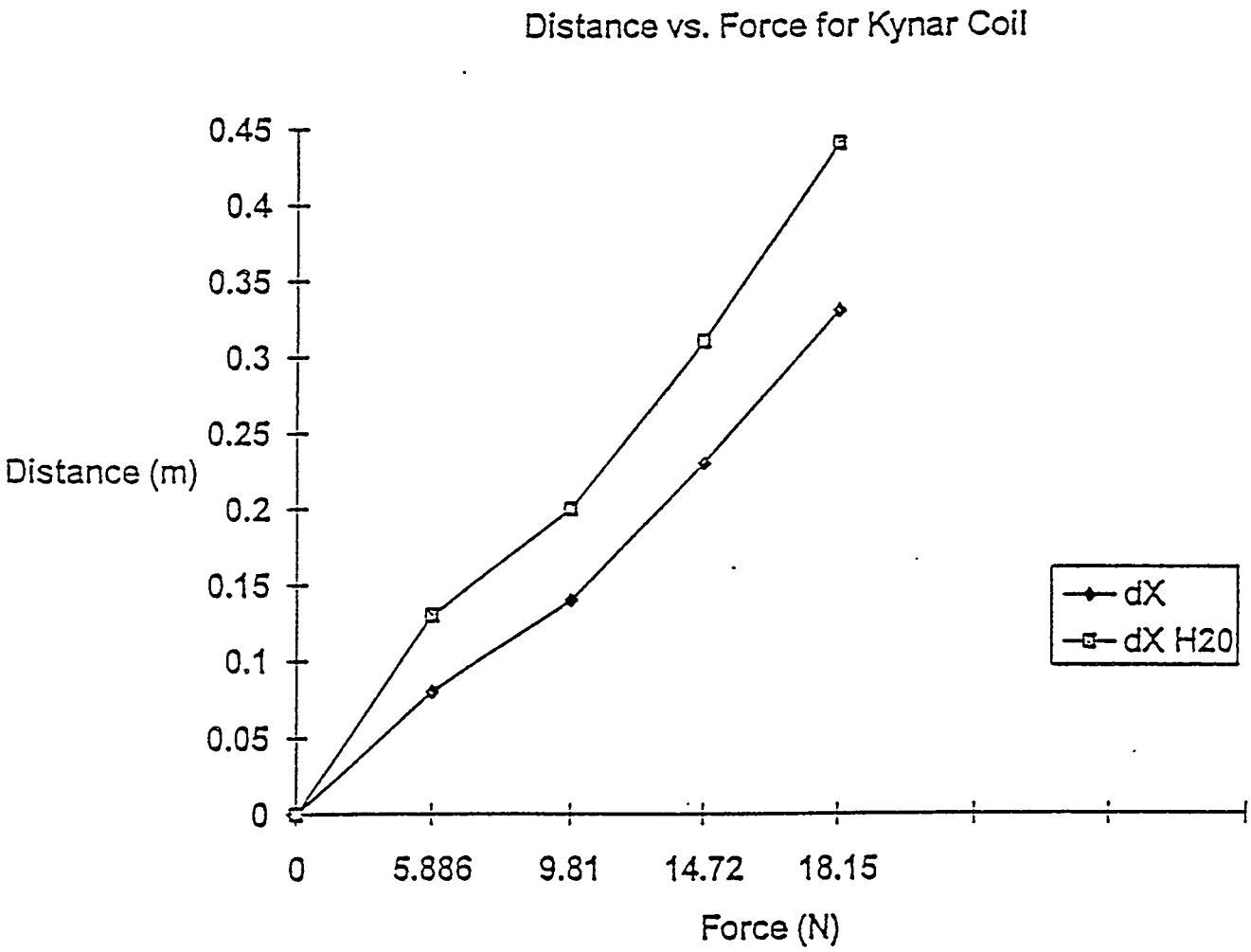
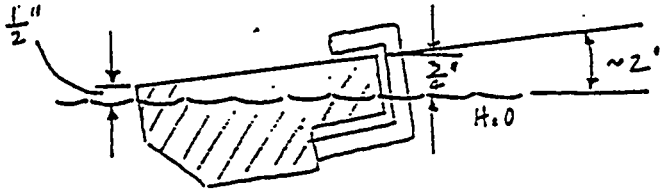


Fig. 8 Distance vs. Force for Kynar Coil

WT OF SKIMMER : 2695 g
WT OF FITTINGS : 468 g

WT OF SKIMMER & FITTINGS : 3163 g

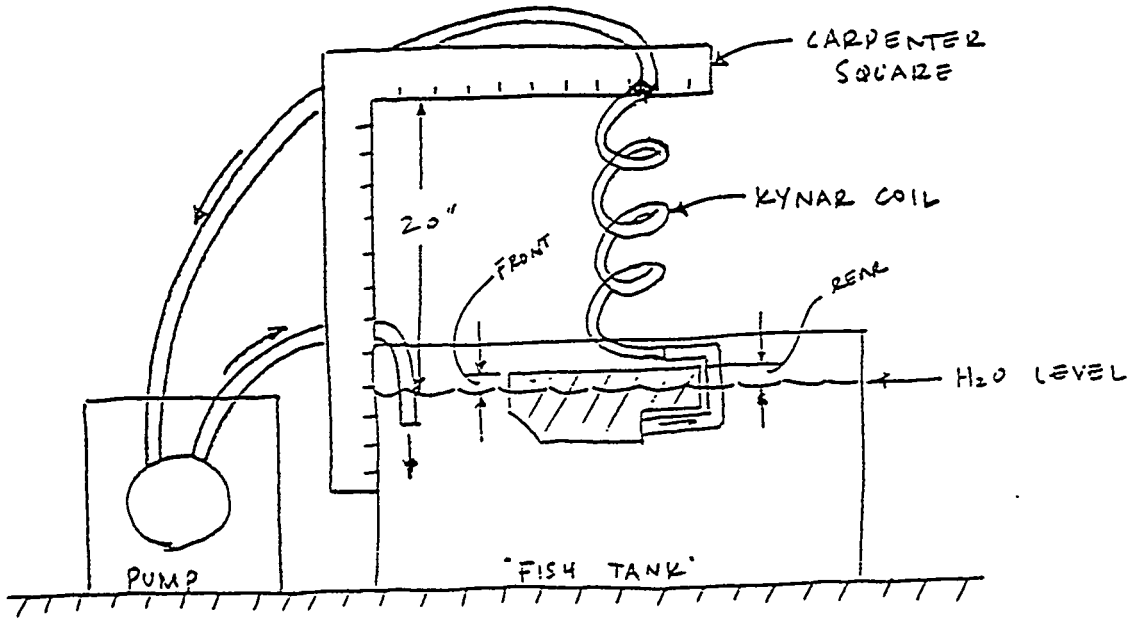
- SKIMMER W/ FITTINGS FLOATED AS ILLUSTRATED BELOW :



- KYNAR COIL TEST

	WEIGHT	DIA. (I.D./O.D)	PITCH	LENGTH
COIL A	400 g	4/5 in	~1.25 in	13 in
COIL B	272 g	3.75/4.5 in	~2.75 in	19 in

* COILS TESTED WITH PUMP IN OPERATION AT 8 L/min.



TEST SETUP

COIL TEST RESULTS

	PUMP HOSE TO SKIMMER DISTANCE		
	18"	20"	22"
	FRONT / REAR HEIGHT FROM H_2O		
COIL A	$\frac{1}{16}$" / $\frac{3}{4}$"	$\frac{7}{8}$" / $\frac{5}{8}$"	$1\frac{1}{4}$" / $\frac{3}{4}$"
COIL B	$\frac{1}{8}$" / $\frac{1}{4}$"	$\frac{1}{2}$" / $\frac{5}{8}$"	$\frac{7}{8}$" / $\frac{3}{4}$"

* THESE FRONT AND REAR DISTANCES ARE WITHIN THE BOUNDS OF THE FRONT-TO-REAR TILT LIMITS.

* THERE WAS NO NOTABLE TILTING FROM SIDE-TO-SIDE.

8-4-94

The pump and Kynar coil connection was attached to the skimmer. The skimmer was allowed to float freely in the water tank. Using the apparatus shown below, a relationship was developed for the floatation behavior of the skimmer to the amount of drawdown of the water. Specifically, the ratio of the front to back heights of the skimmer top from the water surface was compared to the flow rate of the pump during different intervals of the two inch drawdown of the water.

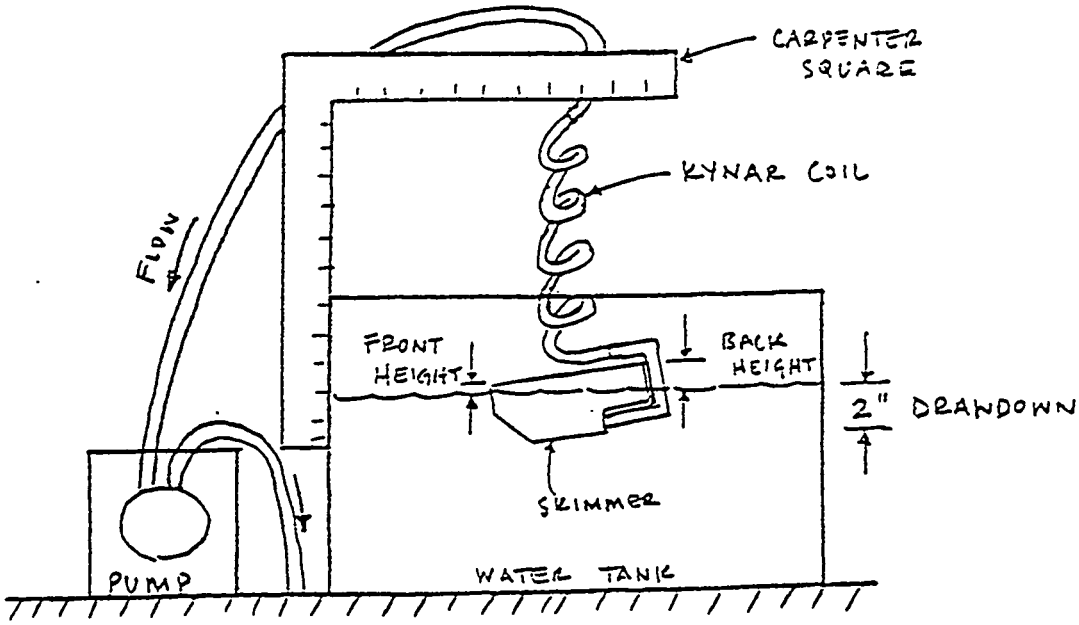
Skimmer

weight:	2695 g
weight with fittings:	3150 g

Coil (Kynar)

weight:	272 g
diameter (I.D./O.D.):	3.75/4.5 in
pitch:	~2.75 in
length:	19 in
no. coils:	6

Apparatus



flow rates used: Q1 = 30 mL/s
Q2 = 60 mL/s
Q3 = 90 mL/s
Q4 = 120 mL/s
Q5 = 150 mL/s

front/back ratios taken at half-inch intervals of the two-inch drawdown.

Results

The skimmer remained level from side-to-side.

Initially, the front/back height ratio was small (front height was much smaller than the back height), but as the water was drawn down the skimmer became more level.

Figure A: Skimmer's average initial floatation position.
Figure B: Skimmer's average final floatation position.

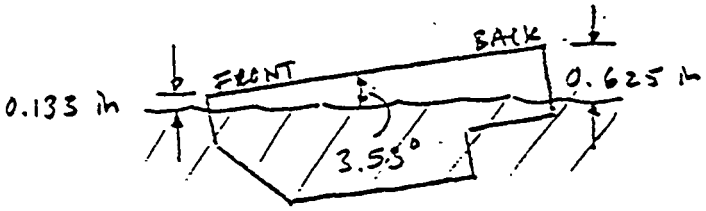


Fig. A

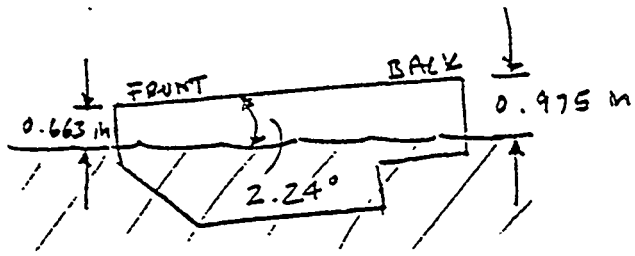


Fig. B

See attached graph.

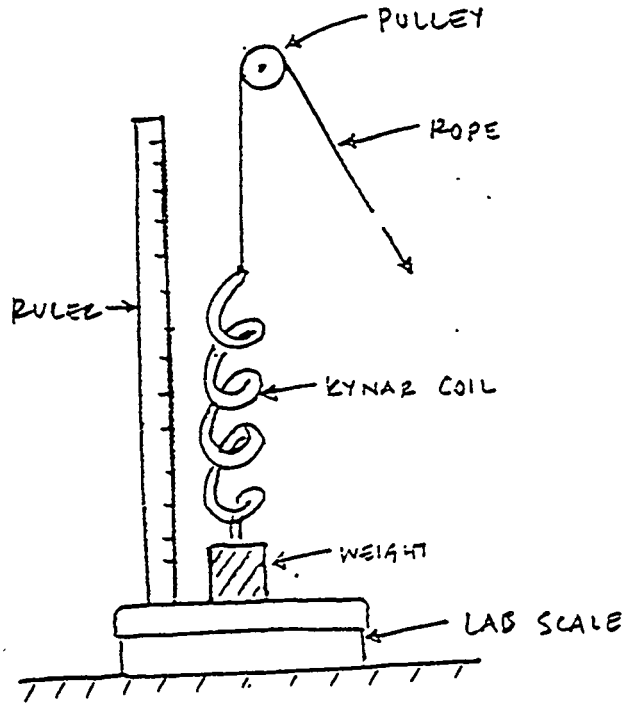
Kynar Coil Spring Constant Test Results

Tests were performed to determine the spring constants of the Kynar coil when dry and when filled with hot water. The Kynar coil was secured to the weighing surface of a lab scale by means of anchoring using a heavy weight. A small rope was attached to the upper end of the coil which ran to the pulley assembly above the coil. The rope was pulled to stretch the coil. The distances of the stretches and the forces applied to the Kynar coil were collected. This was done for both a dry and a hot water-filled Kynar coil.

Kynar Coil

weight:	272 g
dimensions:	1/2" x 5/8"
pitch:	~2.75 in
length:	19 in
no. coils:	6

Apparatus



Note: Temperature of hot water was 45°C.

Results

The data for the forces and distances was graphed.

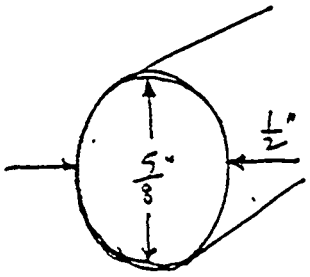
Spring constant for dry coil:	57.0 kg/s^2
Spring constant for water-filled coil:	43.1 kg/^2

KYNAR COIL SPRING CONSTANT TEST

	MASS (g)	DISTANCE (cm)	(m)	FORCE (N)
DRY TEST	0	44	1.12	0
	600	41	1.04	5.886
	1000	38.5	0.98	9.810
	1500	35	0.89	14.715
	1850	31	0.79	18.149
H_2O @ 45°C	0	42.5	1.08	0
	600	37.5	0.95	5.886
	1000	34.5	0.88	9.810
	1500	30.5	0.77	14.715
	1850	25	0.64	18.149

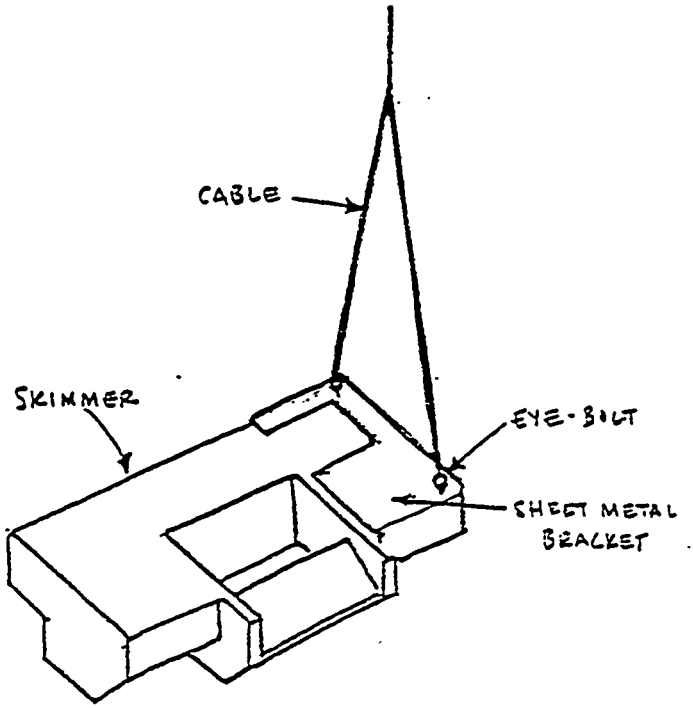
* $g = 9.81\ m/s^2$

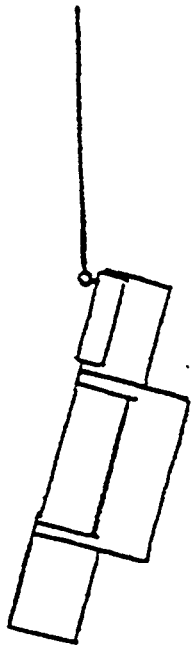
- HOSE DIMENSIONS



TH 8-11

One method of skimmer deployment was tested. The skimmer was suspended using a light cable which was connected to eye-bolts placed at the top two corners of one side of the skimmer (see below). Due to restrictions on damaging the skimmer, a bracket made of light-weight sheet metal was utilized instead of welding on the skimmer to attach the eye-bolts.





VIEW OF FRONT OF SKIMMER WHILE SUSPENDED.

Deployment Tests

With the bracket and cable attached, the skimmer was lowered into the water at different velocities.

With the same arrangement, the skimmer was deployed through a 12" PVC pipe into the water.

Results

Deploying the skimmer at moderate velocities, it had the tendency to float nose-up not allowing for water to flow over the weir resulting in an inoperable skimmer. Better results were obtained when the skimmer was deployed at slower or faster velocities, although at times the skimmer would stabilize in a submerged position also resulting in an inoperable skimmer.

While deploying the skimmer through the 12" PVC pipe, the arrangement had just adequate space at the angle with which the skimmer was held. The skimmer was able to be lowered through the pipe although contact of the skimmer to the walls of the pipe was difficult to avoid. Final positions of the skimmer upon insertion into the water were identical to the results above.

ATTACHMENT
A-2

Westinghouse Hanford Company — **Internal Memo**

From: Chemical Engineering Laboratory 8E130-94-066
Phone: 3-5014 M0384/7 S4-25
Date: July 13, 1994
Subject: EVALUATION OF THE DOUGLAS ENGINEERING SKIM·PAK™ SKIMMER FOR C-103 FLOATING ORGANIC LAYER REMOVAL

To: Robert J. Parazin H5-49

cc: R. J. Dukelow R2-78
G. L. Dunford R1-51
K. L. Morris H5-09
M. J. Schliebe S4-25
J. P. Sederberg R2-11
J. P. Sloughter T6-07
MDB File/CEL LB

1) FAI/94-41, March 1994, *Safe Limit of Residual Organic Material in Hanford Waste Tank C-103, Progress*, Fauske and Associates, Richland, Washington.

2) Britton, Michael D., 1 March 1994, *C-103 Floating Organic Layer Removal Equipment Test Plan*, Internal Letter 12130-94-021 Rev 1, Westinghouse Hanford Co., Richland, Washington.

3) Britton, Michael D., 16 June 1994, *Organic Layer Dispersion Test Report*, Internal Letter 8E130-94-056, Westinghouse Hanford Co., Richland, Washington.

BACKGROUND

The Hanford Federal Facility Agreement and Consent Order, as revised in January 1994, requires that the floating layer of organic waste in Tank C-103 be removed by June 1995. This was mandated because there was an unresolved safety question involving toxic vapor or flammability risks associated with the floating organic layer. Reference 1 concluded that 2 mm or less of residual floating organic material would not pose a risk.

OBJECTIVE

The objective of this test was to determine the suitability of Douglas Engineering's Skim·Pak™ skimmer technology for the removal of the floating organic layer in Tank C-103. Reference 2 was the test plan this work was

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Skim·Pak is a trademark of Douglas Engineering, a Division of U.S. Hydrex, Inc.

performed under. This test was designed to measure the volume fraction of organic (X_{org}) in the retrieved liquid versus the height of the organic layer (H_{org}) in the test tank at several liquid retrieval rates (Q). This data was then used to predict the pumping time that will be required and the volume of organic and aqueous phases (V_{org} and V_{aq}, respectively) that will be retrieved in the actual operation of removing the floating organic layer from tank C-103.

RETRIEVAL EQUIPMENT TESTED

The retrieval equipment tested was a Douglas Engineering Skim·Pak™ Skimmer Model 650-sh. The skimmer was constructed of a stainless steel floatation hull designed to float near the interface of the two liquids. The skimmer selectively retrieves the top layer of the liquid by allowing the upper liquid layer to flow over a flexible piece of Gortex fabric supported by a 10-cm wide self-adjusting weir and into a sump. It is then pumped out of the sump through the bottom port. Figure 1 in the attachment is an illustration of the Skim·Pak™ Skimmer.

SIMULANTS

The skimmer was tested in the Chemical Engineering Laboratory using Tank C-103 organic and aqueous phase simulants developed by Karl Pool of PNL. These simulants duplicate the surface tension and emulsion separation time of the actual tank waste. The compositions of the simulants are listed below.

Tank C-103 Organic Phase Physical Simulant
- 70 wt% TBP
- 30 wt% NPH (PUREX Grade)

Tank C-103 Aqueous Phase Physical Simulant
- 0.03 M Na_2SO_4
- 0.04 M $NaNO_3$
- 0.50 M $NaNO_2$
- 0.02 M Na_2HPO_4
- 0.22 M Na_2CO_3
- 0.21 M $NaHCO_3$
- 0.06 M NaOH
- 100 ppm BRIJ®-35: Polyoxyethylene (23) lauryl ether[1]

The specific gravity of the organic and aqueous simulants is 0.91 and 1.065, respectively. The pH of the aqueous simulant is approximately 10.

BRIJ is a registered trademark of ICI Americas Inc.

[1]This surfactant was added to the C-103 Aqueous Simulant to adjust the emulsion separation time.

TEST PROCEDURE

During the test, the skimmer was floated in a 2½-foot diameter, 100-gallon, stainless-steel tank. This tank had a built in steam jacket through which heated water was pumped to control the temperature of the approximately 300 L (79 gal) of aqueous simulant and 7 L (1.8 gal) organic simulant in the tank.

A PTFE ½-inch tube was used to connect the skimmer to a Micropump™ magnetically coupled metering gear pump. A ball valve on the inlet side of the pump was kept closed while the pump was turned off to keep the liquid from siphoning out of the skimmer's sump. The retrieved liquid was collected in glass beakers or graduated cylinders.

The test procedure was as follows.

1. H_{org} in the tank was brought up to about 10 mm.

2. The temperature of the simulants was brought up to 40°C.

3. The skimmer was placed in the tank.

4. All the aqueous phase was removed from the skimmer's sump and replaced with organic simulant.

5. H_{org} was measured and recorded. (See H_{org} Measurement)

   H_{org} MEASUREMENT: To measure H_{org} in the test tank, a sampler, made of a glass tube (1.508 cm ID) and a PTFE stopcock, was inserted through the organic layer and into the aqueous layer at an angle perpendicular to the surface. The liquid inside the sampler was then removed from the tank and poured into a graduated burette where the organic volume was measured. H_{org} was calculated as the volume of organic in the sampler divided by the cross-sectional area of the sampler.

6. The valve was opened and the pump was turned on for specific time interval (I). The time interval was generally 30 seconds or 1 minute but intervals as high as 51 minutes were used.

7. H_{org} was remeasured and recorded. (See H_{org} Measurement)

8. The volume of liquid collected in the graduated cylinder was recorded as the total volume retrieved (V_{tot}). The volume of the aqueous phase collected (if any) was logged.

9. The aqueous phase in the sump was removed and replaced with organic simulant. The volume of aqueous phase removed from the sump was added to

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Micropump is a trademark of Micropump Corporation.

the volume of aqueous phase collected in the graduated cylinder which was then recorded as the volume of aqueous phase retrieved (V_{aq}).

Steps 6 through 9 were repeated until H_{org} was lower than 1 mm. All the test data was documented in the laboratory notebook WHC-N-907-1. At a minimum, the data recorded was:

- I Time length of time interval with the pump on.
- H_{org} Height of the floating organic layer.
- V_{tot} Volume of total liquid retrieved.
- V_{aq} Volume of aqueous phase retrieved.

RESULTS

General Operation of Skimmer

The Model 650-sh skimmer included PVC fittings to connect the bottom port of the skimmer with a pump. After a few hours of operation with the organic simulant, the outer layer of the PVC became tacky and started to slough material. Since the PVC was not compatible with the organic simulant, the fittings were replaced with stainless steel parts. Because the skimmer was originally designed to float level with plastic fittings, the skimmer tended to tilt backward after the stainless steel fittings were installed. During the test, the heavy back side of the skimmer was supported to keep the skimmer level. The Teflon tube connected to the bottom port was lift up to provide this support.

The skimmer was also designed to float at the interface between water and a lighter than water phase. Since the aqueous simulant being used is denser than water, the skimmer floated higher in the aqueous phase than it should have. In the future, skimmers should be designed to float correctly in the dense aqueous phase being used.

The skimmer is also sensitive to side-to-side pressure the connected tubing may apply on it. Because the connected tubing applied pressure on the skimmer, the skimmer tended to list to one side during the test. Efforts were made during the test to minimize the listing. Corrections to these problems should increase the efficiency of the skimmer beyond what was found in this test.

Run data

Nine runs were performed at flowrates ranging between 10 and 2100 mL/min. Table 1 in the attachment lists the data (I, V_{tot}, V_{aq}, and H_{org},) recorded during these runs. The organic retrieved (V_{org}) was calculated as the difference between V_{tot} and V_{aq}. The total, aqueous, and organic flowrates (Q_{tot}, Q_{aq}, and Q_{org}) were then calculated by dividing the respective retrieval volumes by the time interval (I). H_{org} is listed in mm. The average H_{org}s are calculated as the arithmetic mean between the beginning and ending organic layer heights for each time interval.

Figures 2 through 10 in the attachment display the Q_{tot}, Q_{aq}, Q_{org}, and H_{org} for each run. Q_{tot}, Q_{aq}, and Q_{org} are shown in mL/min and are plotted against the left Y-axis. H_{org} is shown in mm and is plotted against the right Y-axis. These figures show that, for the flowrates investigated, the skimmer starts to retrieve aqueous phase along with organic phase when the H_{org} height drops below approximately 10 mm. Also, as H_{org} declines from 10 mm to less than 1 mm, the composition of the retrieved liquid shifts from primarily organic phase to primarily aqueous phase.

Figures 11 and 12 show the relationship between the H_{org} and X_{org} for the flowrate groups of 500, 950, 1500, and 2000 mL/min. Figure 11 shows the rough data while Figure 12 shows general trends. The legend lists the arithmetic mean and range as well as the squared residual error of the regression (R^2) for each flowrate group. Because these flowrate groups are not a single flowrate but rather a range of flowrates, there is a lot of error in regressing a line. In particular, the regressed lines for the 500 and 950 mL/min flowrate groups have poor residual errors indicating the line is a poor fit. These regressed lines provide a means to compare the H_{org}-X_{org} relationship of the different flowrate groups and are not intended for estimation of actual operation.

Figure 12 shows that lower Q_{tot} are able to retrieve 100% organic phase and 0% aqueous phase at lower organic heights. This general trend of faster flowrates retrieving more aqueous phase continues down below an H_{org} of 2 mm.

Figure 13 graphs the H_{org} versus the Q_{tot}. Retrieving liquid in parameter regions above this line will generally give retrieval compositions of 100% Organic. Operating below the line, yields retrieval of both organic and aqueous phases.

Estimations of Operation in Tank C-103

A new Skim·Pak™ Skimmer with a 26.7 cm (10.5 inch) weir is being procured for actual operation in Tank C-103. Figures 14 through 17 scale up the data from the Skim·Pak™ 650-sh skimmer to estimate how H_{org} and volume of liquid retrieved will change during the retrieval operation. The table of flowrate assumptions for each graph shows a high retrieval rate is used first, and then lowered when X_{org} may start to drop from 100 percent. Figures 14, 15, and 16 show the estimated results for final flowrates of 0.5, 0.92, and 2.0 lpm, respectively.

Figure 17 shows the estimated results if Q_{tot} were continually lowered to minimize V_{aq} without severely effecting the retrieval time. Figure 17 shows it may be possible to lower H_{org} to 1.5 mm while only retrieving about 800 L of aqueous phase, which is 4 percent of the organic volume retrieved.

Of course, all these estimates assume the redesigned skimmer works as well or better than the test model and, more importantly, that the pump doesn't vibrate the skimmer causing it to take in more aqueous phase than expected.

CONCLUSIONS AND RECOMMENDATIONS

It is concluded from this test that the Douglas Engineering Skim·Pak™ skimmer technology can be used to efficiently remove a floating organic layer of C-103 Organic Simulant down below the required 2.0 mm height and probably as low as 0.5 mm or until the organic layer starts to pool. (For information on organic layer pooling effects, see reference 3.) Therefore, this technology is recommended for use in removing the floating organic layer in Tank C-103. There are, however, changes that can be made in the skimmer design to improve its it efficiency and reliability in this particular task.

First, a redesigned skimmer should have all stainless steel or aluminum fittings instead of PVC components. The skimmer should be designed to float with these fittings at the correct level in the denser-than-water C-103 aqueous phase.

Secondly, although it was not noted in this test, Gortex material will shrink when submerged in the Organic Simulant. Because of this incompatibility between Gortex and the Organic Simulant and because changes in the size and shape of the skimmer's weir flap can be detrimental to the skimmer's efficiency, it is recommended that the weir flap be made of another, more suitable material.

Lastly, to increase the speed at which the organic layer is removed from Tank C-103, the skimmer's weir can be made wider. (As noted earlier, a skimmer with a 26.7 cm weir is being procured.) This should increase the retrieval rate with no adverse effects on performance or efficiency.

It is also recommend that the new skimmer be tested in concert with the actual pump that will be used. Such a functional test will help mitigate potential problems during actual operation (e.g. if the pump vibrates the skimmer, it could seriously effect the skimmer's efficiency).

Michael D. Britton, Advanced Chemical Engineer
Chemical Engineering Laboratory

MDB

Figure 1: Sectional View Douglas Engineering's Skim·Pak™ Skimmer Model 650-sh

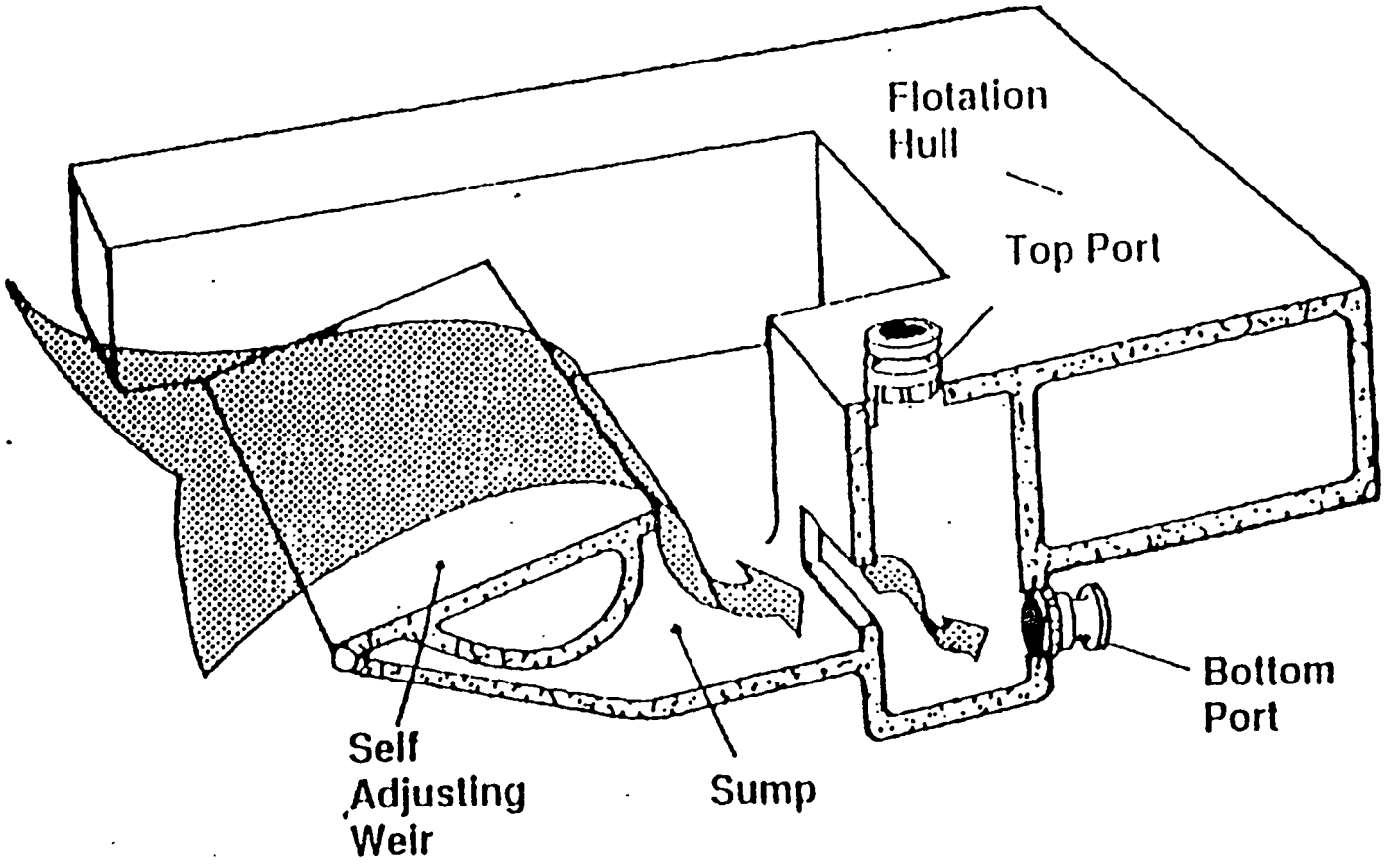


Table 1: Douglas Engineering Skim-Pak Model 650-sh Skimmer Test Data

Run	Accum Time (min)	Time Interval (min)	Volume Retrieved (mL)			Retrieval Rate (mL/min)			Retrieval Composition		H_{org} (mm)	H_{org} Avg (mm)
			V_{tot}	V_{aq}	V_{org}	Q_{tot}	Q_{aq}	Q_{org}	X_{aq}	X_{org}		
Run 1											17.6	
1•1	12.0	12	4575	0	4575	381	0	381	0%	100%	6.2	11.90
1•2	14.5	2.5	830	47	783	332	19	313	6%	94%	3.4	4.76
1•3	17.0	2.5	860	241	619	344	96	248	28%	72%	1.7	2.52
1•4	19.0	2	806	521	285	403	261	143	65%	35%	1.1	1.40
1•5	27.0	8	3180	2750	430	398	344	54	86%	14%	0.3	0.70
1•6	34.0	7	3500	3440	60	500	491	9	98%	2%	0.3	0.28
Run 2											11.2	
2•1	23.5	23.5	3050	0	3050	130	0	130	0%	100%	2.8	7.00
2•2	34.5	11	900	290	610	82	26	55	32%	68%	0.8	1.82
2•3	44.5	10	990	615	375	99	62	38	62%	38%	0.3	0.56
Run 3											8.7	
3•1	96	96	1031	327	704	11	3	7	32%	68%	5.3	7.00
3•2	186	90	985	302	683	11	3	8	31%	69%	3.6	4.48
3•3	237.5	51.5	875	270	605	17	5	12	31%	69%	1.4	2.52
Run 4											5.6	
4•1	5	5	2650	187	2463	530	37	493	7%	93%	3.2	4.40
4•2	10	5	2940	2465	475	588	493	95	84%	16%	0.6	1.88
4•3	15	5	2875	2760	115	575	552	23	96%	4%	0.4	0.48
Run 5											9.2	
5•1	1	1	540	35	505	540	35	505	6%	94%	8.1	8.68
5•2	2	1	363	33	330	363	33	330	9%	91%	6.3	7.22
5•3	3	1	338	27	311	338	27	311	8%	92%	7.6	6.94
5•4	4	1	330	47	283	330	47	283	14%	86%	4.0	5.80
5•5	5	1	321	75	246	321	75	246	23%	77%	2.6	3.33
5•6	6	1	297	119	178	297	119	178	40%	60%	2.5	2.58
5•7	7	1	236	81	155	236	81	155	34%	66%	1.8	2.16
5•8	8	1	247	90	157	247	90	157	36%	64%	1.7	1.74
5•9	9	1	259	132	127	259	132	127	51%	49%	1.6	1.62
5•10	10	1	215	182	33	215	182	33	85%	15%	1.1	1.34
5•11	11	1	283	200	83	283	200	83	71%	29%	1.4	1.26
5•12	12	1	302	265	37	302	265	37	88%	12%	0.8	1.12
5•13	13	1	318	275	43	318	275	43	86%	14%	0.7	0.77
5•14	14	1	303	283	20	303	283	20	93%	7%	0.6	0.63

Table 1: Douglas Engineering Skim–Pak Model 650–sh Skimmer Test Data (cont.)

Index	Accum Time (min)	Time Interval (min)	Volume Retrieved (mL)			Retrieval Rate (mL/min)			Retrieval Composition		H_{org} (mm)	Avg H_{org} (mm)
			V_{tot}	V_{aq}	V_{org}	Q_{tot}	Q_{aq}	Q_{org}	X_{aq}	X_{org}		
Run 6											12.6	
6•1	3.58	3.58	2050	0	2050	572	0	572	0%	100%	7.3	9.94
6•2	4.58	1	530	81	449	530	81	449	15%	85%	4.5	5.88
6•3	5.58	1	500	52	448	500	52	448	10%	90%	3.1	3.78
6•4	6.58	1	505	106	399	505	106	399	21%	79%	5.0	4.06
6•6	8.58	1	500	277	223	500	277	223	55%	45%	3.4	2.94
6•7	9.58	1	515	425	90	515	425	90	83%	17%	1.1	2.24
6•8	10.58	1	520	425	95	520	425	95	82%	18%	1.1	1.12
6•9	11.58	1	530	472	58	530	472	58	89%	11%	0.4	0.76
6•10	12.58	1	525	492	33	525	492	33	94%	6%	0.8	0.59
6•11	13.58	1	523	504	19	523	504	19	96%	4%	0.4	0.59
6•12	14.58	1	515	514	1	515	514	1	100%	0%	0.6	0.48
6•5	7.58	1	510	–	510	510					2.5	3.78
Run 7											11.2	
7•1	0.75	0.75	750	0	750	1000	0	1000	0%	100%	9.1	10.13
7•2	1.25	0.5	490	78	412	980	156	824	16%	84%	8.6	8.82
7•3	1.75	0.5	490	110	380	980	220	760	22%	78%	7.0	7.78
7•4	2.25	0.5	485	60	425	970	120	850	12%	88%	5.9	6.44
7•5	2.75	0.5	490	113	377	980	226	754	23%	77%	4.5	5.18
7•6	3.25	0.5	460	135	325	920	270	650	29%	71%	3.8	4.12
7•7	3.75	0.5	465	226	239	930	452	478	49%	51%	3.3	3.53
7•8	4.25	0.5	460	271	189	920	542	378	59%	41%	2.7	3.00
7•9	4.75	0.5	465	378	87	930	756	174	81%	19%	2.4	2.52
7•10	5.25	0.5	460	332	128	920	664	256	72%	28%	2.0	2.16
7•11	5.75	0.5	460	402	58	920	804	116	87%	13%	1.7	1.82
7•12	6.25	0.5	455	369	86	910	738	172	81%	19%	1.4	1.54
7•13	6.75	0.5	455	394	61	910	788	122	87%	13%	1.2	1.32
7•14	7.25	0.5	460	432	28	920	864	56	94%	6%	1.1	1.18
7•15	8.25	1	950	887	63	950	887	63	93%	7%	1.0	1.04
7•16	9.25	1	970	957	13	970	957	13	99%	1%	0.7	0.81
7•17	10.25	1	990	976	14	990	976	14	99%	1%	0.6	0.62

Table 1: Douglas Engineering Skim-Pak Model 650-sh Skimmer Test Data (cont.)

Index	Accum Time (min)	Time Interval (min)	Volume Retrieved (mL)			Retrieval Rate (mL/min)			Retrieval Composition		H_{org}	Avg H_{org}
			V_{tot}	V_{aq}	V_{org}	Q_{tot}	Q_{aq}	Q_{org}	X_{aq}	X_{org}	(mm)	(mm)
Run 8											9.6	
8•1	0.5	0.5	730	66	664	1460	132	1328	9%	91%	9.4	9.49
8•2	1.0	0.5	752	70	682	1504	140	1364	9%	91%	7.2	8.26
8•3	1.5	0.5	752	155	597	1504	310	1194	21%	79%	6.0	6.58
8•4	2.0	0.5	730	322	408	1460	644	816	44%	56%	4.8	5.40
8•5	2.5	0.5	700	372	328	1400	744	656	53%	47%	3.5	4.17
8•6	3.0	0.5	710	448	262	1420	896	524	63%	37%	3.1	3.30
8•7	3.5	0.5	725	512	213	1450	1024	426	71%	29%	2.5	2.80
8•8	4.0	0.5	745	612	133	1490	1224	266	82%	18%	2.3	2.41
8•9	4.5	0.5	740	650	90	1480	1300	180	88%	12%	2.0	2.13
8•10	5.0	0.5	740	650	90	1480	1300	180	88%	12%	1.6	1.79
8•11	5.5	0.5	760	659	101	1520	1318	202	87%	13%	1.4	1.51
8•12	6.0	0.5	735	703	32	1470	1406	64	96%	4%	1.1	1.26
8•13	6.5	0.5	820	797	23	1640	1594	46	97%	3%	0.8	0.98
8•14	7.0	0.5	770	763	7	1540	1526	14	99%	1%	0.6	0.70
Run 9											9.7	
9•1	0.5	0.5	1050	160	890	2100	320	1780	15%	85%	7.0	8.34
9•2	1.0	0.5	1020	402	618	2040	804	1236	39%	61%	5.7	6.33
9•3	1.5	0.5	1020	640	380	2040	1280	760	63%	37%	4.5	5.07
9•4	2.0	0.5	1030	798	232	2060	1596	464	77%	23%	3.6	4.06
9•5	2.5	0.5	1080	918	162	2160	1836	324	85%	15%	3.0	3.30
9•6	3.0	0.5	1070	877	193	2140	1754	386	82%	18%	2.2	2.58
9•7	3.5	0.5	1010	890	120	2020	1780	240	88%	12%	2.0	2.07
9•8	4.0	0.5	1080	930	150	2160	1860	300	86%	14%	1.7	1.82
9•9	4.5	0.5	1010	1005	5	2020	2010	10	100%	0%	1.4	1.54
9•10	5.0	0.5	1020	978	42	2040	1956	84	96%	4%	1.1	1.26
9•11	5.5	0.5	1000	978	22	2000	1956	44	98%	2%	0.9	1.01
9•12	6.0	0.5	990	984	6	1980	1968	12	99%	1%	0.8	0.84

Figure 2: Skim•Pak Model 650–SH Skimmer, Run 1

Average Liquid Retrieval Rate = 393 mL/min

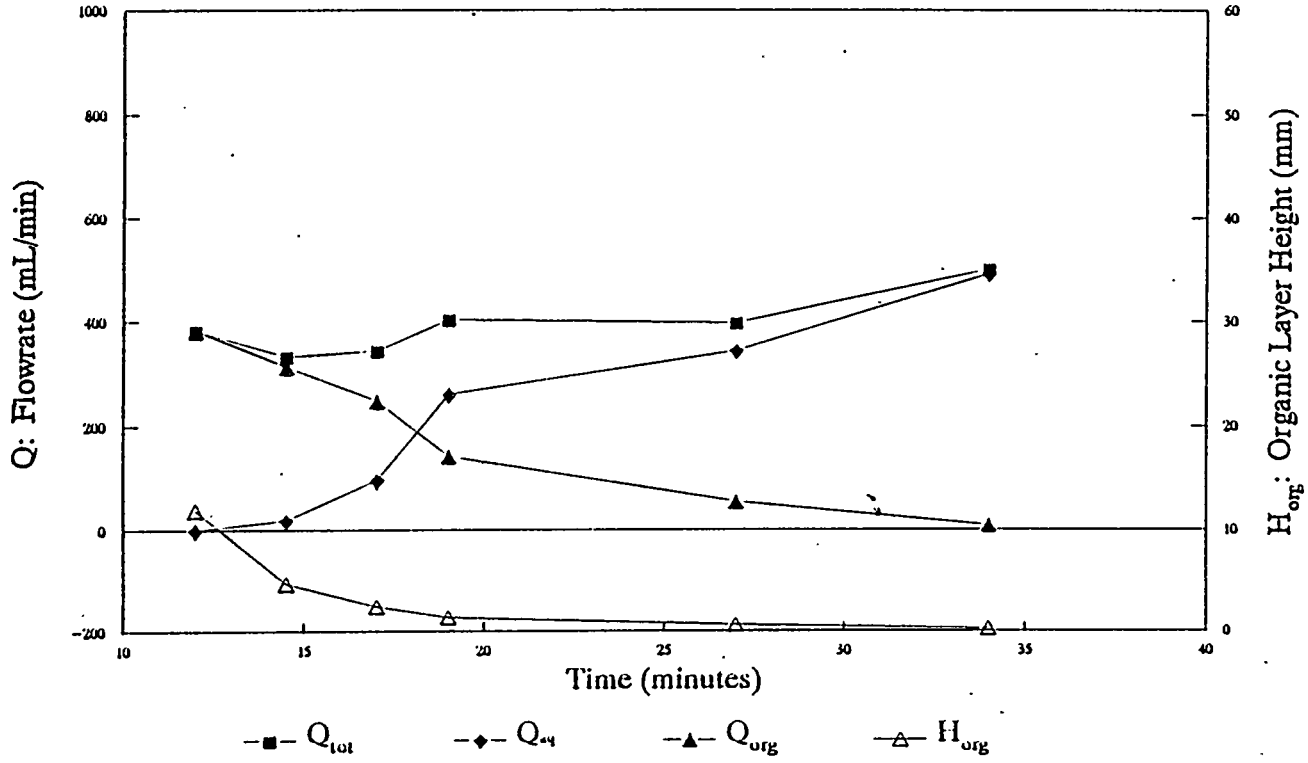
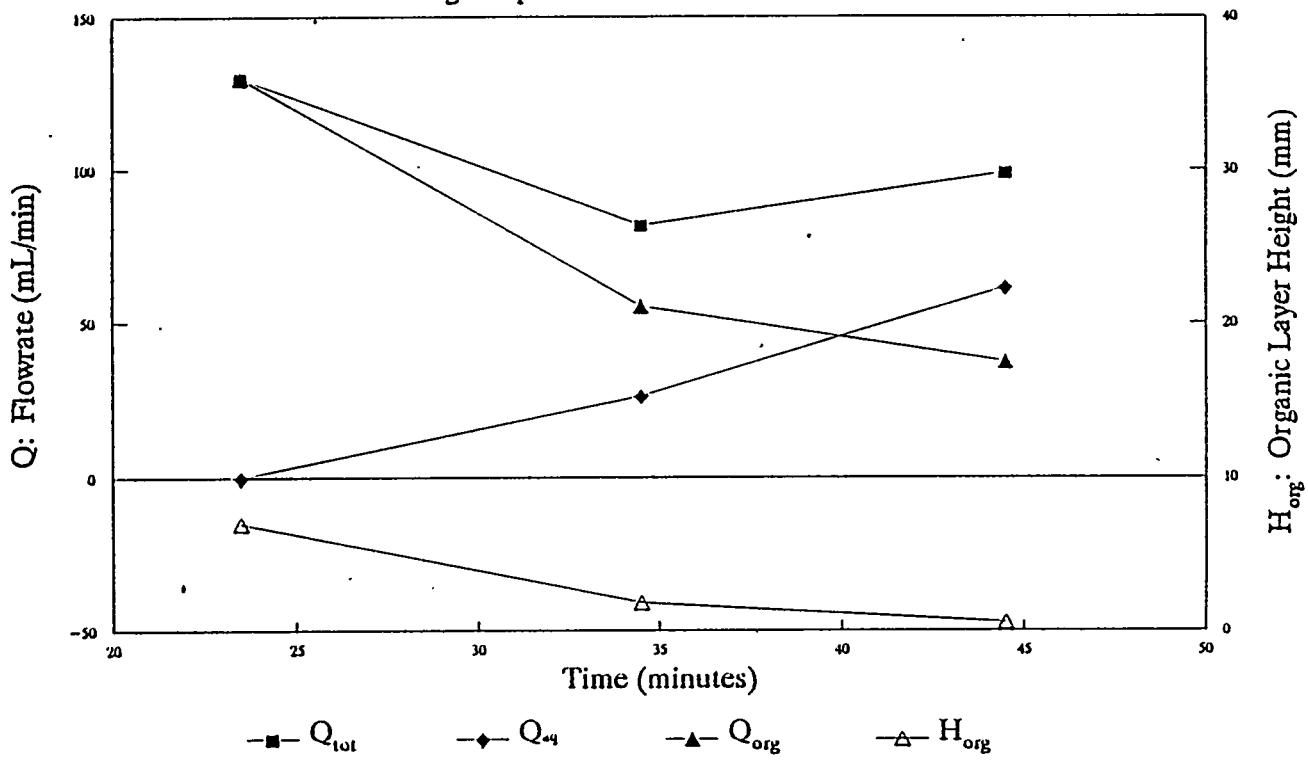


Figure 3: Skim•Pak Model 650–SH Skimmer, Run 2

Average Liquid Retrieval Rate = 104 mL/min



A-2-11

Figure 4: Skim•Pak Model 650–SH Skimmer, Run 3

Average Liquid Retrieval Rate = 13 mL/min

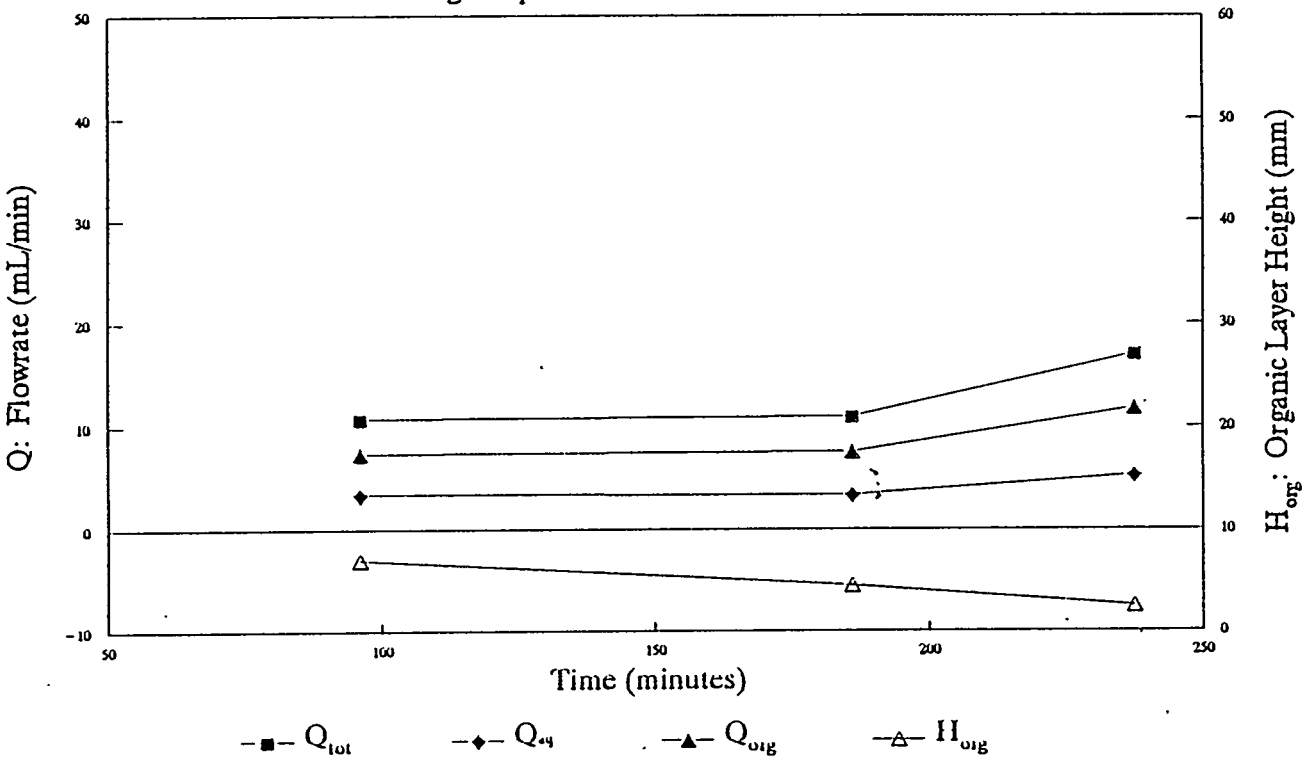
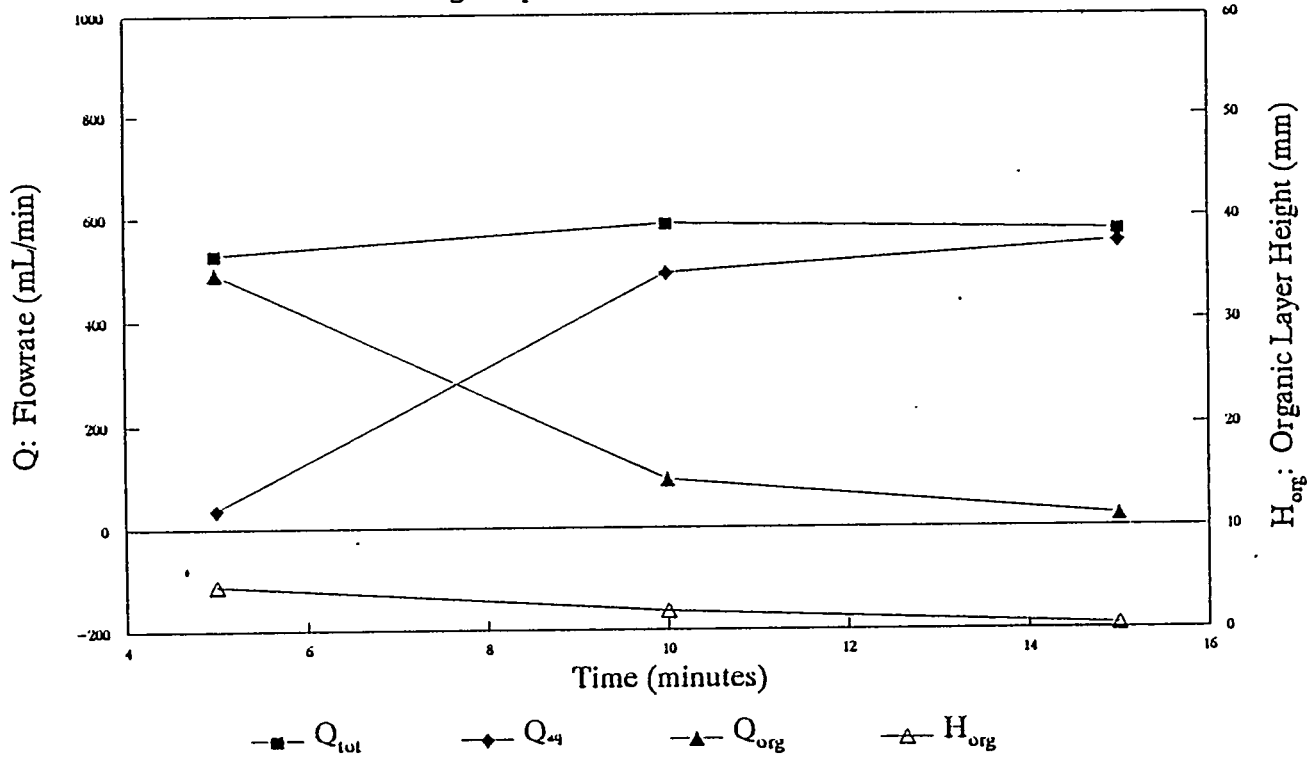


Figure 5: Skim•Pak Model 650–SH Skimmer, Run 4

Average Liquid Retrieval Rate = 564 mL/min



A-2-12

Figure 6: Skim•Pak Model 650–SH Skimmer, Run 5
Average Liquid Retrieval Rate = 311 mL/min

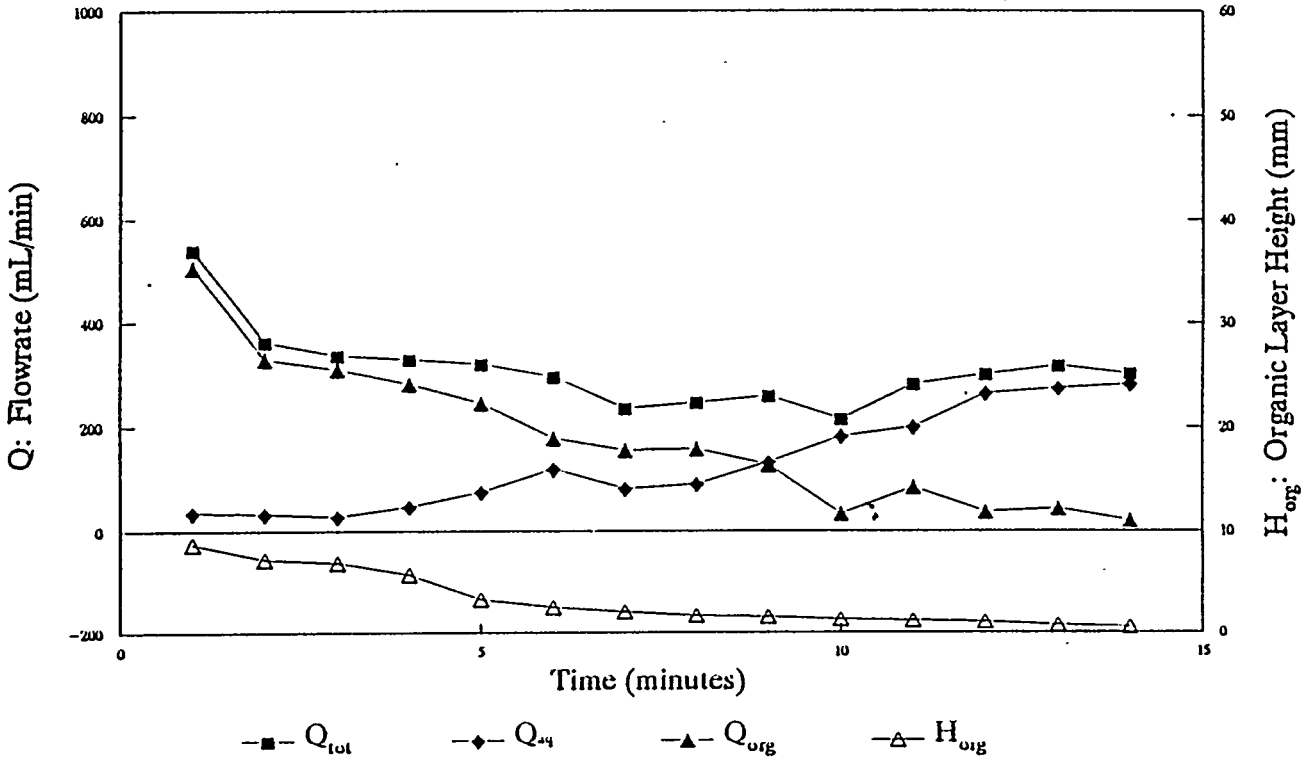


Figure 7: Skim•Pak Model 650–SH Skimmer, Run 6
Average Liquid Retrieval Rate = 521 mL/min

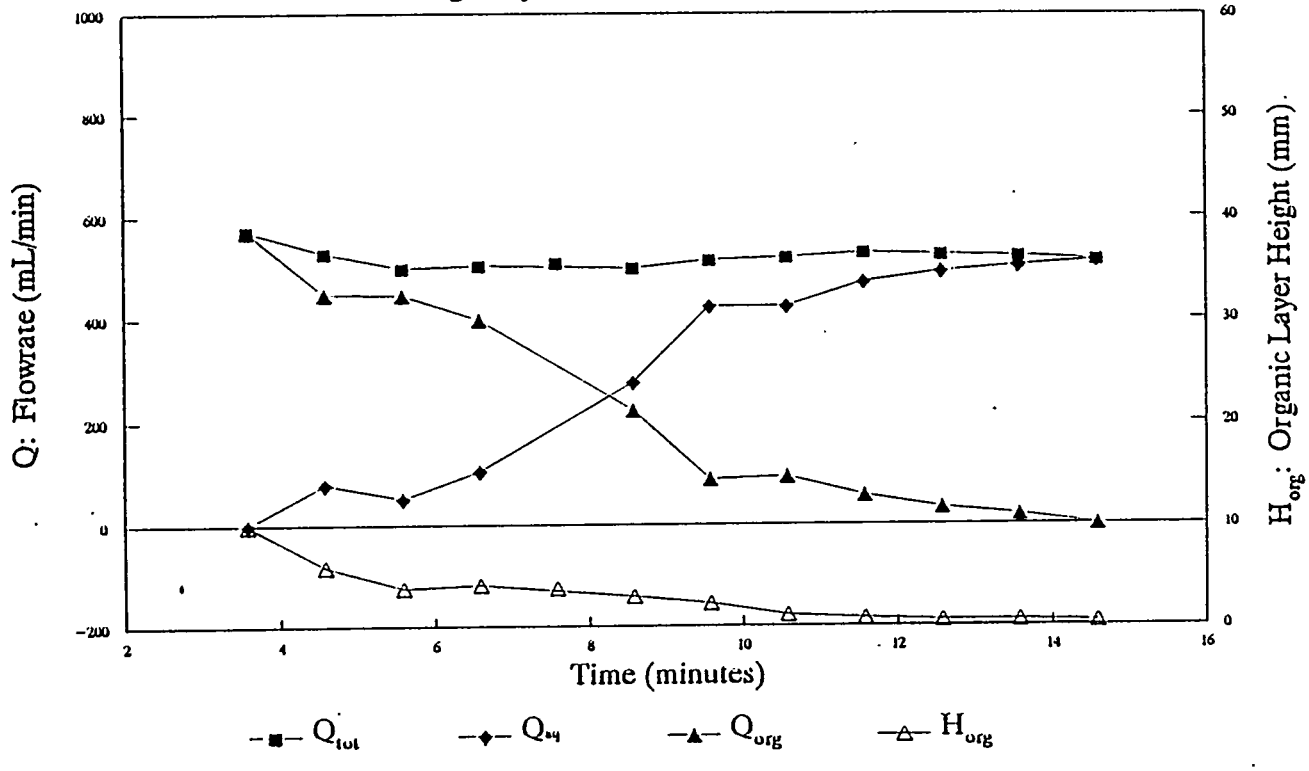


Figure 8: Skim•Pak Model 650–SH Skimmer, Run 7

Average Liquid Retrieval Rate = 947 mL/min

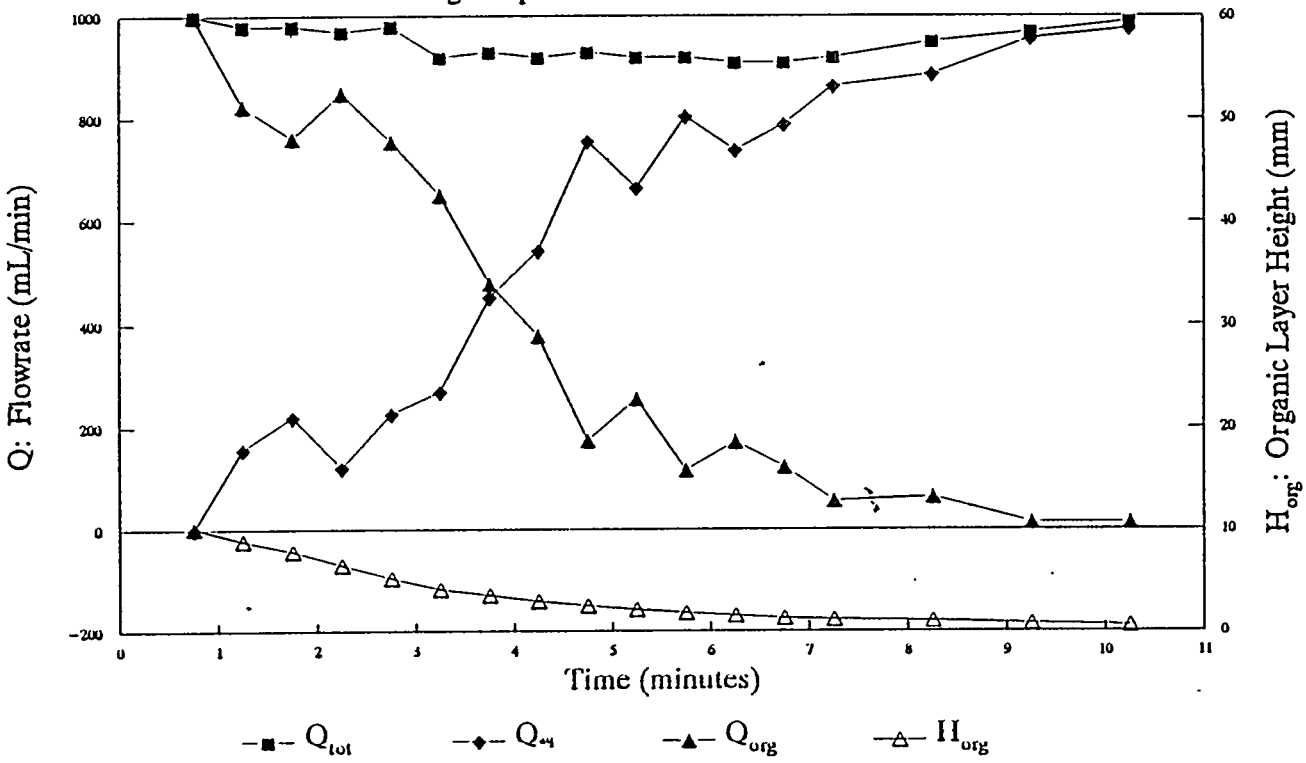
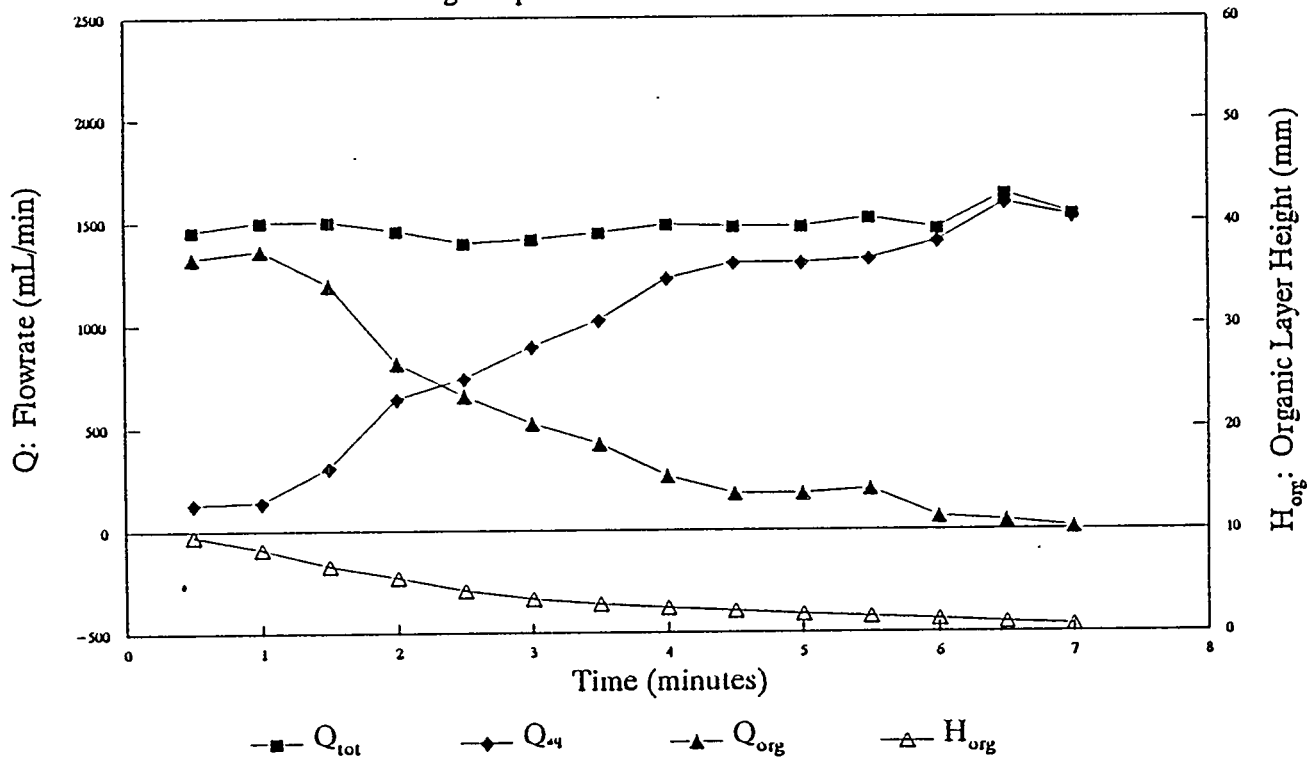


Figure 9: Skim•Pak Model 650–SH Skimmer, Run 8

Average Liquid Retrieval Rate = 1487 mL/min



A-2-14

Figure 10: Skim•Pak Model 650–SH Skimmer, Run 9

Average Liquid Retrieval Rate = 2063 mL/min

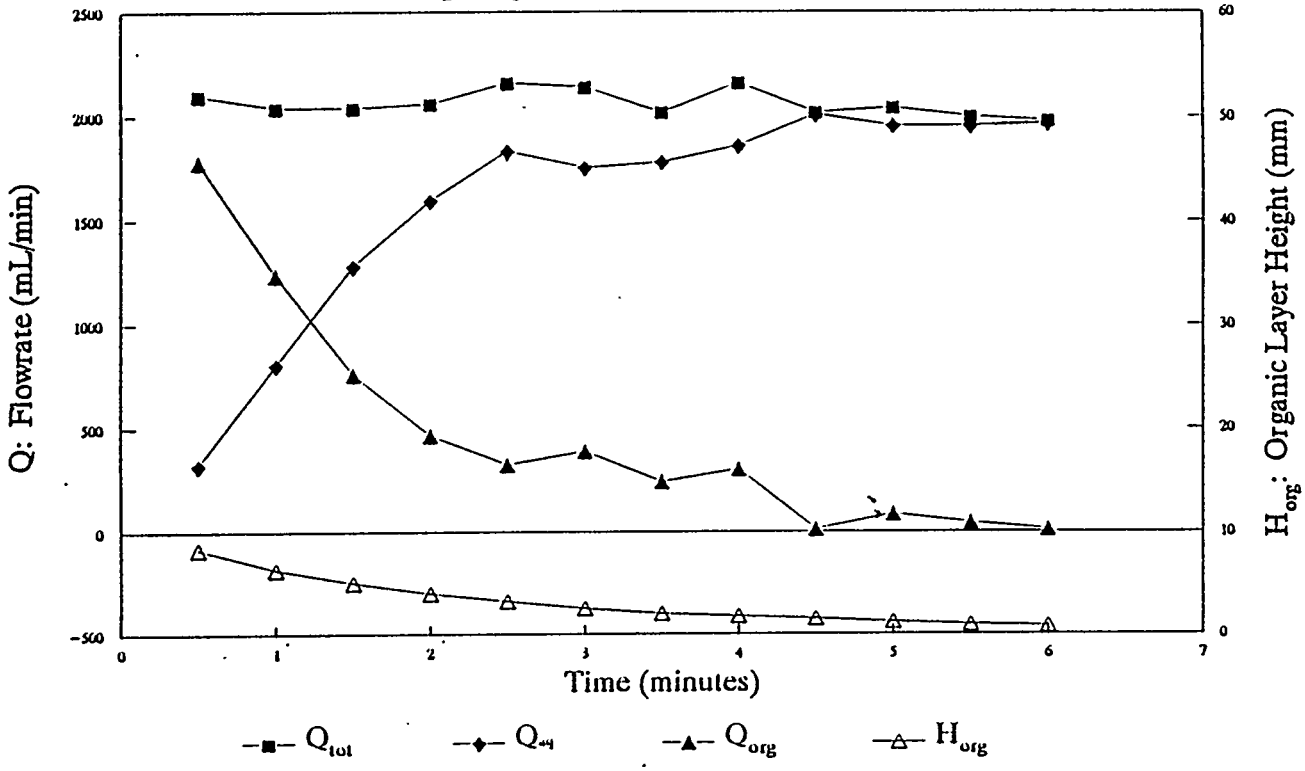
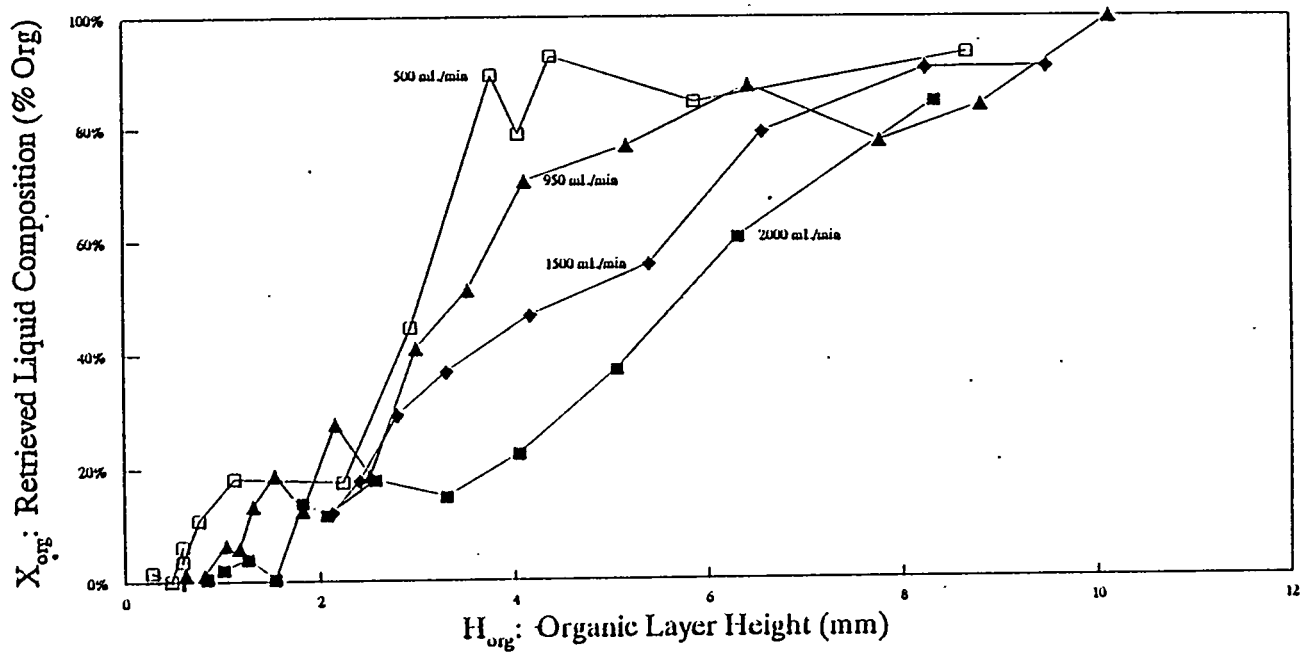


Figure 11: Retrieved Liquid Composition vs. Organic Layer Height

Skim–Pak Model 650–sh Skimmer



Q_{tot} = 2063 ± 90 mL/min

Q_{tot} = 1475 ± 70 mL/min

Q_{tot} = 947 ± 45 mL/min

Q_{tot} = 518 ± 20 mL/min

A-2-15

Figure 12: Retrieved Liquid Composition vs. Organic Layer Height
Skim-Pak Model 650-sh Skimmer

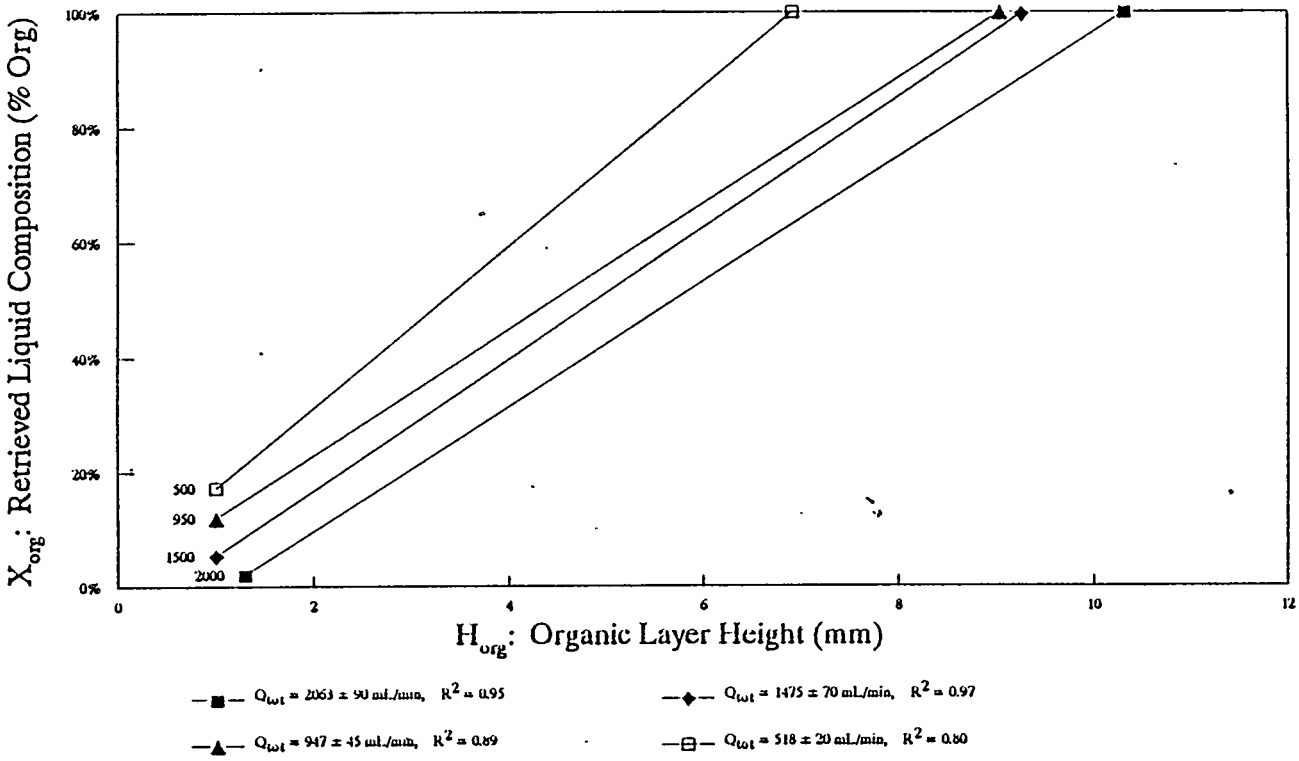
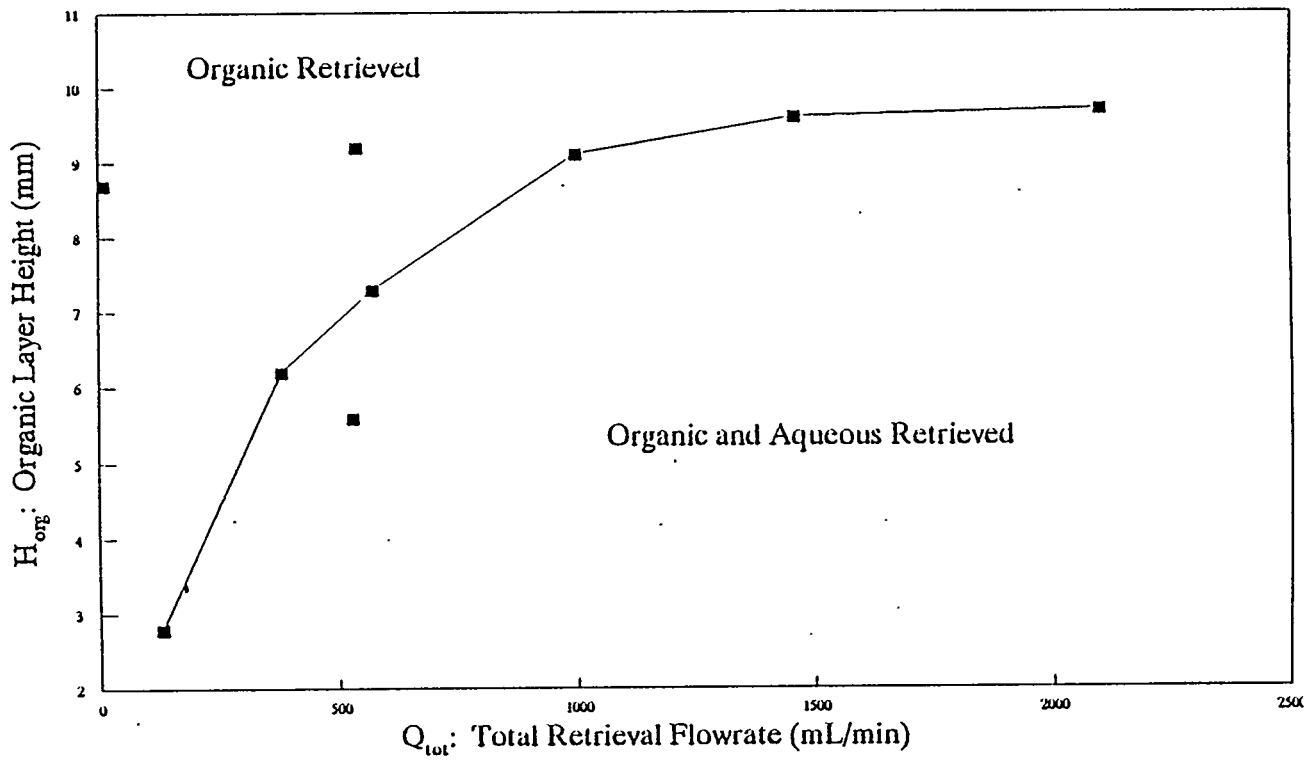
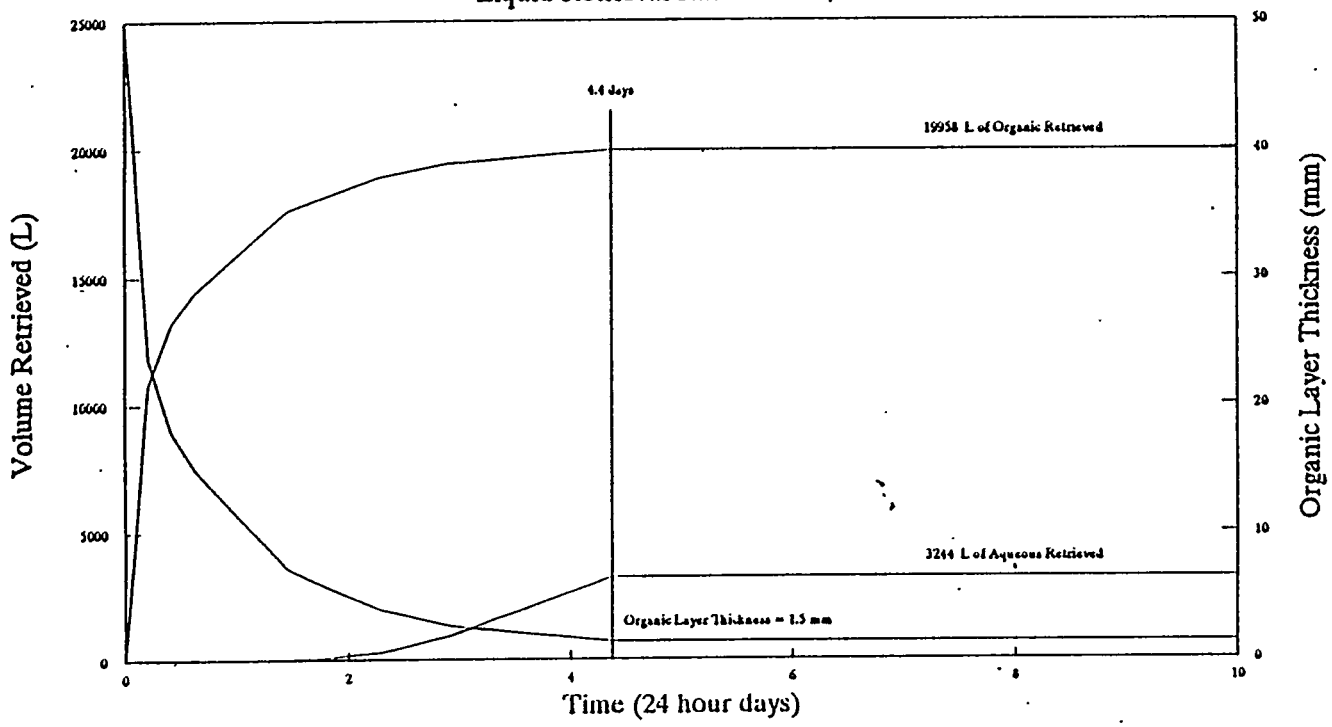


Figure 13: H_{org} vs. Q_{tot} for X_{org} = 100%
Skim-Pak Model 650-sh Skimmer



A-2-16

Figure 14: Estimation of Skim–Pak Skimmer Operation in Tank C–103

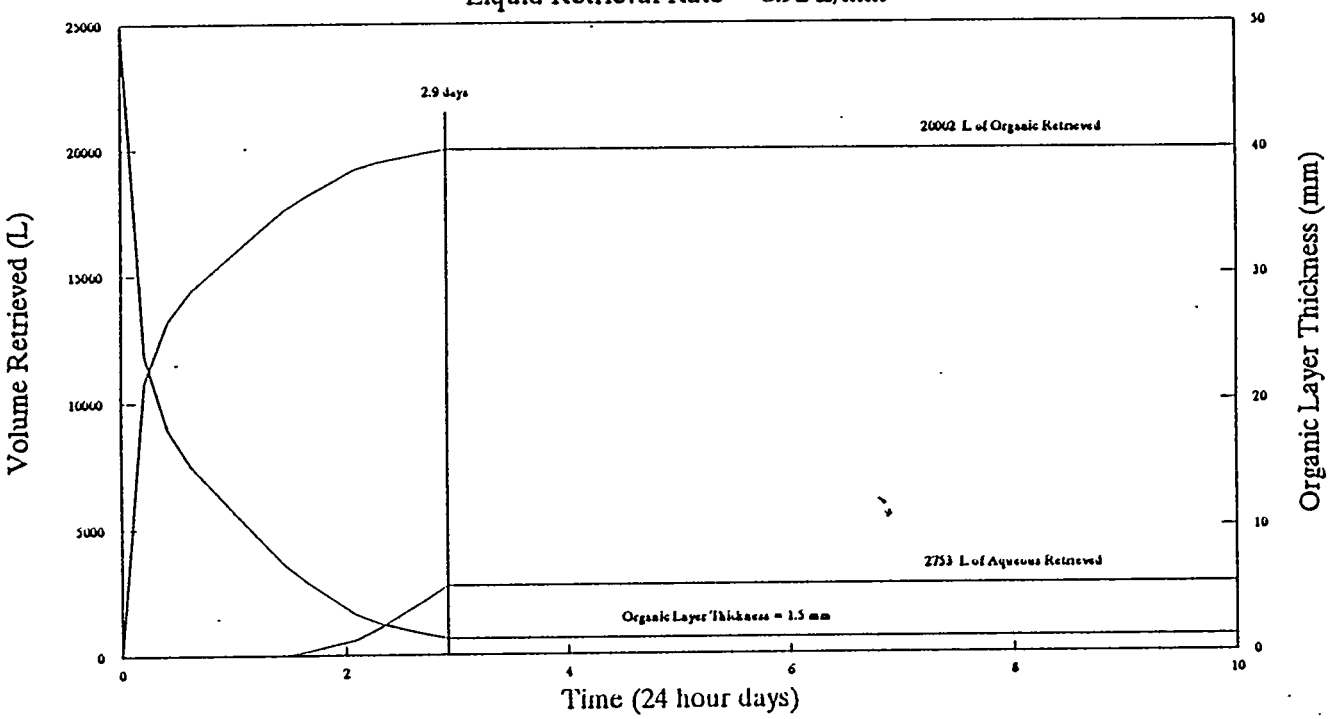


Starting Org volume	20,540	L	5427	gal
Tank cross sectional area	410	m^2	4418	ft^2
Final Organic Layer Thickness	1.5	mm		
Volume of organic retrieved	19,958	L	5273	gal
Volume of aqueous retrieved	3244	L	857	gal

Flowrate Assumptions			
H_{org} >	Q_{tot} (lpm)		X_{org}
(mm)	650–sh	New	(% Org)
25.0	13.50	36.00	100%
20.0	3.00	8.00	100%
15.0	1.50	4.00	100%
9.0	1.00	2.67	100%
7.3	0.50	1.33	100%
5.9	0.50	1.33	85%
4.1	0.50	1.33	79%
2.9	0.50	1.33	45%
1.1	0.50	1.33	18%
1.0	0.50	1.33	5%
1.0	0.50	1.33	5%

A-2-17

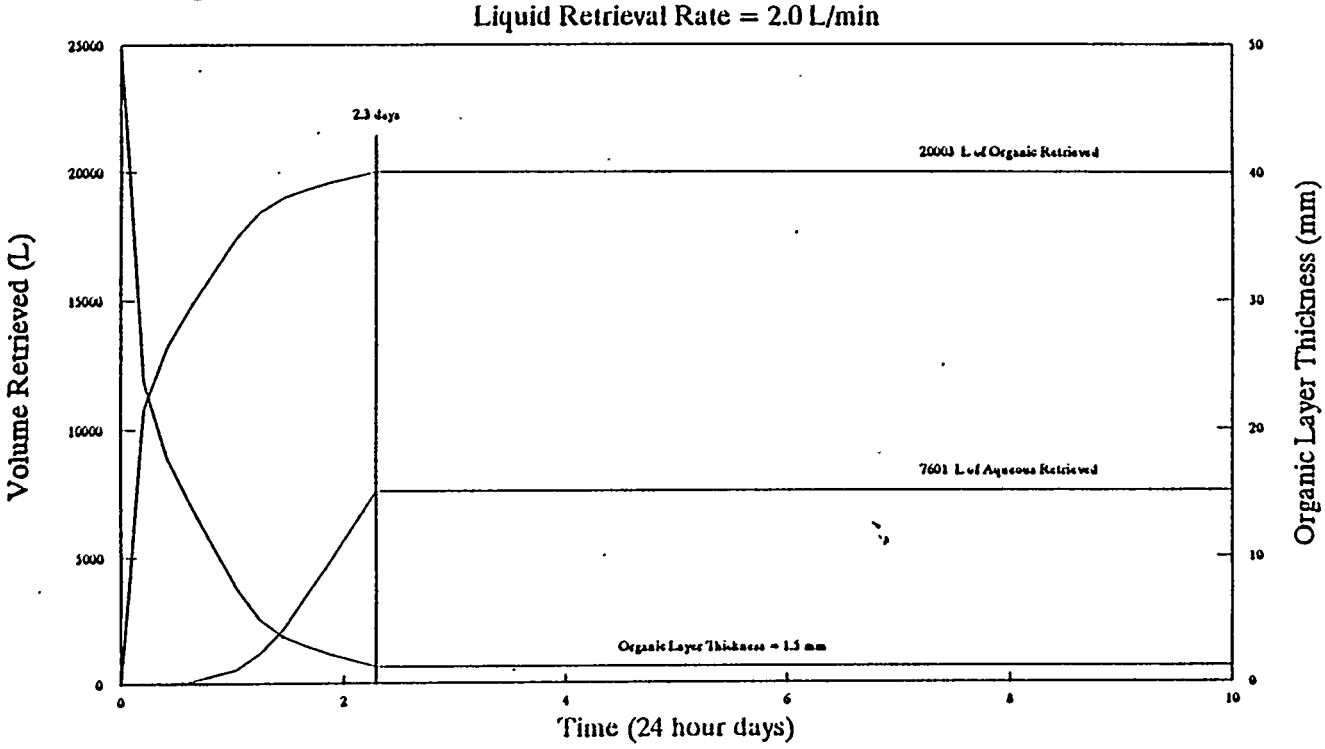
Figure 15: Estimation of Skim–Pak Skimmer Operation in Tank C–103



Starting Org volume	20,540	L	5427	gal
Tank cross sectional area	410	m^2	4418	ft^2
Final Organic Layer Thickness	1.5	mm		
Volume of organic retrieved	20,002	L	5285	gal
Volume of aqueous retrieved	2753	L	727	gal

Flowrate Assumptions			
H_{org} >	Q_{tot} (lpm)		X_{org}
(mm)	650–sh	New	(% Org)
25.0	13.50	36.00	100%
20.0	3.00	8.00	100%
15.0	1.50	4.00	100%
9.0	1.00	2.67	100%
8.6	0.97	2.59	84%
6.4	0.92	2.45	77%
4.1	0.92	2.45	70%
3.5	0.92	2.45	50%
3.0	0.92	2.45	40%
2.1	0.92	2.45	25%
1.5	0.92	2.45	19%

Figure 16: Estimation of Skim–Pak Skimmer Operation in Tank C–103

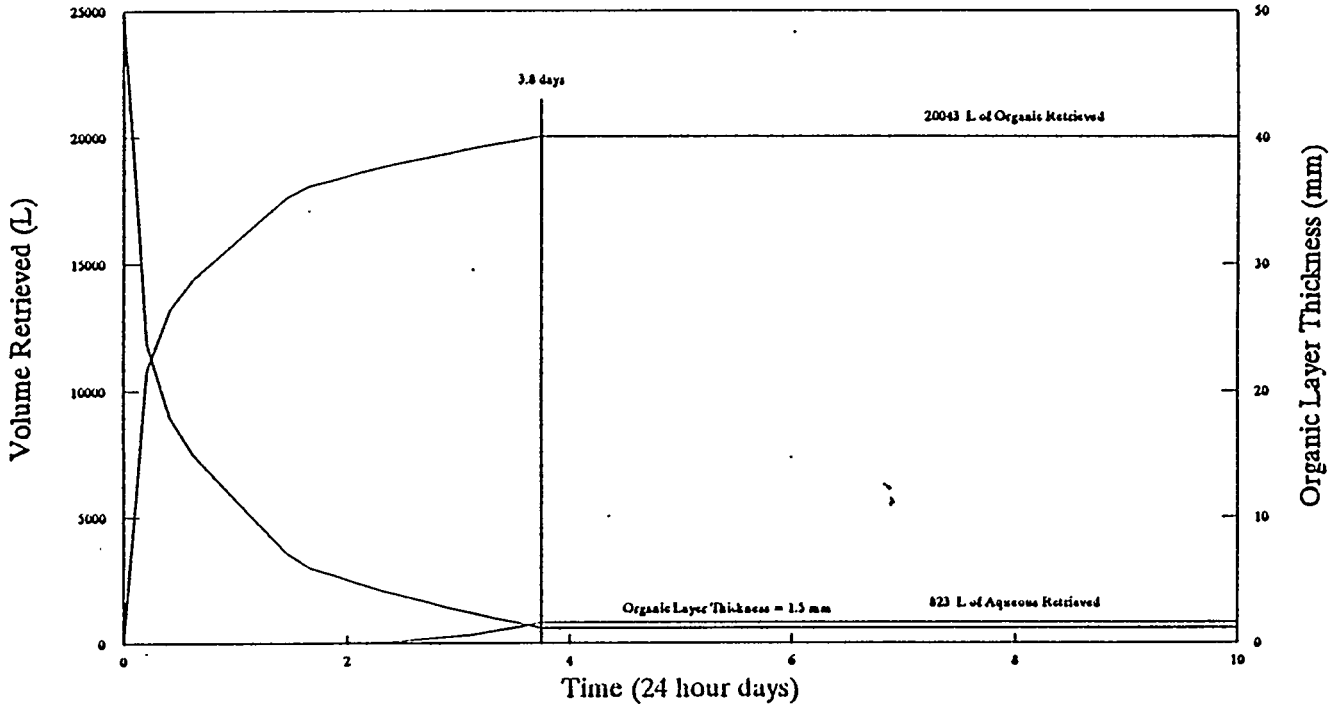


Starting Org volume	20,540	L	5427	gal
Tank cross sectional area	410	m^2	4418	ft^2
Final Organic Layer Thickness	1.5	mm		
Volume of organic retrieved	20,003	L	5285	gal
Volume of aqueous retrieved	7601	L	2008	gal

Flowrate Assumptions			
H_{org} >	Q_{tot} (lpm)		X_{org}
(mm)	650–sh	New	(% Org)
25.0	13.50	36.00	100%
20.0	3.00	8.00	100%
15.0	2.00	5.33	95%
8.3	2.00	5.33	85%
6.3	2.00	5.33	61%
5.1	2.00	5.33	37%
4.1	2.00	5.33	23%
2.6	2.00	5.33	18%
2.1	2.00	5.33	13%
1.8	2.00	5.33	13%
1.0	2.00	5.33	2%

A-2-19

Figure 17: Estimation of Skim–Pak Skimmer Operation in Tank C–103
Liquid Retrieval Rate is Variable



Starting Org volume	20,540	L	5427	gal
Tank cross sectional area	410	m^2	4418	ft^2
Final Organic Layer Thickness	1.5	mm		
Volume of organic retrieved	20,043	L	5295	gal
Volume of aqueous retrieved	823	L	218	gal

Flowrate Assumptions			
H_{org} >	Q_{tot} (lpm)		X_{org}
(mm)	650–sh	New	(% Org)
25.0	13.50	36.00	100%
20.0	3.00	8.00	100%
15.0	1.50	4.00	100%
9.0	1.00	2.67	100%
7.0	0.57	1.52	100%
6.2	0.38	1.01	100%
4.7	0.33	0.88	94%
2.5	0.33	0.88	72%
1.4	0.40	1.07	50%
1.0	0.34	0.92	5%
1.0	0.30	0.80	5%

A-2-20

Westinghouse Hanford Company | **Internal Memo**

From: Chemical Engineering Laboratory 8E130-94-056
Phone: 3-5014 MO384/7 S4-25
Date: June 16, 1994
Subject: ORGANIC LAYER DISPERSION TEST REPORT

To: Robert J Parazin

cc: R. J. Dukelow R2-78
G. L. Dunford R1-51
K. L. Morris H5-09
M. J. Schliebe S4-25
J. P. Sloughter T6-07
MDB File/CEL LB

OBJECTIVE

Several Dispersion tests were performed in the Chemical Engineering Laboratory as they were planned in Internal Memo 12130-94-014: Test Plan for ORS Filter Pretest and Organic Layer Dispersion Test. The purpose of the Dispersion Test was to observe whether a very small amount of organic simulant will disperse over the aqueous simulant in a thin layer or whether it will break up into pools. This is important for the removal of the organic layer in Tank C-103 because, if the organic phase tends to pool and not disperse well, the retrieval method chosen will need to move to these pools to retrieve them. All the test data was documented in the laboratory notebook WHC-N-907-1.

SIMULANTS

The Dispersion test was performed using Tank C-103 organic and aqueous phase simulants developed by Karl Pool of PNL. These simulants duplicate the surface tension and emulsion separation time of the actual tank phases. The compositions of the simulants are listed below.

Tank C-103 Organic Phase Physical Simulant
70 wt% TBP
30 wt% NPH (PUREX Grade)

Tank C-103 Aqueous Phase Physical Simulant

0.03 M Na_2SO_4
0.04 M $NaNO_3$
0.50 M $NaNO_2$
0.02 M Na_2HPO_4
0.22 M Na_2CO_3
0.21 M $NaHCO_3$
0.06 M NaOH
100 ppm BRIJ®-35: Polyoxyethylene (23) lauryl ether[1]

DISPERSION TEST 1

A steel pan was filled with enough aqueous simulant to cover the bottom of the pan with a minimum of 1 cm of aqueous. The steel pan used was 9½" by 13¾" with a surface area of 842.75 cm^2 (130.6 in^2).

The first test was performed using an aqueous simulant without the BRIJ-35 surfactant. Small volumes of the organic simulant were gently placed on the aqueous phase and dispersion or pooling was observed. If pooling occurred, more organic was added until the organic dispersed over the aqueous. The minimum volume of organic required to make the organic layer disperse was divided by the surface area to calculated the reported minimum organic height. An organic height of 2.8 mm was calculated for the solutions at 20°C.

The steel pan was placed on a heating plate and the simulants were brought up to 40°C. It was noted that the organic layer was dispersed over the entire surface and the pan was left at 40°C overnight. The next morning, the organic was still dispersed over the surface.

DISPERSION TEST 2

The circular pan used in the second test had an 8" diameter and a surface area of 324.3 cm^2. At 20°C, the minimum organic height was calculated to be 0.68 mm. When heated to 40°C, the organic pooled. Several thermal cycles were performed and in each cycle, the organic dispersed at the cooler temperatures and pooled at the warmer ones. More organic was added and the minimum organic height at 40°C was calculated to be 0.99 mm.

®BRIJ is a registered trademark of ICI Americas Inc.

[1]This surfactant was added to the C-103 Aqueous Simulant to adjust the surface tension. It was not used in the first Dispersion Test, but was used in the remaining Dispersion and Skimmer tests.

DISPERSION TEST 3

In the third test, organic was placed on the aqueous simulant in a 100 gallon tank. This tank had a diameter of 75 cm and a surface area of 4418 cm^2. At a temperature of 38.2°C, the minimum organic height was calculated to be 1.24 mm.

DISPERSION RESULTS FROM THE SKIMMER TEST

Ten skimmer tests were performed in the 100-gallon tank. The temperature of the top layer of fluid in the tank was maintained between 35 and 41°C. In these tests, a skimmer selectively removed the organic layer from the tank. During at least two of these tests, enough the organic was removed to cause the organic layer to pool. In the other tests, either pooling did not occur or it simply was not recorded in the logbook. For these cases, the actual minimum organic height is less than or equal to the supplied value.

SkimPak Skimmer Test 1	≤ 0.28 mm	
Longyear Skimmer Test 1	0.56 mm	pooling occurred
SkimPak Skimmer Test 2	0.28 mm	pooling occurred
SkimPak Skimmer Test 3	≤ 1.40 mm	
SkimPak Skimmer Test 4	≤ 0.40 mm	
SkimPak Skimmer Test 5	≤ 0.56 mm	
SkimPak Skimmer Test 6	≤ 0.56 mm	
SkimPak Skimmer Test 7	≤ 0.56 mm	
SkimPak Skimmer Test 8	≤ 0.56 mm	
SkimPak Skimmer Test 9	≤ 0.78 mm	

RESULTS

The C-103 simulants used in this test were designed to closely approximate the surface tension and disengaging time of the actual waste. The surfactant, BRIJ-35, was added to the aqueous phase to decrease the surface tension which increases the emulsion disengaging time. With the exception of the first dispersion test which used no surfactant, all the dispersion and skimmer tests used 100 ppm BRIJ-35 dissolved in the Aqueous Simulant. The recommended Aqueous Simulant formulation has since been changed to 75 ppm BRIJ-35 in order to more accurately mimic the emulsion disengaging time.

Using the C-103 simulants described above, the organic, which is originally dispersed over the aqueous phase, will start to break apart into pools when the organic height drops below 1 mm. When the organic layer nears its minimum height, the organic layer starts to receded from the edges of the tank and equipment. Then, the organic will start to break apart, forming pools of organic with fingers of uncovered aqueous separating them. These pools can easily be seen in vessels one foot or more in diameter.

Temperature effected the minimum height of the organic layer. In the temperature range between 20 and 40°C, an increase in the temperature will increase the minimum obtainable organic layer height. A decrease allows the

organic to spread over the aqueous in a thinner layer. At all the temperatures between 20 and 40°C, the minimum organic height does not exceed the maximum organic height of 2 mm required after the organic retrieval from Tank C-103 is complete.

CONCLUSIONS

Assuming the simulants used accurately model the Tank C-103 waste, the organic layer will continue to spread evenly over the aqueous phase until the organic height is below the required 2 mm level.

Michael D. Britton, Advanced Chemical Engineer
Chemical Engineering Laboratory

MDB

DON'T SAY IT --- *Write It!*

DATE: May 9, 1994

TO: Kimberly L. Morris

FROM: Michael D. Britton S4-25
Telephone: 3-5014

cc: G. T. Dukelow R2-78
R. J. Parazin H5-49
M. J. Schliebe S4-25
CEL file

SUBJECT: Econo Flex EPDM Hose Chemical Compatibility with Organic Simulant

I received a 7 cm piece of 1-in. hose with the request that I test it for chemical compatibility with the C-103 Organic Phase Simulant (70% TBP, 30% NPH). The literature accompanying the hose indicated this was Econo Flex black, multi-purpose hose, sold by Gates Rubber Company as Specification 3204EB/SB. This hose is a composite of three layers which are listed in the literature as:

Tube: Type P (EPDM). Black
Reinforcement: Synthetic, high tensile textile cord.
Cover: Type P (EPDM). Black

The covering was listed in the literature as Type P (EPDM) - Black. Please note that the covering was actually red and performed significantly different from the tube material which is also listed as Type P (EPDM) - Black. In my opinion, there is an exceedingly remote chance that the covering and tube are made of the same material.

On 5/5/94, the composite hose material was cut and a sample of the black tubing and a sample of the red cover were extracted. These samples were then weighed and placed in a beaker of the organic simulant at ~40°C. On 5/9/94, the samples were removed, washed with distilled water, dried with a paper towel, and weighed. After weighing, they were put in the organic simulant for further testing.

After being submerged in the C-103 Organic Simulant at ~40°C for 87 hours, the black tube sample lost almost 1 percent of its mass. It also left black streaks when rubbed against a paper towel. This shows that the black tubing was breaking down and sloughing particles. If the black tubing continues to slough off particles, and as these are very compressible particles, it may pose a problem to filters down line. Particularly to backwashable filters.

In the same 87 hours, the red covering sample increase in mass by 7.51%. This was accomplished by the adsorption of the solvent which is normally accompanied by swelling of the material. Since the physical dimensions of the samples were not measured, swelling data is not available.

Another noteworthy observation is that the red covering sample changed from a red color to a pink or salmon color. Also the organic solution went from a light yellow color to a dark-yellow or almost gold color. This may

indicate nothing more than the leaching of the coloring dyes used in this material.

Econo Flex EPDM?	Mass (g)		Deviation	
	5/5/94 1755	5/9/94 0850	(g)	Percent of original
Black	1.3834	1.3709	-0.0125	-0.9 %
Red	1.4515	1.5605	+0.109	+7.51 %

I also noticed in the Econo Flex literature that the minimum order quantity is 25,000 feet. You might keep this in mind while considering the costs of the tubing material.

DON'T SAY IT --- *Write It!*

DATE: June 28, 1994

TO: Kimberly L. Morris

FROM: Michael D. Britton S4-25
Telephone: 3-5014

cc: G. T. Dukelow R2-78
R. J. Parazin H5-49
M. J. Schliebe S4-25
CEL file

SUBJECT: Chemical Compatibility of Materials with C-103 Organic Simulant

The following is raw data from the material compatibility study. The materials listed were submerged in C-103 Organic Simulant, which is composed of 70% TBP and 30% NPH. For the information up to 6/10/93, the solutions were heated by placing the beakers on a hot plate. On 6/10/94, the heating method was switched to a water bath.

A-2-27

C-103 OLR MATERIALS COMPATIBILITY STUDY

Kalrez, perfluoroelastomer
Slab K#005041, compound 1050, dated 2/24/94.

Date		5/23/94	6/1/94		6/10/94		6/13/94		6/27/94	
Exposure time (h)		0	217		432		500		835	
Temperature (°C)		50	48.4		50		39.3		50	
Mass (g)		1.2872	1.2863	0.1% ↓	1.2881	0.1% ↑	1.2966	0.7% ↑	1.3078	1.6% ↑
Dimensions (in)	A	1.1406	1.1563	1.4% ↑	1.1563	1.4% ↑			1.1563	1.4% ↑
	B	0.8125	0.8438	3.8% ↑	0.8594	5.8% ↑			0.8594	5.8% ↑
	C	1.0938	1.1250	2.9% ↑	1.1250	2.9% ↑			1.1250	2.9% ↑
	D	0.7969	0.8125	2.0% ↑	0.8125	2.0% ↑			0.8125	2.0% ↑
Notes		Good resistance to the organic simulant.								

Santoprene
Hudson Extrusions, Inc.
½ inch tubing

Date		5/23/94	6/1/94		6/10/94		6/13/94		6/27/94	
Exposure time (h)		0	193		410		478		813	
Temperature (°C)		49	48.8		44		39.3		50	
Mass (g)		1.9006	2.0344	7.0% ↑	2.2047	16.0% ↑	1.9497	2.6% ↑	1.9316	1.6% ↑
Dimensions (in)	L	1.0000	1.0313	3.1% ↑	1.0313	3.1% ↑			1.0000	0.0% –
	OD	0.6250	0.7500	20.0% ↑	0.6250	0.0% –			0.6563	5.0% ↑
	ID	0.5000			0.5000	0.0% –			0.5000	0.0% –
Notes		Good resistance to the organic simulant.								

XR-5 Polyester (Dacron)/Evaloy 8130
Seaman Corp.
6.5 oz./yard

Date		6/10/94	6/13/94	
Exposure time (h)		0	67	
Temperature (°C)		40	39	
Mass (g)		2.3494	1.0764	54.2% ↓
Dimensions (in)	L	3.0000	2.9688	1.0% ↓
	H	1.1875	1.1875	0.0% –
	W	0.0313		
Notes		This material failed the test. Test stopped.		

HDPE (High Density PolyEthylene)
Grundle Lining
80 mil (2.0 mm)

Date		6/10/94	6/13/94		6/27/94					
Exposure time (h)		0	67		403					
Temperature (°C)		40	39		50					
Mass (g)		1.5833	1.633	3.1% ↑	1.675	5.8% ↑				
Dimensions (in)	L	3	3.9688	32.3% ↑	3.0938	3.1% ↑				
	H	0.4375	0.4375	0.0% –	0.4375	0.0% –				
	W	0.0938	0.0938	0.0% –	0.0938	0.0% –				
Notes										

'.DPE (very low density polyethylene)
.undle Lining
30 mil

Date		6/10/94	6/13/94		6/27/94					
Exposure time (h)		0	67		403					
Temperature (°C)		40	39		50					
Mass (g)		1.1506	1.2905	12.2% ↑	1.3124	14.1% ↑				
Dimensions (in)	L	3.0000	3.1563	5.2% ↑	3.1875	6.3% ↑				
	H	0.7813	0.7969	2.0% ↑	0.8125	4.0% ↑				
	W	0.0313								
Notes										

Teflon
½ inch tubing

Date		6/10/94	6/13/94		6/27/94					
Exposure time (h)		0	67		403					
Temperature (°C)		40	39		50					
Mass (g)		9.0627	9.0638	0.0% ↑	9.0682	0.1% ↑				
Dimensions (in)	L	3.0000	2.9688	1.0% ↓	2.9844	0.5% ↓				
	OD	0.5000	0.5000	0.0% –	0.5000	0.0% –				
	wall	0.0625	0.0625	0.0% –	0.0625	0.0% –				
Notes										

PTFE Sample 1
Gore–Tex Joint Sealant Self Adhering Gasket
V. L. Gore & associates
Lot # D–981–S

Date		6/6/94	6/13/94		6/27/94					
Exposure time (h)		0	13		483					
Temperature (°C)		40	39		50					
Mass (g)		1.4389								
Dimensions (in)	L	6.0000	5.8125	3.1% ↓	5.5000	8.3% ↓				
	W	0.3125	0.3125	0.0% –						
	H	0.0938								
Notes										

PTFE Sample 2
PTFE Thread Seal Tape

Date		6/6/94	6/7/94		6/27/94					
Exposure time (h)		0	13		483					
Temperature (°C)		40	40		50					
Mass (g)		0.2960								
Dimensions (in)	L	30.2500	30.2500	0.0% –	28.5625	5.6% ↓				
	W									
	H									
Notes										

alar–MBF
CTFE: ethylene–chlorotrifluoroethylene
This material is a fine mesh fabric.

Date	6/24/94	6/27/94							
Exposure time (h)	0	13							
Temperature (°C)	40	40							
Mass (g)	1.9376	2.1648	11.7% ↑						
Dimensions (in) L	8.4063	8.3750	0.4% ↓						
Notes	The mass increase is probably due to incomplete drying of the fabric. The length contraction is insignificant.								

DON'T SAY IT --- *Write It!*

DATE: June 14, 1994

TO: Kimberly L. Morris

FROM: Michael D. Britton S4-25
Telephone: 3-5014

cc: G. T. Dukelow R2-78
R. J. Parazin H5-49
M. J. Schliebe S4-25
CEL file

SUBJECT: Chemical Compatibility of Materials with C-103 Organic Simulant

The following is raw data from the material compatibility study. The materials listed were submerged in a beaker of C-103 Organic Simulant, which is composed of 70% TBP and 30% NPH. For the information up to 6/10/93, the solutions were heated by placing the beakers on a hot plate. On 6/10/94, the heating method was switched to a water bath.

Kalrez, perfluoroelastomer, slab K#005041, compound 1050, dated 2/24/94.								
Date		5/23/94	6/1/94		6/10/94		6/13/94	
Exposure (h)		0	216.5		432.5		499.8	
Temp (°C)		50	48.4		50		39.3	
Mass (g)		1.2872	1.2863	0.1% ↓	1.2881	0.1% ↑	1.2966	0.7% ↑
Dimensions (in.)	A	1.1406	1.1563	1.4% ↑	1.1563	1.4% ↑		
	B	0.8125	0.8438	3.8% ↑	0.8594	5.8% ↑		
	C	1.0938	1.1250	2.9% ↑	1.1250	2.9% ↑		
	D	0.7969	0.8125	2.0% ↑	0.8125	2.0% ↑		
Notes								

Santoprene Hudson Extrusions, Inc. ½ inch tubing								
Date		5/23/94	6/1/94		6/10/94		6/13/94	
Exposure (h)		0	193		410.4		478.1	
Temp. (°C)		49	48.8		44		39.3	
Mass (g)		1.9006	2.0344	7.0% ↓	2.2047	16.0% ↑	1.9497	2.5% ↑
Dimen -sions (in.)	L	1.0	1.0313	3.1% ↑	1.0313	3.1% ↑		
	OD	0.625	0.75	20% ↑	0.625			
	ID	0.5			0.5			
Notes								

XR-5 Polyester (Dacron)/Evaloy 8130 Seaman Corp. 6.5 oz./yard				
Date		6/10/94	6/13/94	
Exposure (h)		0	67.15	
Temp (°C)		40	39.3	
Mass (g)		2.3494	1.0764	54.2% ↓
Dimensions (in.)	L	3.0	2.9688	1.0% ↓
	H	1.1875	1.1875	0.0
	W	~0.3125		
Status		FAILED. Test Stopped.		
Notes		It appears that this material is a composite with a woven textile, probably the polyester, coated with another material. This outer material almost completely dissolved, leaving the woven material exposed.		

HDPE - High Density Polyethylene Grundle Lining 80 mil (2.0 mm)				
Date		6/10/94	6/13/94	
Exposure (h)		0	67.15	
Temp (°C)		40	39.3	
Mass (g)		1.5833	1.6330	3.1% ↑
Dimensions (in.)	L	3.0	3.0313	1.0% ↑
	H	0.4375		0.0
	W	0.0937		
Notes				

VLDPE - Very Low Density Polyethylene Grundle Lining 30 mil				
Date		6/10/94	6/13/94	
Exposure (h)		0	67.15	
Temp (°C)		40	39.3	
Mass (g)		1.1506	1.2905	12.2% ↑
Dimensions (in.)	L	3.	3.1563	5.2% ↑
	H	0.7813	0.7969	
	W	0.0313		
Notes				

Teflon ½ in. tubing				
Date		6/10/94	6/13/94	
Exposure (h)		0	67.15	
Temp (°C)		40	39.3	
Mass (g)		9.0627	9.0638	0.01% ↑
Dimensions (in.)	L	3.	2.9688	1.0 % ↓
	OD	0.5	0.5	
	Wall	0.0625	0.625	
Notes				

DON'T SAY IT --- *Write It!*

DATE: June 7, 1994

TO: Kimberly L. Morris

FROM: Michael D. Britton S4-25
Telephone: 3-5014

cc: G. T. Dukelow R2-78
R. J. Parazin H5-49
M. J. Schliebe S4-25
T. R. Wilson H5-09
CEL file

SUBJECT: Materials Compatibility: Gore-Tex Type PTFE

Because of the recent concern over the chemical compatibility of Gore-Tex type PTFE with the C-103 Simulants, I have started a chemical compatibility test.

PTFE Sample 1: Gore-Tex Joint Sealant
Self Adhering Gasket
W.L. Gore & Associates
Lot # D-981-S

Length: 6"
Width: 5/16"
Height: 3/32
Mass: 1.4389 g
Exposure Time: 13.3 hrs
Exposure Conditions: Immersion in 70% TBP, 30% NPH at 40C.
Exposure Results: 3.1% length contraction

PTFE Sample 2: PTFE Thread Seal Tape

Length: 30 1/4"
Mass: 0.2960 g
Exposure Time: 13.2 hrs
Exposure Conditions: Immersion in 70% TBP, 30% NPH at 40C.
Exposure Results: No change in length

Based on the results from the Gore-Tex sample, I would assume the shrinkage of the Gore-Tex flap at Douglas Engineering is from an incompatibility between the Gore-Tex and the C-103 Organic Simulant. I you would like, I could talk to your Gore-Tex technical expert.

ATTACHMENT

B-1

84100-94-JEM-267
ATTACHMENT
35 Pages

Westinghouse Hanford Company | **Internal Memo**

From: Packaging Safety Engineering 84100-94-JEM-267
Phone: 376-0298 G2-02
Date: September 2, 1994
Subject: PACKAGING DESIGN CRITERIA FOR TANK 241-C-103 LIQUID ORGANIC BULK WASTE CONTAINER

To: R. J. Parazin H5-49

cc: R. J. Chesterfield G2-02*
D. W. Hendrickson L5-31
R. A. Schwarz HO-35
G. T. Dukelow S7-15*
T. R. Wilson H5-09
JEM File/PSE Route/LB
*w/o attachment

The purpose of this letter is to distribute a draft of the packaging design criteria for the Tank 241-C-103 Liquid Organic Bulk Waste Container. The document has been completed and will be updated and issued in FY 1995 if deemed necessary. The draft criteria are to be included in the closure documentation for the organic removal operation involving Tank 241-C-103.

The draft has been internally reviewed by Packaging Safety Engineering and has been approved by management. Please contact me if you have any comments or questions.

J. E. Mercado
Senior Engineer

dmr

Attachment

CONCURRENCE BY:

Date 9/2/94
J. G. Field
Manager

B-1-1

DRAFT September 2, 1994

EXECUTIVE SUMMARY

The purpose of this document is to provide packaging design criteria for the design, safety analysis, and procurement of a container to ship and temporarily store the liquid organic waste contained in Tank 241-C-103. The safety of the transfer operation will be evaluated and documented in a Safety Evaluation for Packaging (SEP). The safety of the container for onsite transfer will be based on meeting the onsite transportation safety criteria as implemented by the *Hazardous Material Packaging and Shipping* manual, WHC-CM-2-14*. This is a draft PDC which will be issued if the plan to remove the liquid organic is verified as necessary in the FY-95.

In July 1987, noxious vapors emitted from the Tank 241-C-103 caused illness and resulted in hospitalization (for observation) of two WHC workers. The detection of combustible organic vapors in the headspace of 241-C-103 and the subsequent verification of a liquid organic phase in the tank resulted in placing 241-C-103 on the "Watch List" of waste tanks with high organic content. In addition to the toxicity of the vapors, the primary concerns regarding the floating organic layer are the flammability of the liquid and the explosiveness of the vapor. As a result of the perceived danger in 241-C-103 the Tri-Party Agreement contained a milestone that the liquid organics in the tank must be removed.

*WHC-CM-2-14, *Hazardous Material Packaging and Shipping*, Westinghouse Hanford Company, Richland, Washington.

DRAFT September 2, 1994

TABLE OF CONTENTS

1.0 INTRODUCTION 1
1.1 BACKGROUND 1
1.2 PURPOSE AND SCOPE 2
1.3 JUSTIFICATION 2

2.0 PACKAGE CONTENTS: LIQUID ORGANIC WASTE 3
2.1 DESCRIPTION 3
2.1.1 Physical Characterization 3
2.1.2 Chemical Characterization 3
2.1.3 Radiological Characterization 3
2.2 TRANSPORTATION CLASSIFICATION 4
2.3 STORAGE CLASSIFICATION 4
2.4 FISSILE CLASSIFICATION 5

3.0 FACILITY OPERATIONS 5
3.1 ORIGINATING FACILITY 5
3.2 STORAGE FACILITY 5

4.0 PACKAGING/TRANSPORT SYSTEM DESIGN CRITERIA 5
4.1 GENERAL 5
4.2 PACKAGING DESIGN CRITERIA 6
4.2.1 Construction Materials 6
4.2.2 Packaging Dimensions 6
4.2.3 Weight of Contents 7
4.2.4 Maximum Gross Weight 7
4.2.5 Venting 7
4.2.6 Lifting Attachments 7
4.2.7 Tiedown Attachments 7
4.2.8 Closure Design 8
4.2.9 Containment 8
4.2.10 Shielding 8
4.2.11 Service Life 9
4.2.12 Decontamination 9
4.3 TRANSPORT SYSTEM 9
4.3.1 General 9
4.3.2 Tiedowns 9
4.3.3 Shielding 11

5.0 GENERAL REQUIREMENTS: BASIS FOR PACKAGING SAFETY 11
5.1 SAFETY CLASSIFICATION 11
5.2 TRANSPORTATION SAFETY 12
5.2.1 Normal Conditions of Transfer 12
5.2.2 Accident Conditions 12
5.2.3 Shielding 13
5.2.4 Thermal 13
5.2.5 Criticality 13

TABLE OF CONTENTS (Continued)

5.2.6 Fire Protection 13
5.3 PACKAGE DISPOSAL CRITERIA 14
5.4 ALARA 14
5.5 QUALITY ASSURANCE 14
5.6 SAFETY 15
5.7 PACKAGING AND SHIPPING 15
5.8 DESIGN FORMAT 15
5.10 MAINTENANCE 15

6.0 REFERENCES 16

TABLE

Table 1. Radioisotopic Source Term for Organic/Aqueous/1% Aqueous Mixture of 22,700 L (6000 gallons) 4

DRAFT September 2, 1994

THE 241-C-103 LIQUID ORGANIC BULK WASTE CONTAINER

1.0 INTRODUCTION

1.1 BACKGROUND

Tank 241-C-103 is one of twelve 2,000,000 L (530,000 gal) steel lined concrete tanks constructed in 1943-1944 to store high-level aqueous waste solutions. Initially the tank received metal waste solution from the bismuth phosphate process at B Plant. The metal waste was subsequently removed in the 1950's, later, coating waste and other miscellaneous waste solutions of intermediate radioactivity were discharged into the tank directly from the Plutonium-Uranium Extraction (PUREX) Plant. In the years following, the tank received waste from a number of different sources, but was a primary receiver for the PUREX Acidified Sludge (PAS) secondary recovery operations. Other sources of 241-C-103 tank waste are: B Plant high-level waste, B Plant low-level waste, thoro waste, and strontium semiworks waste.

Tank 241-C-103 remained active until July 1979, after which no wastes were transferred into or out of the tank. In July 1987, noxious vapors emitted from the tank caused illness and resulted in hospitalization (for observation) to two Westinghouse Hanford Company (WHC) workers. Analysis of the headspace gases revealed that the tank contained a mixture of volatile organics and ammonia gas, with concentrations exceeding the threshold limit values.

The organic was deposited in tank 241-C-103 by a transfer from tank 241-C-102, which originally received the organic from a PUREX solvent stream. Ineffective separation of the PUREX organic wash waste from the aqueous wash resulted in the transfer of organics into the waste system.

The detection of combustible organic vapors in the headspace of 241-C-103 and the subsequent verification of a liquid organic phase in the tank resulted in placing 241-C-103 on the "Watch List" of waste tanks with high organic content. In addition to the toxicity of the vapors, the primary concerns regarding the floating organic layer are the flammability of the liquid and the explosiveness of the vapor. These latter two concerns have been the subjects of recent studies. Experiments at Pacific Northwest Laboratory (PNL) yielded an average value for the flash point of the 241-C-103 organic of 119 °C, which means the hazard is real, but less serious than originally thought.

The potential for explosion and in-tank fire, with a resultant dispersion of radioactivity to the environment was the reason for the declaration of an unreviewed safety question (USQ). The approach to resolve the safety issue is to remove the organic from the tank. This approach has

DRAFT September 2, 1994

Table 1. Radioisotopic Source Term for Organic/Aqueous/1% Aqueous Mixture of 22,700 L (6000 gallons).

Radioisotope	Organic Conc. (μCi/mL)	Organic Activity (Ci)	Aqueous Conc. (μCi/mL)	Aqueous Activity (Ci)	Mixture Conc. (μCi/mL)	Mixture Activity (Ci)
^{238}Pu	7.85 E-05	1.76 E-03	0.00 E+00	0.00 E+00	7.77 E-05	1.76 E-03
$^{239/240}Pu$	1.69 E-04	3.79 E-03	0.00 E+00	0.00 E+00	1.54 E-04	3.79 E-03
^{241}Pu	5.38 E-03	1.21 E-01	0.00 E+00	0.00 E+00	5.33 E-03	1.21 E-01
^{241}Am	1.56 E-04	3.49 E-03	0.00 E+00	0.00 E+00	1.54 E-04	3.48 E-03
^{244}Cm	3.70 E-05	8.30 E-04	0.00 E+00	0.00 E+00	3.66 E-05	8.31 E-04
^{90}Sr	4.79 E-01	1.07 E+01	7.05 E+01	1.60 E+01	1.16 E+00	2.68 E+01
^{90}Y	4.79 E-01	1.07 E+01	7.05 E+01	1.60 E+01	1.16 E+00	2.68 E+01
^{60}Co	6.48 E-04	1.45 E-02	5.10 E-02	1.16 E-02	1.15 E-03	2.61 E-02
^{137}Cs	3.59 E-02	8.06 E-01	5.78 E+01	1.31 E+01	6.14 E-01	1.39 E+01
^{137m}Ba	3.59 E-02	8.06 E-01	5.78 E+01	1.31 E+01	6.14 E-01	1.39 E+01
^{154}Eu	2.76 E-04	6.72 E-03	0.00 E+00	0.00 E+00	2.73 E-04	6.20 E-03
^{155}Eu	2.74 E-04	6.67 E-03	0.00 E+00	0.00 E+00	2.71 E-04	6.15 E-03
TOTAL	1.04 E+00	2.32 E+01	2.57 E+02	5.82 E+01	3.60 E+00	8.16 E+01

The exact mixture and source term will not be known until after removal of the waste occurs, therefore this packaging design criteria includes all possible source terms by assuming a conservative worst case scenario.

2.2 TRANSPORTATION CLASSIFICATION

The LOBWC package contents are shown (see Appendix) to be a greater than Type A, LSA quantity of radioactive liquid material if the waste remains homogenous after removal, as defined in 49 CFR 173. If the aqueous settles out, the waste is a Type B quantity, as defined in 49 CFR 173.

2.3 STORAGE CLASSIFICATION

The waste has been classified as mixed waste for storage purposes, and as such the LOBWC packaging is subject to the storage regulations/requirements in Washington Administrative Code (WAC) 173-303 and the *Environmental Compliance Manual*, WHC-CM-7-5.

2.4 FISSILE CLASSIFICATION

The LOBWC package contents have been classified as fissile-exempt by 49 CFR 173.435(a), because the waste contains less than 15 g of fissile material (see Appendix).

3.0 FACILITY OPERATIONS

3.1 ORIGINATING FACILITY

The organic waste will originate from tank 241-C-103 in the Tank Farms C complex. The LOBWC assembly design shall be compatible with existing loading and unloading facility configurations. Design compatibility with the pump/skimmer and coalescer facilities which are anticipated to associate with the LOBWC assembly is required. Drawing details of the coalescer and facility are included in Appendix I of the Preliminary Design Report Removal and Separation of the Floating Organic Layer in Tank 241-C-103 (PDR).

The dimensions of concern include the position of the access ports on top of the tank as well as the overall length, width, and height of the LOBWC assembly.

3.2 STORAGE FACILITY

The LOBWC is a single use shipping container. The organic waste will be shipped from Tank Farms C complex to Tank Farms B complex, southwest corner, where it will be stored for a maximum of five years.

4.0 PACKAGING/TRANSPORT SYSTEM DESIGN CRITERIA

4.1 GENERAL

The LOBWC and assembly (i.e., the tank and transport vehicle) shall be designed and constructed to provide one containment barrier for the transfer of the waste contents identified in Section 2.0 of this document. In addition, the design shall meet all applicable requirements of WHC-CM-2-14 for onsite hazardous materials transfers. No protective overpack shall be used.

The LOBWC assembly must be compatible with the intended facilities (listed in Sections 3.1 and 3.2) for transfer, loading, and unloading. Also, maintenance of the assembly, including prevention of corrosion and leakage, must be considered in the design.

The LOBWC and assembly must be compatible with the weekly visual inspection to be done as documented in WAC 173-303. In addition, attention to the potential need for cleaning, and replacement parts will be included in the LOBWC design.

4.2 PACKAGING DESIGN CRITERIA

4.2.1 Construction Materials

The LOBWC assembly construction materials shall meet the following requirements.

1. Packaging construction materials shall be selected to assure that there will be no significant chemical, galvanic, or other reaction among the packaging components or between the packaging components and the package contents (i.e. between the waste and the steel tank shell), during the specified service life (Section 4.2.11) of the packaging. The type of steel suitable for tank construction was determined by a corrosivity study to be American Iron and Steel Institute (AISI) Type 316L stainless steel.

2. The tank shall be constructed within the rules of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel (B&PV) Code, Section VIII.

3. Material certifications shall, as a minimum, describe the chemical composition, yield strength, and ultimate strength. Vendor supplied materials such as gaskets and mechanical components shall be traceable to valid manufacturer's data or performance specifications.

4.2.2 Packaging Dimensions

The LOBWC shall be adequately sized to contain and transfer a maximum of 22,700 L (6,000 gal) of waste.

The dimensions of the LOBWC must allow it to be transported and tied down safely on the transport vehicle.

A proposed transport vehicle is HO-64-5298, a trailer capable of transporting 60 tons, with the following usable bed dimensions:

Length: 12.2 m (40.0 ft)
Width: 4.1 m (13.5 ft)

The overall height of the LOBWC assembly on the transport vehicle shall not exceed 4.1 m (13.5 ft).

4.2.3 Weight of Contents

The LOBWC shall be capable of carrying the volume specified in Section 4.2.2 of this document. Specifically, a maximum load of 19,800 kg (43,700 lb) net.

4.2.4 Maximum Gross Weight

The maximum gross weight of the loaded LOBWC assembly shall not exceed route transfer limits, or any limits imposed by the following Sections 3.1, 3.2, or 4.3.1.

4.2.5 Venting

The tank will be closed during transport, but during storage it will be vented through a high-efficiency particulate air (HEPA) filter assembly.

The tank will be compatible with the designed filter assembly, including a flange or gasket providing the necessary filter fitting.

4.2.6 Lifting Attachments

Any lifting attachment that is a structural part of the LOBWC assembly shall be designed with a minimum safety factor of three to the yield strength, and five to the ultimate strength. Stresses over the entire structure shall be considered. The design of the lifting device(s) shall be such that failure of any lifting device under excessive load will not impair the ability of the LOBWC tank to meet other requirements of this packaging design criteria.

The LOBWC shall include suitable lifting attachments such that the filled LOBWC may be loaded and unloaded from the transport vehicle according to DOE-RL-92-36, *Hanford Site Hoisting and Rigging Manual* (RL 1993).

4.2.7 Tiedown Attachments

Tiedown attachments that are a structural part of the LOBWC must be capable of withstanding, without generating stress in any material of the package in excess of its yield strength, a static force applied to the center of gravity of the package having a vertical component of two times the weight of the package with its contents, a horizontal component along the direction in which the vehicle travels of 10 times the weight of the package with its contents, and a horizontal component in the transverse direction of five times the weight of the package with its contents.

Each tiedown device which is a structural part of a package must be designed so that failure of the device under excessive load would not impair the ability of the package to meet other requirements of this section.

4.2.8 Closure Design

The LOBWC shall have positive closure devices on all access ports. These closure devices shall be designed such that they cannot be opened unintentionally. The closures shall be designed for ease of access and operation to minimize radiation exposure.

The LOBWC shall be fitted with ports and fittings for loading and unloading. These ports shall be located above the liquid level in the tank near the midpoint of the tank axis. The ports and fittings shall include suitable protection devices so that containment cannot be lost due to accidental damage.

The LOBWC shall be provided with apparatus for sampling and measuring the liquid level as shown in drawing detail ES-ER5602-M1 included in the PDR.

4.2.9 Containment

Containment for the waste will be provided by the steel walls and valves of the tank, which will be constructed according to ASME B&PV Code, Section VIII.

4.2.10 Shielding

The LOBWC does not require integral shielding to meet any transportation regulations. However, in order for the LOBWC to serve as the waste storage container it must be shielded in some manner to meet the 100 mrem/h high radiation area storage limit. Shielding scenarios were done for the LOBWC at distances of 1 cm, 30 cm, and 200 cm, with three types of shielding material lead, steel, and concrete (see Appendix). Any shielding design for the LOBWC shall take into account the increased dose rates due to separation of the aqueous phase from the organic phase waste. The design of the shielding for the LOBWC is to take into account these factors:

1. Cost
2. ALARA principles
3. Weekly visual inspections
4. Re-shipment of LOBWC in five years time

Two strategies for shielding the LOBWC have been proposed.

1. Integral concrete shielding attached to the dedicated LOBWC transport vehicle, or
2. A concrete shielding box separate from the LOBWC to be constructed at the loading and storage facilities.

(b) *Tiedown assemblies.* The aggregate working load limit of the tiedown assemblies used to secure an article against movement in any direction must be at least 0.5 times the weight of the article. Chain used as a component of a tiedown assembly must conform to the requirements of the June 15, 1990, edition of the National Association of Chain Manufacturers' Welded Steel Chain Specifications, applicable to all types of chain. Steel strapping used as a component of the tiedown assembly must conform to the requirements of the 1991 edition of the American Society for Testing and Materials (ASTM) Standard Specification for Strapping, Flat Steel and Seals, ASTM D3953-91. Steel strapping that is 2.54 cm (1 in.) wide or wider must have at least two pairs of crimps in each seal and when end-over-end laps are formed must be sealed with at least two seals. Wire rope used as a component of a tiedown assembly must conform to the requirements of the November 1985 second edition of the Wire Rope Technical Board's Wire Rope Users Manual.

(c) *Load binders and hardware.* The strength of the load binders and hardware that are part of, or used in conjunction with, a tiedown assembly must be equal to, or greater than the minimum strength specified for that tiedown assembly in paragraph (b) of this section.

(d) *Attachments to the vehicle.* The hook, bolt, weld, or other connector by which a tiedown assembly is attached to a vehicle, and the mounting place and means of mounting the connector, must be at least as strong as the tiedown assembly when that connector is loaded in any direction in which the tiedown assembly may load it.

(e) *Winches or other fastenings.* The anchorages of a winch or other fastening device mounted on a vehicle and used in conjunction with a tiedown assembly must have a combined tensile strength equal to, or greater than, the strength of the tiedown assembly.

(f) *Adjustability.* A tiedown assembly and its associated connectors and attachment devices must be designed, constructed, and maintained so that the driver of an in-transit vehicle can tighten them. However, the criteria in this paragraph do not apply to a securement system in which the tiedown assembly consists of steel strapping or to a tiedown assembly which is not required by the criteria in this section.

4.3.2.2 Blocking and Bracing

(a) *Protection against longitudinal movement.* The cargo must be secured so that, when the vehicle decelerates at a rate of 20 ft/s/s, the cargo will remain on the vehicle and will not penetrate the vehicle's front-end structure.

(b) *Protection against lateral movement.* The cargo must either be securely blocked or braced against the side, sideboards, or stakes of the vehicle or be secured by devices that conform to the either of the following:

(1) The vehicle must have at least one tiedown assembly that meets the requirements of Section 4.3.2.1 for each 10 linear feet of lading or fraction thereof.

(2) The vehicle must have other means of preventing shifting or falling cargo which are similar to, and at least as effective as, the requirement specified in (1).

4.3.2.3 Additional Tiedown Requirements

Consideration shall be given to tiedown methods (such as remote operations or permanent systems integral to the packaging and transport vehicle) to maximize the distance and/or minimize the time spent near the payload.

4.3.3 Shielding

The LOBWC shielding criteria have been included in Section 4.2.10.

5.0 GENERAL REQUIREMENTS: BASIS FOR PACKAGING SAFETY

The safety of onsite transfers using the LOBWC assembly will be based on meeting onsite transportation safety criteria by design, safety analysis, and risk assessment as delineated in WHC-SD-TP-RPT-001, *Report on Equivalent Safety for Transportation and Packaging of Radioactive Materials* (WHC 1993).

A combination of packaging design, operational controls, risk assessment, and dose consequence analysis will document the package safety in the SEP. The SEP analyses will demonstrate the ability of the packaging to provide containment, and limit dose consequences.

5.1 SAFETY CLASSIFICATION

A safety class determination will be done to analyze the waste from the following two perspectives: radioactivity and chemical toxicity.

The radioactivity determination was performed through a dose consequence analysis which showed an offsite dose of 1.0×10^{-5} rem and onsite of 0.03 rem assuming unmitigated loss of tank contents (see Section 5.2.2.2). Since none of the dose equivalents are above 5 rem the LOBWC is safety class 3.

A toxicological study will be performed for the SEP to determine the safety class of chemical constituents in the waste using the Emergency Response Protection Guidelines created by the American Industrial Hygiene Association as the governing controls.

DRAFT September 2, 1994

5.2 TRANSPORTATION SAFETY

5.2.1 Normal Conditions of Transfer

5.2.1.1 Vibration

The LOBWC and assembly shall be able to withstand the effects of any vibration or vibration resonance that is normally incident to transport.

5.2.1.2 Heat and Cold

Containment and shielding will be maintained by the package during transportation and storage in a temperature range of -40 °C (-40 °F) to 70 °C (158 °F) with account being taken for the possibility of brittle fracture. A thermal analysis will be included in the SEP which accounts for an ambient temperature up to 46 °C (115 °F), solar insolation, and decay heat contribution.

5.2.1.3 Pressure

The packaging must be able to withstand a reduced external pressure of 20 kPa (3.5 psi) absolute and an increased internal pressure of 140 kPa (20 psi) absolute. In addition, the package must be able to perform at any of the expected operational pressures.

5.2.1.4 Transfer Route

The specific transfer route for shipment has not yet been determined, but some relevant information has been included. The total distance travelled will not be more than 3.2 km (2.0 mile), on a combination of dirt, gravel and asphalt roads. There will be very tight turns on the route, some 90° or more. The transfer route is assumed to have slopes up to a 10% grade, any designed tiedown system shall address this.

5.2.2 Accident Conditions

The package design need not provide for any specific accident condition requirements or tests, because vehicle accidents involving the LOBWC are considered incredible.

5.2.2.1 Accident Frequency Analysis

The LOBWC and assembly shipping scenario has been shown by an accident frequency assessment to have an incredible probability of an accident event. Incredible events meet the following criteria:

> *Incredible Events* - Any unplanned event that has a calculated frequency less than 1×10^{-6} per year is incredible. Events with annual frequencies approaching 1×10^{-6} (i.e., $> 1 \times 10^{-8}$) shall

not result in an offsite dose consequence of greater than 25 rem effective dose equivalent (EDE). Incredible events (< 1 x 10^{-8} per year) do not require evaluation.

5.2.2.2 Dose Consequence Analysis

A dose consequence analysis of the LOBWC transfer (see Appendix) was performed assuming complete loss of payload from all engineered barriers. An onsite worker is expected to receive a committed dose equivalent of 0.03 rem while an offsite individual at the worst case site boundary is expected to receive a committed effective dose of 1 x 10^{-5} rem. This scenario is considered safe for transportation purposes.

5.2.3 Shielding

A shielding analysis shall be provided in the SEP to assure that the packaging will safely limit the dose rate at accessible surfaces of the tank to a maximum of 1000 mrem/h, and 10 mrem/h at 2 m during transfer, or provide equivalent safety. Acceptable maximum dose limits for onsite waste transfers shall be 2 mrem/h (WHC-CM-4-9, *Radiological Design*) at any normally occupied space on the transport vehicle.

5.2.4 Thermal

Decay heat generation of the waste shall not prevent the package from maintaining its integrity during transfer.

The maximum surface temperature of the tank shall be evaluated in the SEP for occupational safety. No external surface of the tank shall have a temperature exceeding 82 °C (180 °F) in still ambient air temperature of 38 °C (100 °F) in the shade.

5.2.5 Criticality

Criticality is not an issue in this shipment because the payload is fissile exempt, therefore it contains less than 15 g of fissile material, which is under the limit of 450 g required to start an uncontrolled criticality (see Appendix for calculation).

5.2.6 Fire Protection

A flammable gas generation study will be performed and included in the SEP documentation, so that the safety of the packaging for transportation purposes is confirmed.

5.3 PACKAGE DISPOSAL CRITERIA

This package is not intended for disposal. The loaded package will be stored until the contents can be disposed. The packaging may be suitable for reuse subject to cleaning and inspection.

5.4 ALARA

Design features of the packaging shall be consistent with the requirements in WHC-CM-4-11, *ALARA Worksheet*. Exposure of personnel to radiological and other hazardous materials associated with the loading, closure, unloading, storage, and maintenance of the tank car shall be minimized.

5.5 QUALITY ASSURANCE

Design, construction, testing, and verification activities for the tank car shall be in accordance with WHC-CM-4-2, *Quality Assurance Manual*. All inspections and testing shall be documented.

The approval requirements for documentation associated with the analysis, design, and fabrication of the LOBWC and components shall be in accordance with *Management Requirements and Procedures* (MRP) 5.43, WHC-CM-1-3.

A graded approach for the Quality Assurance requirements shall be used. All packaging components shall be assigned a Quality Category appropriate to its impact on packaging safety. The three Quality Categories are as follows:

(a) Quality Category A

Critical Impact - Includes items and activities that could have a direct impact on public radiological health and safety. This classification includes items and activities for which omission, error, or failure could result in consequences exceeding the requirements specified in or based on applicable Federal regulations. All material used in fabrication and fabrication welding shall be certified and documented.

(b) Quality Category B

Major Impact - Includes items and activities for which failure could indirectly impact public radiological health and safety. This classification encompasses items and activities whose failure could adversely impact the performance of Category A items. Fabrication material used shall be procured in such a manner that it is verifiable to be as specified in drawings.

(c) Quality Category C

Minor Impact - Includes items for which failure is unlikely to result in a significant adverse impact on public radiological health and safety. Materials should be of standard commercial grade or better.

5.6 SAFETY

Documentation and analysis of safety requirements for the onsite transfer and storage of the LOBWC shall be provided by development of a SEP per MRP 5.20 (WHC-CM-1-3).

5.7 PACKAGING AND SHIPPING

General requirements for the packaging and shipping of hazardous radioactive materials shall be in accordance with WHC-CM-2-14. A procedure shall be prepared by the organization to control the transfer loading and unloading operations in accordance with the SEP. The procedure shall be reviewed and approved by Packaging Safety Engineering.

5.8 DESIGN FORMAT

Development of design drawings, design changes, and design documentation shall be in accordance with DOE Order 6430.1A (*General Design Criteria*) WHC-CM-6-1 (*Standard Engineering Practices*), and WHC-CM-6-3 (*Drafting Standards*). A "U" stamp shop shall have design control in accordance with ASME.

5.9 ENVIRONMENTAL COMPLIANCE

Actions and conditions for the protection of the environment during the transfer operation and storage shall comply with the requirements of the *Environmental Compliance Manual*, WHC-CM-7-5.

5.10 MAINTENANCE

Ease and minimization of maintenance shall be considered in the design of the LOBWC assembly. Vendor spare parts and maintenance data, if applicable, shall be provided for equipment specified in the design. Special tools required to operate, replace, or repair components shall be provided as part of the project.

The LOBWC will be equipped with devices, or fittings for devices designed to measure the temperature and pressure of the LOBWC interior. The placement of these devices is given in detail drawing ES-ER5602-M1.

6.0 REFERENCES

10 CFR 71, 1992, "Packaging and Transportation of Radioactive Materials," *Code of Federal Regulations*, as amended.

49 CFR 173, 1991, "Transportation," *Code of Federal Regulations*, as amended.

NRC, 1981, *Recommendations for Protecting Against Failure by Brittle Fracture in Ferritic Steel Shipping Containers Up to Four Inches Thick*, NUREG/CR-1815, U.S. Nuclear Regulatory Commission, Washington, D.C.

Pool, K. H., and R. M. Bean, 1994, *Waste Tank Organic Safety Project Analysis of Liquid Samples from Hanford Waste Tank 241-C-103*, PNL-9403, Pacific Northwest Laboratory, Richland, Washington, March 1994.

RL, 1993, *Hanford Site Hoisting and Rigging Manual*, DOE-RL-92-36, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

WAC 173-303, 1990, "Dangerous Waste Regulations," *Washington Administrative Code*, as amended.

WHC-CM-1-3, *Management Requirements and Procedures*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-2-14, *Hazardous Material Packaging and Shipping*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-4-2, *Quality Assurance Manual*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-4-9, *Radiological Design*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-4-11, *ALARA Program Manual*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-4-29, *Nuclear Criticality Safety Manual*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-6-1, *Standard Engineering Practices*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-6-3, *Drafting Standards*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-7-5, *Environmental Compliance Manual*, Westinghouse Hanford Company, Richland, Washington.

WHC, 1993, *Report on Equivalent Safety for Transportation and Packaging of Radioactive Materials*, WHC-SD-TP-RPT-001, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

DRAFT September 2, 1994

Transportation Classification: C-103 Organic/Aqueous Waste

Done by: Reid, Chesterfield 8/23/94 Checked by: J. E. Meacham 8/22/94

Volume = 22,700 Liter
Waste Form: Liquid
Density = 0.871g/mL

Nuclide	Concentration (uCi/mL)	(mCi/g)	Activity (Ci)	A2 (Ci)	Fi	Fi/A2	LSA Fraction
Co-60	1.15E-03	1.32E-06	2.61E-02	7	6.40E-04	9.14E-05	4.41E-06
Sr-90	1.18E+00	1.35E-03	2.68E+01	0.4	6.55E-01	1.64E+00	2.71E-01
Y-90	1.18E+00	1.35E-03					
Cs-137	6.14E-01	7.05E-04	1.39E+01	10	3.41E-01	3.41E-02	2.35E-03
Ba-137m	6.14E-01	7.05E-04					
Eu-154	2.73E-04	3.13E-07	6.20E-03	5	1.52E-04	3.03E-05	1.04E-06
Eu-155	2.71E-04	3.11E-07	6.15E-03	60	1.51E-04	2.51E-06	1.04E-06
Pu-238	7.77E-05	8.92E-08	1.76E-03	0.003	4.32E-05	1.44E-02	8.92E-04
Pu-239/240	1.67E-04	1.92E-07	3.79E-03	0.002	9.28E-05	4.64E-02	1.92E-03
Pu-241	5.33E-03	6.12E-06	1.21E-01	0.1	2.96E-03	2.96E-02	1.22E-03
Am-241	1.54E-04	1.76E-07	3.48E-03	0.008	8.53E-05	1.07E-02	1.76E-03
Cm-244	3.66E-05	4.20E-08	8.31E-04	0.01	2.03E-05	2.03E-03	4.20E-04
Totals	3.60E+00		4.09E+01			1.78E+00	2.80E-01
Type B		LSA		Mix. A2 =	5.63E-01		

Note: Y-90 and Ba-137m are not included in the transportation determination because they are less than 10 day daughter products, so the parents A2 value includes their presence.

Fissile Classification Calculations

Nuclide	Conc. (Ci/mL)		Ci total	Spec. Act. (	Mass (g)
Pu-238	7.77E-11	x 2.27E+07	1.76E-03	1.71E+01	1.03E-04
Pu-239/40	1.67E-10	x 2.27E+07	3.79E-03	6.22E-02	6.10E-02
Pu-241	5.33E-09	x 2.27E+07	1.21E-01	1.03E+02	1.17E-03
Total			1.27E-01		6.23E-02

Since 6.23E-02 < 15 grams: the waste shipment qualifies as fissile exempt.

Westinghouse Hanford Company **Internal Memo**

From: Radiation Physics and Shielding 8D530-HJG-94-021
Phone: 376-3765 HO-35
Date: July 22, 1994
Subject: DOSE CONSEQUENCE ANALYSIS OF TANK C-103 LIQUID ORGANIC/AQUEOUS MIXTURE -- SAFETY CLASS ASSESSMENT

To: J. E. Mercado G2-02

cc: J. G. Field G2-02
J. Greenborg HO-35
R. J. Chesterfield G2-02
HJG File/LB

The organic layer of the C-103 tank is to be removed from that tank and stored in the south west corner of the B-tank farm. In addition to the organic compounds, it has been postulated that 1% of the aqueous solution will "travel" with the organics. The source term is;

Table 1. Source Term

Isotope	Activity (Ci)
^{60}Co	2.62×10^{-2}
^{90}Sr	$2.68 \times 10^{1*}$
^{90}Y	$2.68 \times 10^{1*}$
^{137}Cs	1.39×10^{1}
^{137m}Ba	1.31×10^{1}
^{154}Eu	6.20×10^{-3}
^{155}Eu	6.16×10^{-3}
^{238}Pu	1.76×10^{-3}
$^{239/240}Pu$	3.79×10^{-3}
^{241}Pu	$1.21 \times 10^{-1**}$
^{241}Am	3.49×10^{-3}
^{244}Cm	$8.30 \times 10^{-4***}$

* All of the beta ray dose was assumed to be $^{90}Sr/Y$.
** ^{241}Pu in the amount consistent with the ^{241}Am activity was added to the received source term. This was based on 12% ^{240}Pu aged 10 years.
*** The portion of the total alpha not accounted for by the listed activities was assumed to be ^{244}Cm.

In order to determine a safety classification for the storage and transportation container, this analysis of the results of a postulated release has been performed

For the purposes of this analysis it has been assumed that the entire inventory in the container has been released from any engineered barriers and is at risk for release. The respirable aerodynamic release fraction was taken from the recommendations of J. Mishima (Recommended Values and Technical Bases for Airborne Fractions [ARFs], Airborne Release Rates [ARRs], and Respirable Fractions [RFs] for Materials from Accidents in DOE Fuel Cycle, Ex-Reactor Facilities, Revision 2).

For aqueous liquids on equipment that is dropped three meters or less onto a hard surface the recommended bounding (and recommended) value is 2×10^{-4}. The resuspension release fraction for this source with windspeeds up to 30 mph is 4×10^{-6}/hr. Thus, this factor would not be significant unless the spill were left unattended for about 50 hours and stayed liquid for this time.

The 2×10^{-4} value was used in this analysis to ascertain the expected doses on two receptors, a worker 100 m away from the point of release, and an offsite individual. Both receptors are immersed in the cloud for the entire time of its passage.

The computer program GXQ was run to find the meteorology which is not exceeded more than 0.5% of the time according to Hanford meteorological data. The nine year (1983 - 1991) averaged Hanford data for 200 area release at a height of 10m (created 8/26/92) was used. The worst case normalized exposure (Ψ/Q) was calculated to be 3.41×10^{-2} sec/m^3 for the worker 100 m to the east of the release, and 1.55×10^{-5} sec/m^3 for an individual at the site boundary 15,040 m to the east of the release. Only inhaled doses were calculated.

The computer code GENII was then used to calculate the actual dose received. The libraries used were as tabulated below;

GENII Default Parameter Values (28-Mar-90 RAP)
Radionuclide Library - Times<100 years (23-July-93 PDR)
External Dose Factors for GENII in person Sv/yr per Bq/n (8-May-90 R
Worst-Case Solubilities, Yearly Dose Increments (23-Jul-93 PDR)

The worker is expected to receive a committed effective dose equivalent of 0.03 rem while the off-site individual at the worst case site boundary is expected to receive a committed effective dose equivalent of 1×10^{-5} rem.

Note that none of the effective dose equivalents to the public are over 0.5 rem and none of the effective dose equivalents to a worker are over 5 rem so that as far as radiological criteria are concerned this proposed container can be safety class 3.

Sample Input Deck

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: 103-C Organic Removal - Farmer

Executed on: 07/19/94 at 14:56:02 Page A. 1

This is a far-field (wide-scale release, multiple site) scenario.
Release is acute
Individual dose

THE FOLLOWING TRANSPORT MODES ARE CONSIDERED
Air

THE FOLLOWING EXPOSURE PATHS ARE CONSIDERED:
Infinite plume, external
Inhalation uptake

THE FOLLOWING TIMES ARE USED:
Intake ends after (yr): 1.0
Dose calculations ends after (yr): 50.0

========== FILENAMES AND TITLES OF FILES/LIBRARIES USED ==========

Input file name: \GENII\103c-f.in
GENII Default Parameter Values (28-Mar-90 RAP)
Radionuclide Library - Times<100 years (23-July-93 PDR)
External Dose Factors for GENII in person Sv/yr per Bq/n (8-May-90 R
Worst-Case Solubilities, Yearly Dose Increments (23-Jul-93 PDR)

	----Release Terms----		
Release Radio-nuclide	Air Ci/yr	Surface Water Ci/yr	Buried Source Ci/m3
CO60	2.6E-02	0.0E+00	0.0E+00
SR90	2.7E+01	0.0E+00	0.0E+00
Y 90	2.7E+01	0.0E+00	0.0E+00
CS137	1.4E+01	0.0E+00	0.0E+00
EU154	6.2E-03	0.0E+00	0.0E+00
EU155	6.2E-03	0.0E+00	0.0E+00
PU238	1.8E-03	0.0E+00	0.0E+00
PU239	3.8E-03	0.0E+00	0.0E+00
PU241	1.2E-01	0.0E+00	0.0E+00
AM241	3.5E-03	0.0E+00	0.0E+00
CM244	8.3E-04	0.0E+00	0.0E+00

========== AIR TRANSPORT ==========
1.5E-05 Input E/Q value (s/m3)

========== EXTERNAL EXPOSURE ==========
1.0E+00 Fraction of time spent in cloud

========== INHALATION ==========
Resuspension not considered

Input prepared by: _____ Date: _____

Input checked by: _____ Date: _____

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: 103-C Organic Removal - Farmer

Executed on: 07/19/94 at 14:56:18 Page C. 1

Acute release
Uptake/exposure period: 1.0
Dose commitment period: 50.0
Dose units: Rem

Organ	Committed Dose Equivalent	Weighting Factors	Weighted Dose Equivalent
Gonads	9.3E-03	2.5E-01	2.3E-03
Breast	2.3E-03	1.5E-01	3.5E-04
R Marrow	1.9E-01	1.2E-01	2.3E-02
Lung	1.2E-02	1.2E-01	1.4E-03
Thyroid	2.3E-03	3.0E-02	7.0E-05
Bone Sur	8.2E-01	3.0E-02	2.4E-02
Liver	8.3E-02	6.0E-02	5.0E-03
LL Int.	1.1E-02	6.0E-02	6.5E-04
UL Int.	5.7E-03	6.0E-02	3.4E-04
S Int.	3.2E-03	6.0E-02	1.9E-04
Stomach	2.8E-03	6.0E-02	1.7E-04
Internal Effective Dose Equivalent			5.8E-02
External Dose			2.6E-05
Annual Effective Dose Equivalent			5.8E-02

Controlling Organ:	Bone Sur
Controlling Pathway:	Inh
Controlling Radionuclide:	SR90
Total Inhalation EDE:	5.8E-02
Total Ingestion EDE:	0.0E+00

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: 103-C Organic Removal - Farmer

Executed on: 07/19/94 at 14:56:18 Page C. 2

Acute release
Uptake/exposure period: 1.0
Dose commitment period: 50.0
Dose units: Rem

	Dose Commitment Year 1	2	3	...		
Internal Intake Year: 3			0.0E+00	...		
2		0.0E+00	0.0E+00	...		Internal Effective Dose Equivalent
1	8.3E-03 +	3.9E-03 +	3.3E-03 + ...		= 5.8E-02	
Internal Annual Dose	8.3E-03 +	3.9E-03 +	3.3E-03 + ...		= 5.8E-02	Cumulative Internal Dose
External Annual Dose	2.6E-05	0.0E+00	0.0E+00	...	2.6E-05	
Annual Dose	8.3E-03 +	3.9E-03 +	3.3E-03 + ...		= 5.8E-02	Cumulative Dose
					8.3E-03	Maximum Annual Dose Occurred In Year 1

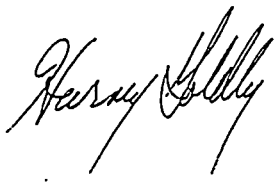
GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

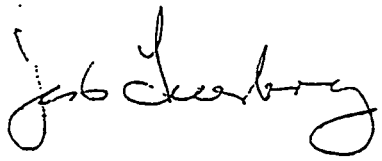
Case title: 103-C Organic Removal - Farmer

Executed on: 07/19/94 at 14:56:18 Page C. 3

Acute release
Uptake/exposure period: 1.0
Dose commitment period: 50.0
Dose units: Rem

Radio-nuclide	Inhalation Effective Dose Equivalent	Ingestion Effective Dose Equivalent	External Dose	Internal Effective Dose Equivalent	Annual Effective Dose Equivalent
CO 60	2.6E-05	0.0E+00	2.1E-07	2.6E-05	2.6E-05
SR 90	2.8E-02	0.0E+00	1.7E-08	2.8E-02	2.8E-02
Y 90	1.2E-03	0.0E+00	6.1E-07	1.2E-03	1.2E-03
CS 137	2.2E-03	0.0E+00	2.5E-05	2.2E-03	2.2E-03
EU 154	8.8E-06	0.0E+00	2.4E-08	8.8E-06	8.8E-06
EU 155	1.3E-06	0.0E+00	8.0E-10	1.3E-06	1.3E-06
CM 244	1.0E-03	0.0E+00	3.6E-13	1.0E-03	1.0E-03
PU 238	3.6E-03	0.0E+00	8.9E-13	3.6E-03	3.6E-03
PU 241	5.0E-03	0.0E+00	1.4E-16	5.0E-03	5.0E-03
U 237	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
AM 241	8.0E-03	0.0E+00	1.2E-10	8.0E-03	8.0E-03
PU 239	8.3E-03	0.0E+00	1.3E-12	8.3E-03	8.3E-03





Harvey J. Goldberg
Principal Engineer

CONCURRENCE: _____
Jess Greenborg, Manager
Radiation Physics and Shielding

CHECKLIST FOR INDEPENDENT TECHNICAL REVIEW

DOCUMENT REVIEWED
NUMBER: 8D530-HJG-94-021
TITLE: DOSE CONSEQUENCE ANALYSIS OF TANK C-103
AUTHOR(s): H. J. Goldberg

I. Method(s) of Review

(✓) Input data checked for accuracy
(✓) Independent calculation performed
(✓) Hand calculation
(na) Alternate computer code:_____
(na) Comparison to experiment or previous results
(na) Alternate method (define)_____

II. Checklist (either check or enter NA if not applied)

(✓) Task completely defined
(✓) Activity consistent with task specification
(✓) Necessary assumptions explicitly stated and supported
(✓) Resources properly identified and referenced
(✓) Resource documentation appropriate for this application
(✓) Input data explicitly stated
(✓) Input data verified to be consistent with original source
(na) Geometric model adequate representation of actual geometry
(na) Material properties appropriate and reasonable
(na) Mathematical derivations checked including dimensional consistency
(✓) Hand calculations checked for errors
(✓) Assumptions explicitly stated and justified
(✓) Computer software appropriate for task and used within range of validity
(na) Use of resource outside range of established validity is justified
(✓) Software runstreams correct and consistent with results
(✓) Software output consistent with input
(na) Results consistent with applicable previous experimental or analytical findings
(✓) Results and conclusions address all points and are consistent with task requirements and/or established limits or criteria
(✓) Conclusions consistent with analytical results and established limits
(na) Uncertainty assessment appropriate and reasonable
(na) Other (define)_____

III. Comments:_____

IV. REVIEWER: Paul Rittmann DATE: 7-22-94

HEDOP REVIEW CHECKLIST
for
Radiological and Nonradiological Release Calculations

Document Reviewed: DOSE CONSEQUENCE ANALYSIS OF TANK C-103 LIQUID ORGANIC/ AQUEOUS MIXTURE -- SAFETY CLASS ASSESSMENT

Submitted by: H. J. Goldberg Date Submitted:

Scope of Review: Entire Document

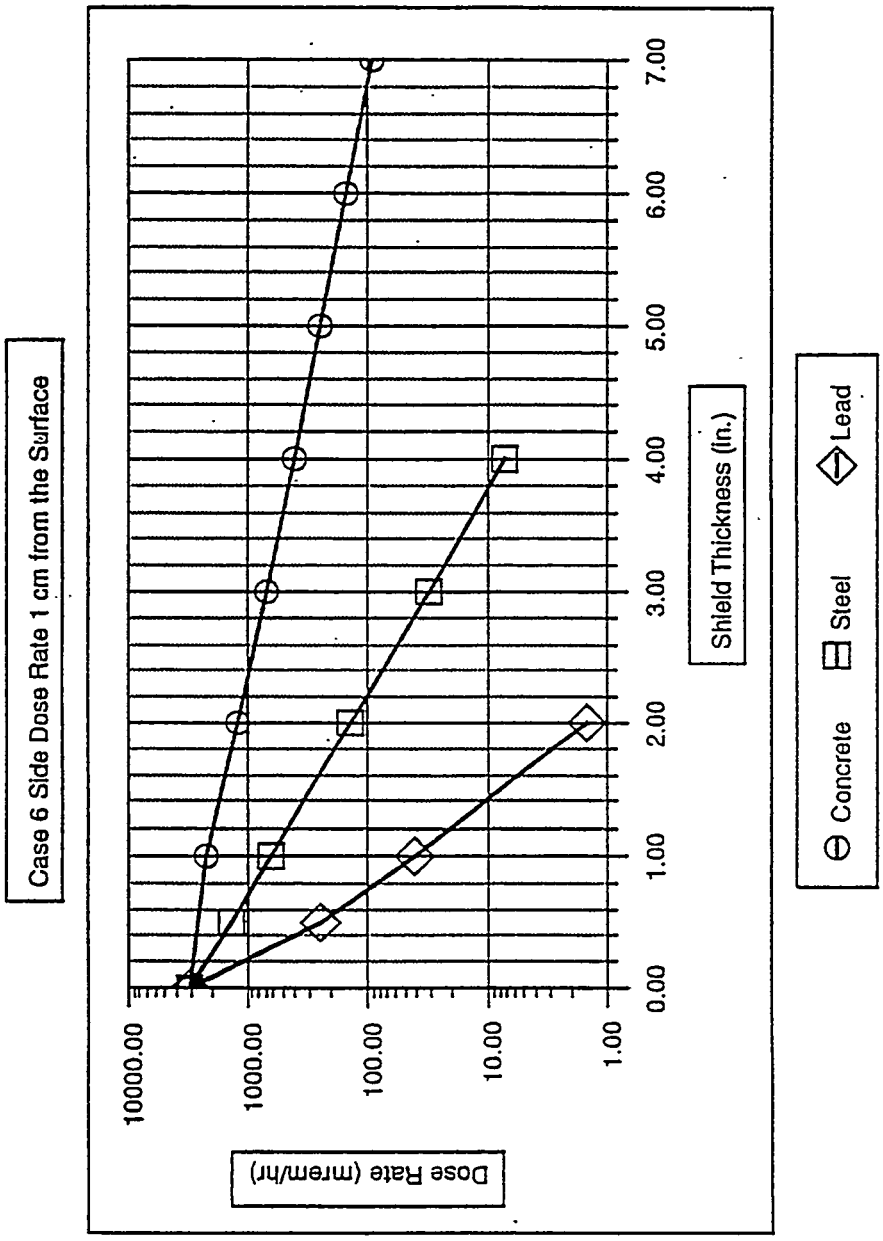
YES	NO*	N/A		
[✓]	[ ]	[ ]	1.	A detailed technical review and approval of the environmental transport and dose calculation portion of the analysis has been performed and documented.
[✓]	[ ]	[ ]	2.	Detailed technical review(s) and approval(s) of scenario and release determinations have been performed and documented.
[✓]	[ ]	[ ]	3.	HEDOP-approved code(s) were used.
[✓]	[ ]	[ ]	4.	Receptor locations were selected according to HEDOP recommendations.
[✓]	[ ]	[ ]	5.	All applicable environmental pathways and code options were included and are appropriate for the calculations.
[✓]	[ ]	[ ]	6.	Hanford site data were used.
[✓]	[ ]	[ ]	7.	Model adjustments external to the computer program were justified and performed correctly.
[✓]	[ ]	[ ]	8.	The analysis is consistent with HEDOP recommendations.
[ ]		[✓]	9.	Supporting notes, calculations, comments, comment resolutions, or other information is attached. (Use the "Page 1 of X" page numbering format and sign and date each added page.)
[X]	[ ]		10.	Approval is granted on behalf of the Hanford Environmental Dose Overview Panel.

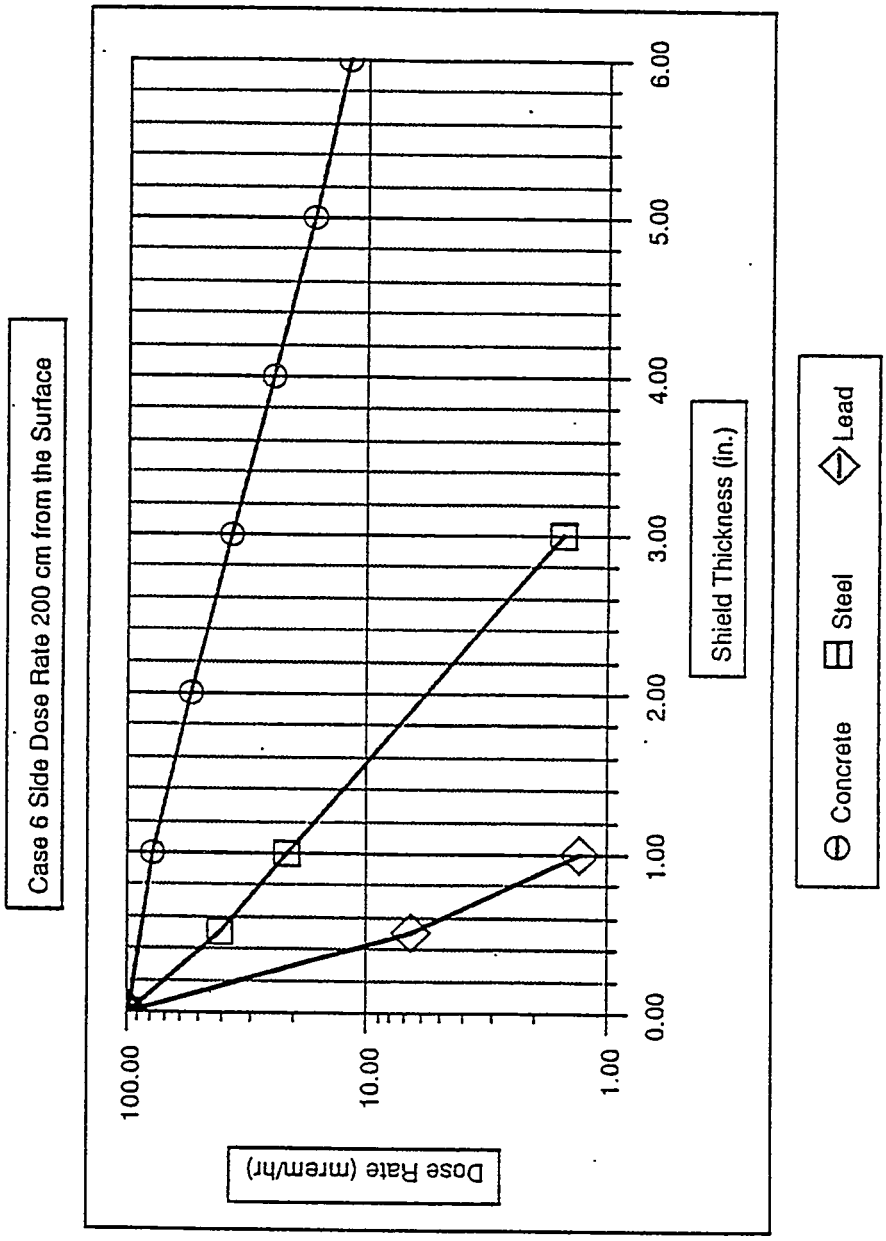
* All "NO" responses must be explained and use of nonstandard methods justified.

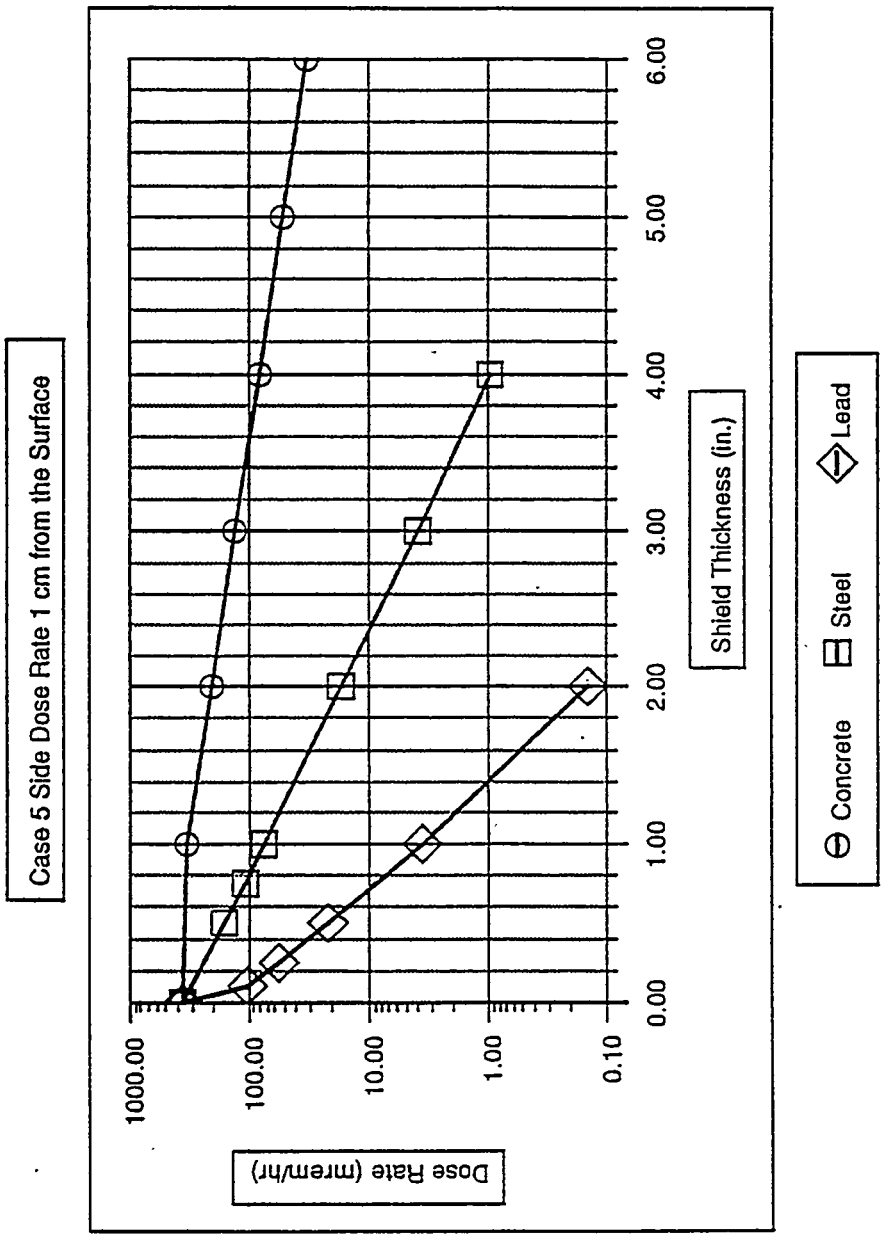
Reviewer Name: Paul D. Rittmann B.A., M.S., Ph.D., C.H.P.
(print or type)

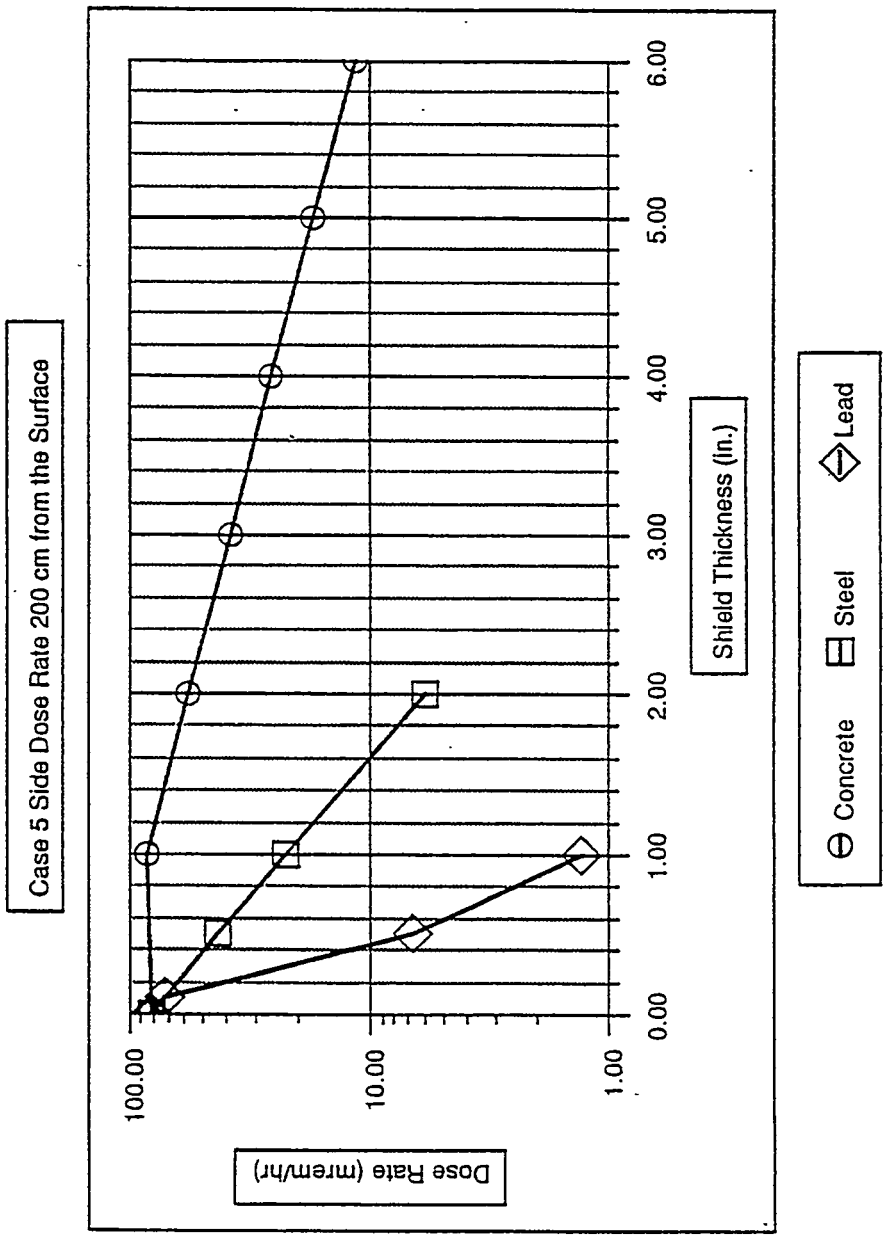
Paul Rittmann 7-22-94
HEDOP-Approved Reviewer (Signature) Date

	A	B	C	D	E	F
3	Case 5 Dose at 1 cm					
4	Concrete Thickness	Dose (mrem/hr)	Steel Thickness	Dose (mrem/hr)	Lead Thickness	Dose (mrem/hr)
5	0.00	361.30	0.00	361.30	0.00	361.30
6	1.00	331.50	0.50	160.30	0.10	102.90
7	2.00	205.30	0.75	109.10	0.25	55.82
8	3.00	129.10	1.00	74.71	0.50	21.60
9	4.00	81.75	2.00	17.07	1.00	3.68
10	5.00	52.02	3.00	4.05	2.00	0.14
11	6.00	33.21	4.00	0.98		
12						
13	Case 5 Dose at 200 cm					
14	Concrete Thickness	Dose (mrem/hr)	Steel Thickness	Dose (mrem/hr)	Lead Thickness	Dose (mrem/hr)
15	0.00	81.08	0.00	81.08	0.00	81.08
16	1.00	84.23	0.50	43.29	0.10	71.76
17	2.00	57.57	1.00	22.54	0.50	6.78
18	3.00	38.91	2.00	5.92	1.00	1.30
19	4.00	26.10				
20	5.00	17.42				
21	6.00	11.58				
22						
23	Case 6 Dose at 1 cm					
24	Concrete Thickness	Dose (mrem/hr)	Steel Thickness	Dose (mrem/hr)	Lead Thickness	Dose (mrem/hr)
25	0.00	3134.00	0.00	3134.00	0.00	3134.00
26	1.00	2207.50	0.50	1385.91	0.50	245.15
27	2.00	1208.13	1.00	635.04	1.00	41.92
28	3.00	697.16	2.00	138.77	2.00	1.49
29	4.00	413.19	3.00	31.68		
30	5.00	248.55	4.00	7.38		
31	6.00	151.16				
32	7.00	92.59				
33						
34	Case 6 Dose at 200 cm					
35	Concrete Thickness	Dose (mrem/hr)	Steel Thickness	Dose (mrem/hr)	Lead Thickness	Dose (mrem/hr)
36	0.00	98.05	0.00	98.05	0.00	98.05
37	1.00	79.08	0.50	40.82	0.50	6.54
38	2.00	54.18	1.00	21.46	1.00	1.30
39	3.00	36.77	3.00	1.54		
40	4.00	24.78				
41	5.00	16.63				
42	6.00	12.13				


Case 6 Side Dose Rate 1 cm from the Surface
Dose Rate (mrem/hr)
10000.00
1000.00
100.00
10.00
1.00
Shield Thickness (In.)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Concrete
Steel
Lead


Case 6 Side Dose Rate 200 cm from the Surface
Dose Rate (mrem/hr)
100.00
10.00
1.00
Shield Thickness (in.)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
Concrete
Steel
Lead


Case 5 Side Dose Rate 1 cm from the Surface
Dose Rate (mrem/hr)
1000.00
100.00
10.00
1.00
0.10
Shield Thickness (in.)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
Concrete
Steel
Lead


Case 5 Side Dose Rate 200 cm from the Surface
Dose Rate (mrem/hr)
100.00
10.00
1.00
Shield Thickness (In.)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
Concrete
Steel
Lead

ATTACHMENT
B-2

RADIOACTIVE ORGANIC WASTE TRANSPORT AND STORAGE TANKS

COST & SCHEDULE ESTIMATE

CONTAINER AND SHIELD STRUCTURE ESTIMATE

Item	Estimated Cost	Start/Complete Date
Engineering - PDE (incl. tank after-market work)	$45,000.	See Attached Graph
Engineering - PSE (incl. PDC prep.)	50,000.	See Attached Graph
Drafting (shield site)	7,500.	See Attached Graph
QE	5,000.	
PQC	5,000.	
NDT	2,500.	
Liquid Container Cost *	40,000. [1]	16 weeks - ARO
Metal Box Cost *	30,000.	
P&MM Adder (11.3%) *	11,580.	8 weeks - ARO
Shipping Cost	2,500.	See Attached Graph
Site Preparation	10,000.	See Attached Graph
Shield Construction *	32,500. [2,3]	See Attached Graph
Contingency	None Used	
Total	$241,580.	

Notes:
1. Value presumes only one container will be required/procured.
2. Value presumes only one shield structure will be required.
3. Two different pre-cast structure designs can be made, but at $4000 difference in cost (see attached figures). The higher cost is used.

From: Packaging Design Engineering 84200-94-RWB-005
Phone: 376-2882 G2-03
Date: September 14, 1994
Subject: STATEMENT OF WORK FOR C-103 RADIOACTIVE ORGANIC LIQUID STORAGE PROJECT

To: R. J. Parazin H5-49

cc: R. J. Chesterfield G2-02
J. G. Field G2-02
J. E. Mercado G2-02
J. W. Thornton G2-03
R. R. Wilson H5-09
RWB File/LB

The work scope of the subject project, for Packaging Safety Engineering (PSE) and Packaging Design Engineering (PDE), Transportation & Packaging, includes the following items:

Packaging Safety Engineering

- Preparation of an approved Packaging Design Criteria document.
- Coordination of analytical effort and followup.
- Review of specifications and purchase requisitions issued by PDE.
- Preparation of approved Safety Evaluation Report for Packaging (SEP).

Packaging Design Engineering

- Preparation of cost and schedule estimate (attached).
- Preparation of approved engineering specification for the liquid storage container and metal boxes.
- Preparation of approved purchase requisitions.
- Preparation of approved specification for the shielding structure.
- Preparation of approved purchase requisition.
- Engineering support on above items through inspection and receiving.
- Coordination of site preparation drawings.
- Engineering support as needed for tank filling, transportation, and placement.

The cost and schedule estimate for the above work scope is attached. Also attached, are conceptual layouts of two options for the shielded storage facility. These structures are pre-cast and field erected, with minimal site preparation requirements. If there are any questions, please feel free to contact me on 376-2882.

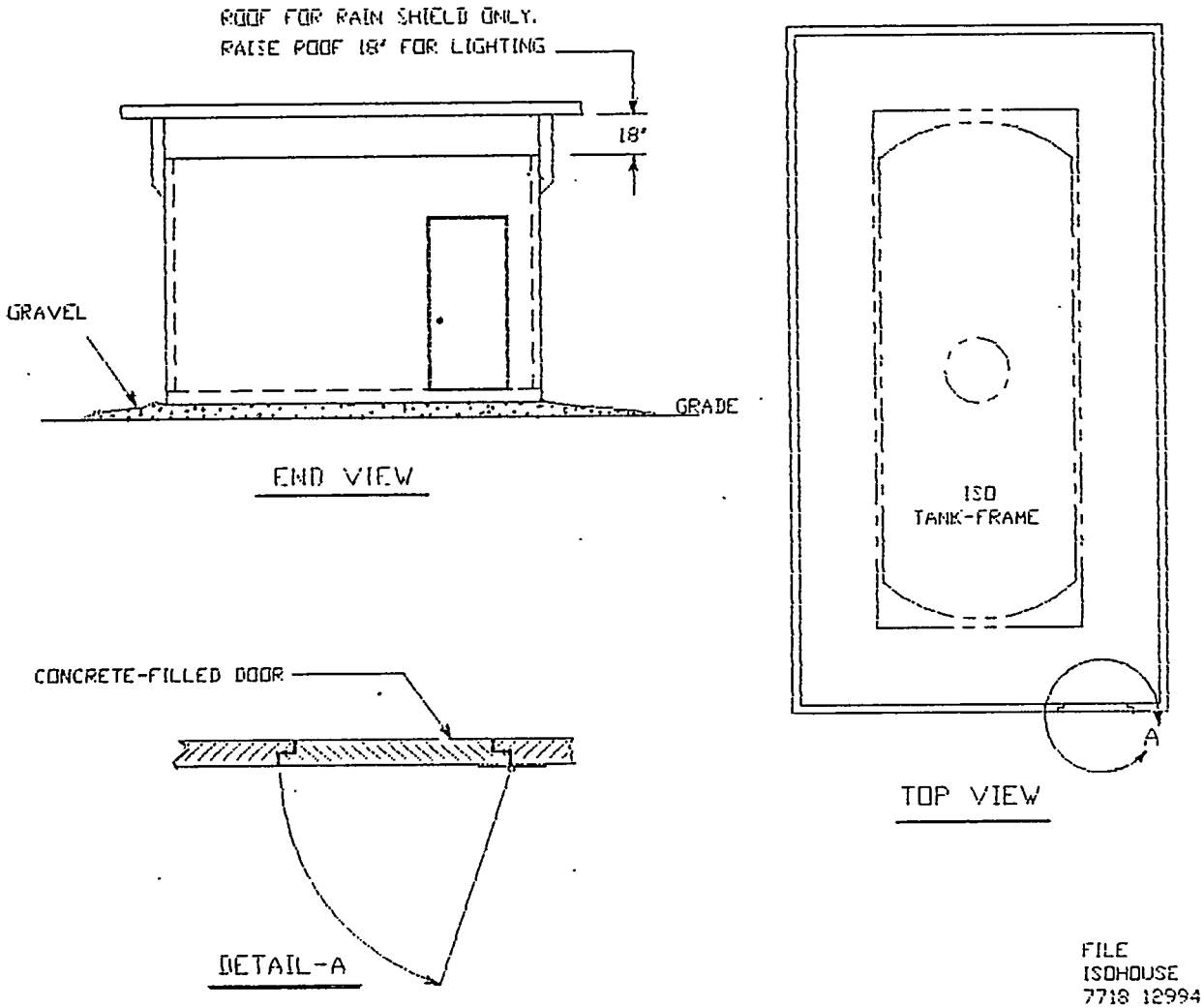
R. W. Barker

R. W. Barker, Project Engineer
Packaging Design Engineering
Transportation and Packaging

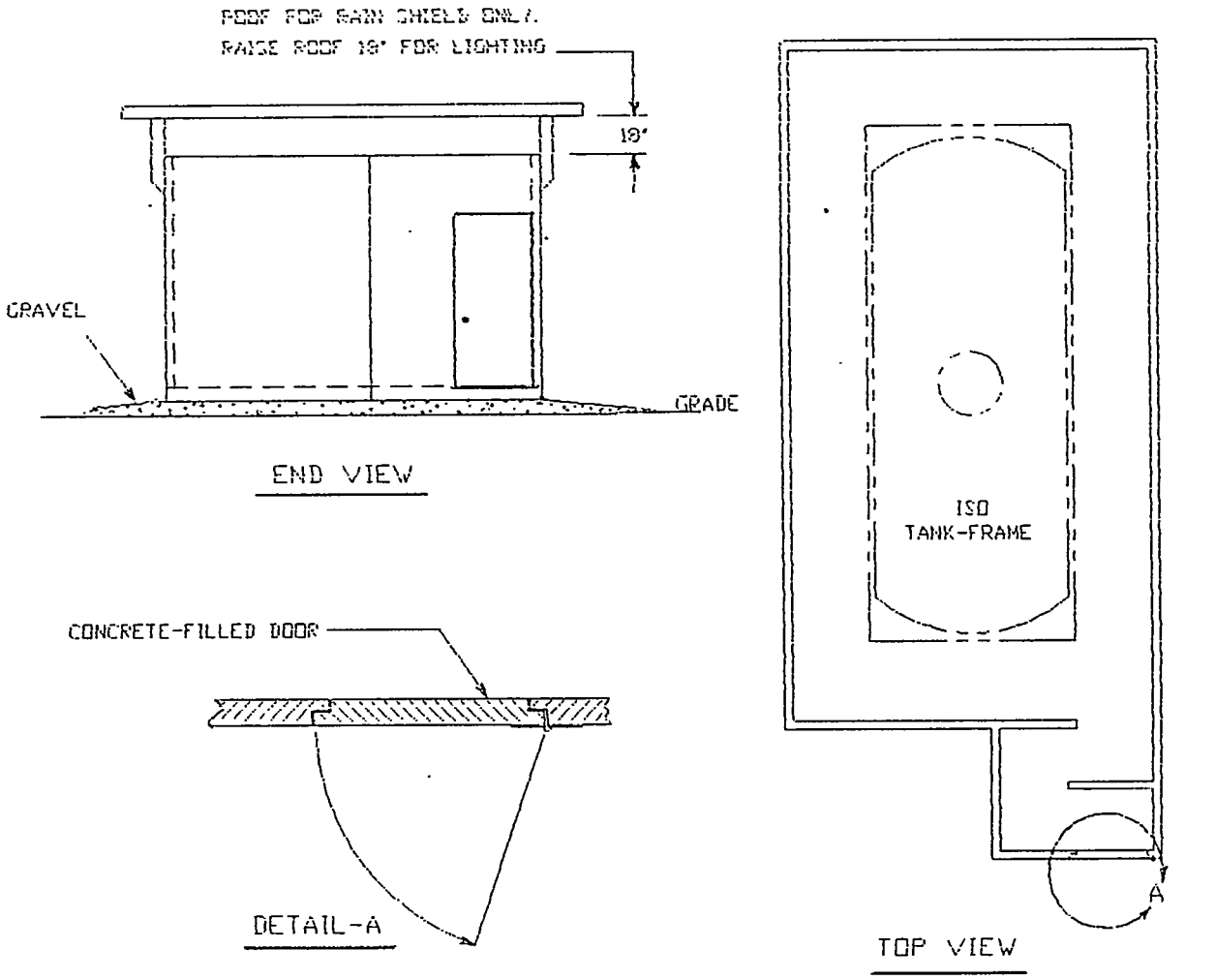
dw

Attachments 4

B-2-2



FILE
ISOHOUSE
7718 12994



FILE
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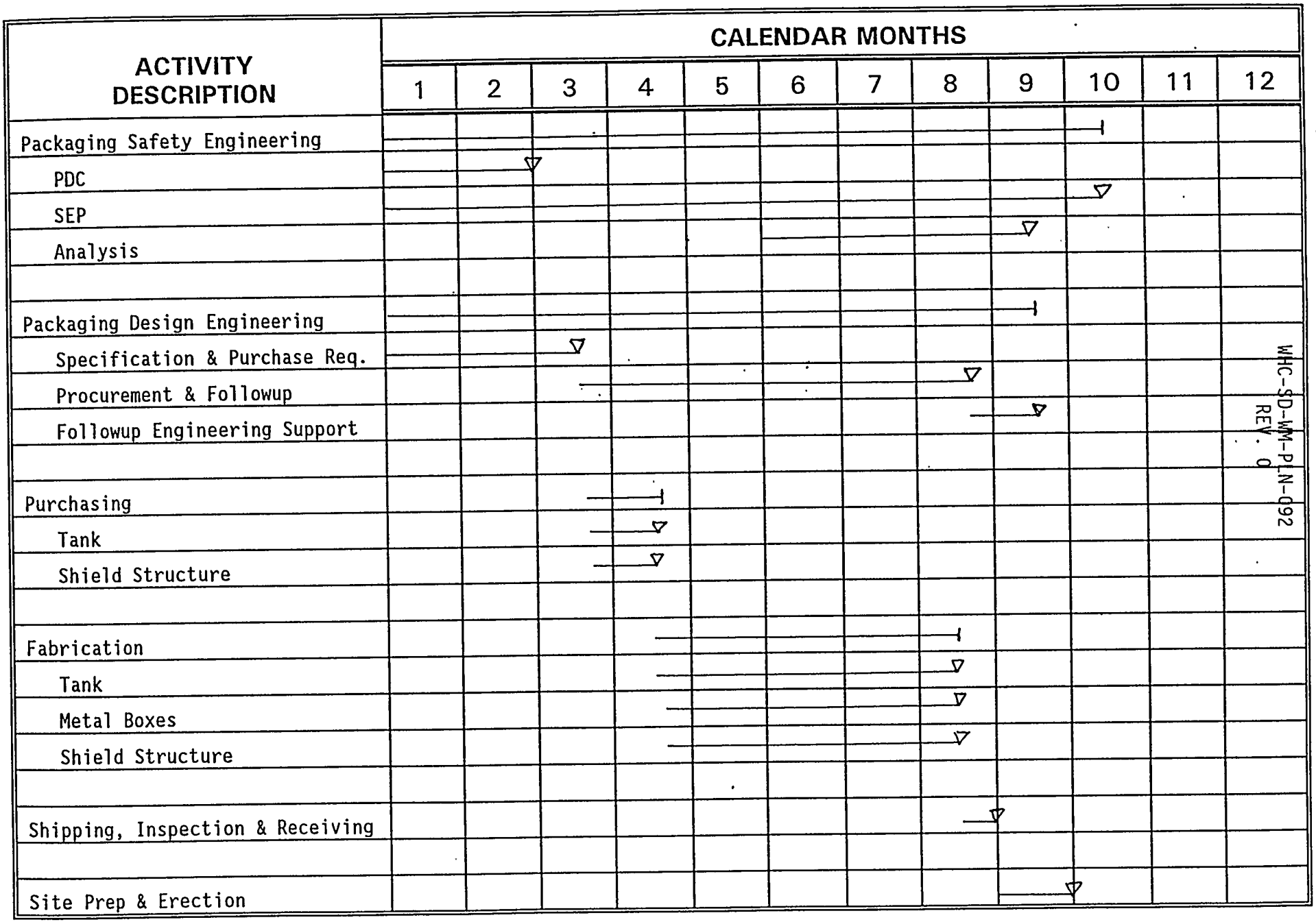
ORGANIC WASTE TRANSPORTATION/STORAGE CONTAINER



ATTACHMENT
B-3

DON'T SAY IT --- *Write It!*

DATE: June 6, 1994

TO: T. R. Wilson

FROM: R. A. Schwarz

Telephone: 376-5977

cc: J. Greenborg

SUBJECT: Dose Rates Outside a 5,567 Gallon Tank of C 103 Waste

Dose rate calculations have been made for a tank filled with waste from tank C 103. The results of these calculations are given in Table 1 for dose rates 30 cm. away from the side of the tank. Dose rates out the top of the tank are a factor of 1.4 times greater. The geometry for these calculations consists of a cylindrical source region 9.5 ft. in diameter and 10.5 ft. in length with a density of 0.868 g/cc., The source is surrounded with a 3/8 in. thick steel container and 6 in. of concrete for shielding.

Calculations were made to determine the dose rate as a function of concrete shielding. Figure 1 shows a plot of the dose rate as the thickness of the concrete shield is varied. Once the concrete becomes less than 1 in. thick, it no longer acts as an effective shield since the 3/8 in. steel shield will dominate as the major shielding material. A calculation was also made using lead instead of concrete as the major shield. The lead is 15 times as effective as the concrete, thus the 6 in. concrete shield could be replaced with a 0.4 in. lead shield. Table 2 lists the dose rates that were used to create Figure 1.

Table 3 provides the source terms used for these calculations. The organic has an activity of 7.20E+5 pCi/mL of ^{137}Cs and 1.10E+3 pCi/mL of ^{60}Co, the aqueous has an activity of 5.79E+7 pCi/mL of ^{137}Cs and 5.11E+4 pCi/mL of ^{60}Co. For these calculations, it was assumed that all of the ^{137}Cs decays to ^{137m}Ba. All of the calculations were performed using Microshield.

Table 1. Dose Rate 30 cm. from the side of a Tank Containing C 103 Waste

Case	Description	Dose Rate (mrem/hr)
1	4,000 gallons of organic.	15.3
2	Homogenous mix of 1,567.5 gallons organic with 0.2% aqueous.	15.4
3	Homogeneous mix of cases 1 and 2 (5,567.5 gallons).	16.0
4	Homogenous mix of 5,567.5 gallons of organic containing 0.2% aqueous.	17.7
5	Homogenous mix of 5,567.5 gallons of organic containing 1.0% aqueous.	27.4
6	5,567 gallons of organic with 1.0% aqueous settled to the bottom of the tank.	63.0*

* Dose rate calculated at the center of the aqueous layer.

Table 2. Dose Raste as a Function of Concrete Thickness for Case 4.

Inches of Concrete	Dose Rate (mrem/hr)
0	173.2
1	165.5
2	105.1
3	67.09
4	42.96
5	27.57
6	17.73

Table 3. Source Terms Used by Microshield.

Case	Description	Curies of Cs 137	Curies of Co 60
1	4,000 gallons of organic	10.90	0.0167
2	1,567.5 gallons of organic, 0.2% aqueous	4.95	0.0071
3	Mix of cases 1 and 2	15.85	0.0238
4	5,567.5 gallons of organic, 0.2% aqueous	17.59	0.0253
5 & 6	5,567.5 gallons of organic, 1.0% aqueous	27.23	0.0337

[16] From: Randolph A Schwarz at ~WHC71 7/29/94 7:48AM (780 bytes: 11 ln)
To: Thomas R Wilson at ~WHC207, Reid J Chesterfield at ~WHC217
cc: Randolph A Schwarz
Subject: Case 7 for C 103 Waste
---------- Message Contents ----------
As requested a new case 7 has been made for estimateing dose rates from the removal of the organic from tank C 103. Case 7 consists of 4,000 gallons of organic and 1,567.5 gallons of organic containing 1 % aqueous, with the aqueous settled to the bottom of the tank. For these conditions there is only 15.675 gallons of aqueous. At 30 cm from the side of the concrete shield, the dose rate is 39.0 mrem/hr which is much lower than the 63.0 for case 6 for 1% of 5,567.5 gallons of waste containing aqueous.

Randy

376-5977

Westinghouse
Hanford Company

Internal
Memo

From: Radiation Physics and Shielding 8D530-RAS-94-010
Phone: 376-5977 H0-35
Date: September 26, 1994
Subject: OPERATIONAL DOSE RATE CALCULATIONS FOR THE TANK C 103 ORGANIC WASTE SEPARATION PROCESS

To: T. R. Wilson H5-09

cc: L.L. Carter H0-35
J. Greenborg H0-35
R.J. Parazin H5-49
RAS File/LB

REFERENCES:

1. K. H. Pool, "*Waste Tank Organic Safety Project Analysis of Liquid Samples from Hanford Waste Tank 241-C-103*," PNL-9403, March 1994.

2. L. L. Carter, "*Certification of MCNP Version 4A for WHC Computer Platforms*", ECN-186710, SD-MP-SWD-30001, Rev. 6, January 1994.

1.0 SUMMARY

Tank C-103 is the only waste tank that contains a floating organic layer. Because of the dangers caused by this organic layer, it is necessary that it be removed from the tank. A process has been developed for the removal of this organic layer. It is the purpose of this memo to calculate the anticipated dose rates from this removal process.

A major component of the separations process is the separations enclosure box where the separation of the organic will tank place. It is anticipated that when separating the organic waste some of the aqueous waste will also be removed from the tank. The separations enclosure will separate the organic waste from the aqueous waste. The aqueous waste will be sent back to the tank and the organic waste will be sent on to a storage container.

This memo will address the dose rates surrounding the separations enclosure box and the transfer lines. Future calculations should be done to address the dose rates around the riser through which the waste will be removed and around the filter box which has not yet been designed.

The dose rates out the front of the enclosure box will be a maximum of 80 mrem/hr and out the side the dose rate increases to a maximum of 740 mrem/hr. Further shielding calculations will need to be made to determine ways to reduce these dose rates to acceptable levels. The dose rate from the aqueous transfer line is 200 mrem/hr at 1 cm, the dose rate is less than 1 mrem/hr for a transfer line filled with organic waste.

2.0 SOURCE

The isotopic composition for the organic and aqueous waste was obtained from Reference I. Table 1 lists the curie content for the organic waste and Table 2 lists the curie content for the aqueous waste. It is assumed that all of the ^{137}Cs will decay into ^{137m}Ba. The ^{90}Sr and ^{90}Y content for these tables was calculated from the beta decay information provided in Reference 2. The total curie inventory in each of the different items analyzed are also included in this table. A density of 0.868 g/cc was used for the organic waste and a density of 1.08 g/cc was used for the aqueous waste.

The gamma ray source term was calculated using the ISOSHLD computer code. Tables 3 and 4 provide the gamma ray source calculated from the information in Tables 1 and 2. This gamma ray information was used by MCNP (Monte Carlo N Particle) computer code (reference 2) to calculate the dose rates.

3.0 GEOMETRY

Figure 1 shows a three dimensional view of the MCNP model of the enclosure box create for calculating the gamma ray dose rates and determining shielding requirements. The dose rate was calculated on the front surface of the box and on the left and right sides of the box. For each of these three sides of the box a contour plot was made showing the dose rate on the outside surface.

Figure 2 shows a view of the enclosure box with the front side, right side, and interior shield wall removed to show the details of the components inside the box. The model consists of the inlet line, shown in yellow, which is conservatively assumed to be full of aqueous waste. The inlet aqueous waste is sent through one of three possible filters (vertical yellow cylinders) and is then transferred to the coalescer where the waste is separated into aqueous and organic waste. The top part of the coalescer contains organic waste and the bottom part contains aqueous (aqueous in red, organic in green). The aqueous in the bottom is then transferred to the storage tank shown (blue box) in this figure and eventually returned back to the waste tank. Recent changes in the configuration of the enclosure box, have the filters and its associated piping removed from the enclosure box. Thus for these calculations there is no source inside the yellow components in this figure.

An interior shield wall is included in the model to shield out the dose rates from the waste in the coalescer and the filters. Figure 3 shows a plot of the coalescer with the interior shield wall in place. With the interior shield wall in place, only the pipes are visible on the side of the interior shield wall where the operator will be standing.

Figure 4 shows a close up of the calculational model of the filters and piping with the interior shield wall removed. As mentioned previously, in the final calculational model it was decided that the filters should be removed from the enclosure box altogether because of their high dose rate contribution and to allow for replacing the filters. Additional

calculations will need to be made once a final decision is made on the placement of the filters and their interface with the enclosure box.

The interior shield wall and all of the external shield walls are modeled as iron. The steel walls of the piping, coalescer, and tank were also included in the calculational model.

4.0 CALCULATIONS

Numerous calculations were made to determine the dose rates and required shielding. Table 5 provides a list of the calculations that were made. The final configuration that was decided on was an enclosure box with 1/2 in. outside walls and a 1 3/4 in. interior shield wall and no filter shield. The filters will be removed from the enclosure box and placed in a separate container which has not yet been completely defined. Therefore, the source from the filters was not included in these calculations.

Each calculation was made using the MCNP computer code. The MCNP computer code was used because of its ability to model very complex three dimensional source terms and shielding configurations. Additionally, the MCNP computer code can calculate the dose rate at hundreds of different dose points. This capability was used to create contour plots of the dose rate at the surface of the enclosure box. Appendix A shows the MCNP input file used for the final calculation of the dose rates on the front surface of the enclosure box.

To create the contour plots, a surface tally was made on the surface of the enclosure box. The surface tally was divided into 25 cm^2 regions and the dose rate within each one of these regions was tallied. A C program was then written to read this dose rate information and reformat so that it could be plotted in a plotting program.

All of the files used for these calculations are stored in cfs in the directory /w97555/c103.

4.0 RESULTS

Figure 5 shows a contour plot of the dose rates for the final configuration (case 10 of Table 5) due to sources in the coalescer, tank, and aqueous piping. This contour plot represents the dose rates upon the front surface of the enclosure box. This plot accounts for the fact that the front of the enclosure box includes a slanted surface. The line at an elevation of 8 cm represents the joining of the upper slanted surface and the lower vertical surface. Dose rates above the line represent the dose rate along the slanted surface. A rough outline of the tank and coalescer are also included on this plot to provide a reference. Most of the dose rates are well below 30 mrem/hr and that the maximum dose rate is 80 mrem/hr.

To determine how much each of the different source terms are contributing to the total dose rate, contour plots were made for each of the different source terms. Figure 6 shows a contour plot of the dose rate from the coalescer source (case 11 of Table 5). The maximum dose rate from the coalescer is 48 mrem/hr. This dose rate can be reduced to below 30 mrem/hr by inserting a 1/2 in. steel shield attached to the inside of the interior shield wall in the region where the coalescer is producing the highest dose rate.

Figure 7 shows a contour plot of the dose rate from the pipe source (case 12 of Table 5). A maximum dose rate of 52 mrem/hr is being produced from this pipe source. The pipe is the one used to transfer aqueous from the coalescer to the holding tank. A least 1/2 in. of steel is required to reduce this dose rate to 30 mrem/hr. This steel shield will need to be placed between the pipe and the front surface of the enclosure box.

Figure 8 shows a contour plot of the dose rate contribution from the tank (case 13 of Table 5). From this plot it can be seen that the tank source only contributes a maximum of 10 mrem/hr to the front surface dose rate and is not a dose rate concern. The source from the tank does not influence the dose rate contours very much due to the 1.5 in. steel shielding around the tank.

A general rule that can be used to estimate the amount of shielding required, is the dose rates will go down by a factor of about 1.72 for every additional cm of steel that is added between the source and the dose point. This factor can be used to estimate shield thicknesses for reducing the dose rate to dose rate limits not discussed here.

The total dose rate out the side and back of the enclosure box is very high and access to the sides of the box should be limited. Figure 9 shows a contour plot of the dose rates along the right side (refer to Figure 1) of the box (case 14 of Table 5). Here the dose rate reaches 748 mrem/hr. As can be seen in this figure, most of the dose rate is due to the source in the coalescer.

Figure 10 shows a contour plot of the total dose rate along the left side (refer to Figure 1) of the box (case 15 of Table 5). Here the maximum dose rate is still 221 mrem/hr due to the presence of the coalescer. Access to this side will also need to be limited or additional shielding will need to be added.

Dose rate calculations were not performed for the back of the box but it is expected that the back of the enclosure box will have dose rates similar to the right side of the box. Access to the back of the box will have to be limited or additional shielding will need to be added.

5.0 TRANSFER LINE CALCULATION

There will be a doubly contained pipe between the waste tank, the enclosure, and the tank car. For calculating dose rates outside this pipe a geometry was created consisting of a 1/2 in. schedule 40 pipe enclosed in a 1 1/2 in. schedule 40 pipe with a hollow region between the two pipes. The source was modeled inside the inner pipe. The pipe was modeled as 200 cm. long to simulate an infinitely long pipe.

For organic waste in the pipe, the dose rate at 1 cm away from the surface of the pipe is less than 1 mrem/hr. With an aqueous source in the pipe the dose rate is 205 mrem/hr at 1 cm away from the surface of the pipe. Figure 11 shows a line plot of the dose rate as a function of distance away from the pipe surface. If it is required that the dose rate outside the aqueous pipe be less than 30 mrem/hr, additional shielding will need to be added around the pipe or all access to the pipe must be limited to 20 cm as indicated in Figure 11.

R. A. Schwarz, Advanced Scientist
Radiation Physics and Shielding

sam

Attachments

Reviewed by: L. L. Carter, Fellow Engineer
Radiation Physics and Shielding

Concurrence: J. Greenborg, Manager
Radiation Physics and Shielding

Table 1. Organic Source Term for Tank C 103 (0.868 grams/cc)

Isotope	Curies/gram	Curies/cc
Cs 137	4.13e-08	3.58e-08
Ba 137m	4.13e-08	3.58e-08
Sr 90	5.46e-07	4.74e-07
Y 90	5.46e-07	4.74e-07
Co 60	7.45e-10	6.47e-10
Eu 154	3.17e-10	2.75e-10
Eu 155	3.15e-10	2.73e-10
Am 241	2.11e-10	1.83e-10

Table 2. Aqueous Source Term for Tank C 103 (1.08 Grams/cc)

Isotope	Curies/gram	Curies/cc
Cs 137	5.36e-05	5.79e-05
Ba 137m	5.36e-05	5.79e-05
Co 60	4.73e-08	5.11e-08
Sr 90	6.54e-05	7.06e-05
Y 90	6.54e-05	7.06e-05

T. R. Wilson
Page 7
September 26, 1994

Table 3. Organic Photon Source

Group	Energy (MeV)	Photons/sec/cc
1	0.015	5.2991e+02
2	0.025	2.9069e+02
3	0.035	2.7333e+02
4	0.045	1.2386e+02
5	0.055	8.9838e+01
6	0.065	7.5507e+01
7	0.075	6.8477e+01
8	0.085	6.5465e+01
9	0.095	5.6029e+01
10	0.150	2.6292e+02
11	0.250	8.6123e+01
12	0.350	4.2098e+01
13	0.475	3.1708e+01
14	0.650	1.2152e+03
15	0.825	8.6531e+00
16	1.000	7.8424e+00
17	1.225	5.4146e+01
18	1.475	8.5767e-01
19	1.700	9.5306e-01
20	1.900	3.7567e-02
21	2.100	2.6734e-02
Total		3.2836e+03

Table 4. Aqueous Photon Source

Group	Energy (MeV)	Photons/sec/cc
1	0.015	8.5890e+04
2	0.025	4.7970e+04
3	0.035	1.8480e+05
4	0.045	1.9670e+04
5	0.055	1.4160e+04
6	0.065	1.2010e+04
7	0.075	1.0810e+04
8	0.085	9.7110e+03
9	0.095	8.6830e+03
10	0.150	3.9420e+04
11	0.250	1.2960e+04
12	0.350	6.3370e+03
13	0.475	4.7440e+03
14	0.650	1.9300e+06
15	0.825	1.0430e+03
16	1.000	7.0280e+02
17	1.225	4.1390e+03
18	1.475	1.1710e+02
19	1.700	1.1560e+02
20	1.900	5.5970e+00
21	2.100	3.9830e+00
22	2.300	0.0000
23	2.500	0.0000
24	2.700	0.0000
25	3.000	0.0000
TOTALS		2.3940e+06

T. R. Wilson
Page 9
September 26, 1994

Table 5. Dose Rate Calculations Made

No.	Input File Name	Model Description
1	c103/full/cont/ipipe	Source in the inlet and outlet pipes only. 3/8 in. outside wall, 3/4 in. shield wall, 1/2 in. filter shield.
2	c103/full/cont/ifilt	Source in the filters only. 3/8 in. outside wall, 3/4 in. shield wall, 1/2 in. filter shield.
3	c103/full/cont/icoal	Source in the coalescer only. 3/8 in. outside wall, 3/4 in. shield wall, 1/2 in. filter shield.
4	c103/full/cont/istal	Source in pipes, filters, coalescer, and tank. 3/8 in. outside wall, 3/4 in. shield wall, 1/2 in. filter shield.
5	c103/full/cont/istala	Source in pipes, filters, coalescer, and tank. 3/8 in. outside wall, 1 1/2 in. shield wall, 1 in. filter shield.
6	c103/full/cont/istalb	Source in pipes, filters, coalescer, and tank. 3/8 in. outside wall, 1 1/2 in. shield wall, 1 in. extended filter shield.
7	c103/full/cont/istalc	Source in pipes, filters, coalescer, and tank. 1 in. outside wall, 1 1/2 in. shield wall, 1 in. extended filter shield.
8	c103/full/cont/istald	Source in pipes, filters, coalescer, and tank. 1 in. outside wall, 1 1/2 in. shield wall, 1 in. extended filter shield. 2 to 3 cm of shielding added to pipes.
9	c103/full/cont/inofilt	Source in piping, coalescer, and tank. 1 in. outside wall, 1 1/2 in. shield wall, 1 in. extended filter shield. 2 to 3 cm of shielding added to pipes.
10	c103/full/cont/final/ifinal	Source in piping, coalescer and tank, 1.75 in. shield wall 0.5 in outside wall. No filter shield.
11	c103/full/cont/final/icoal	Final configuration, source in coalescer only
12	c103/full/cont/final/ipipe	Final configuration, source in pipe only
13	c103/full/cont/final/itank	Final configuration, source in tank only
14	c103/full/cont/final/irside	Final configuration, total source, dose rates on right side of box.
15	c103/full/cont/final/ilside	Final configuration, total source, dose rates on left side of box.
16	c103/full/pipe/iaqu	Transfer line filled with aqueous waste
17	c103/full/pipe/iorg	Transfer line filled with organic waste

NOTE: All of these files are stored in cfs in /w97555/c103

Figure 1

Plot showing the External Surfaces of the Enclosure Box

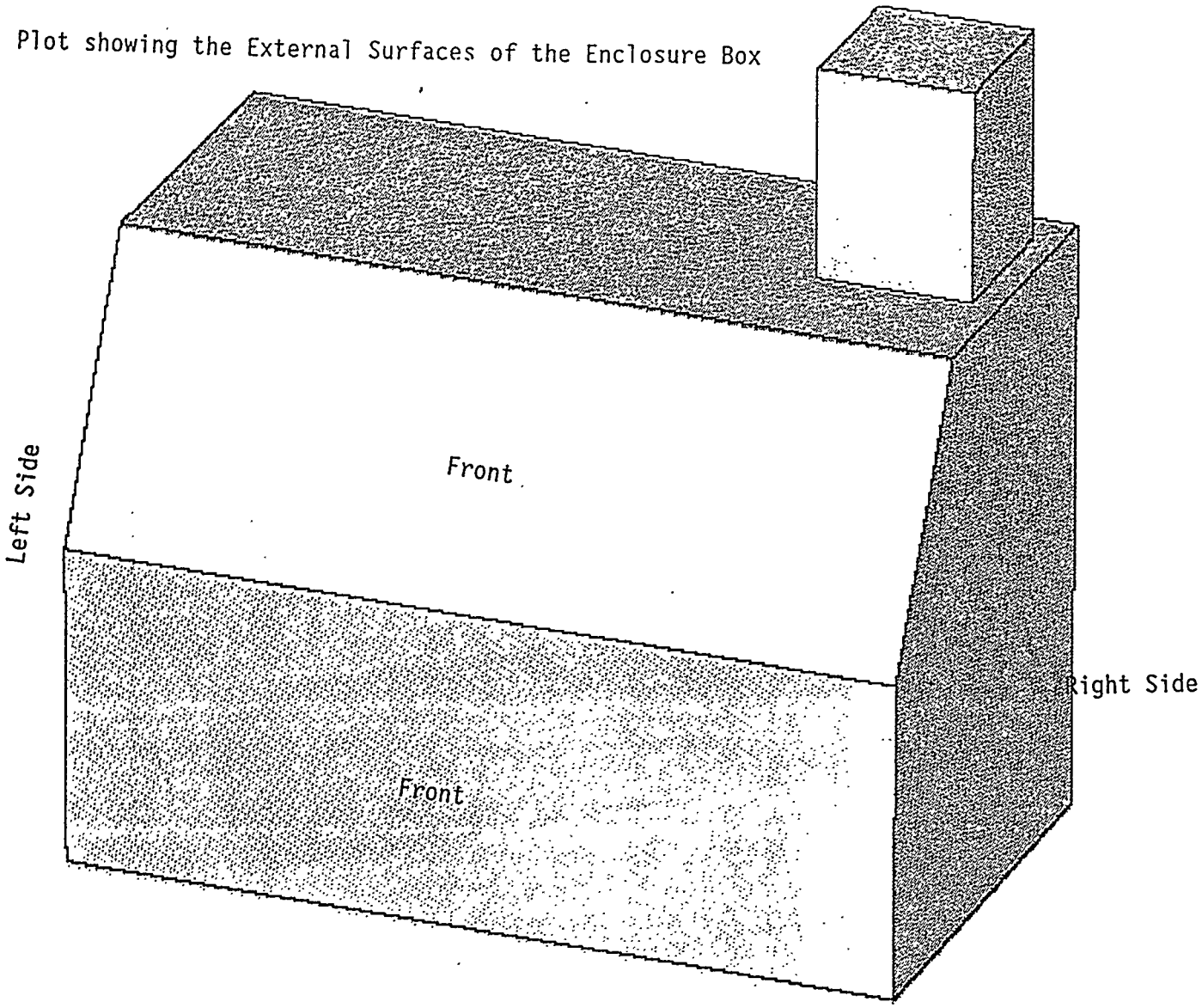
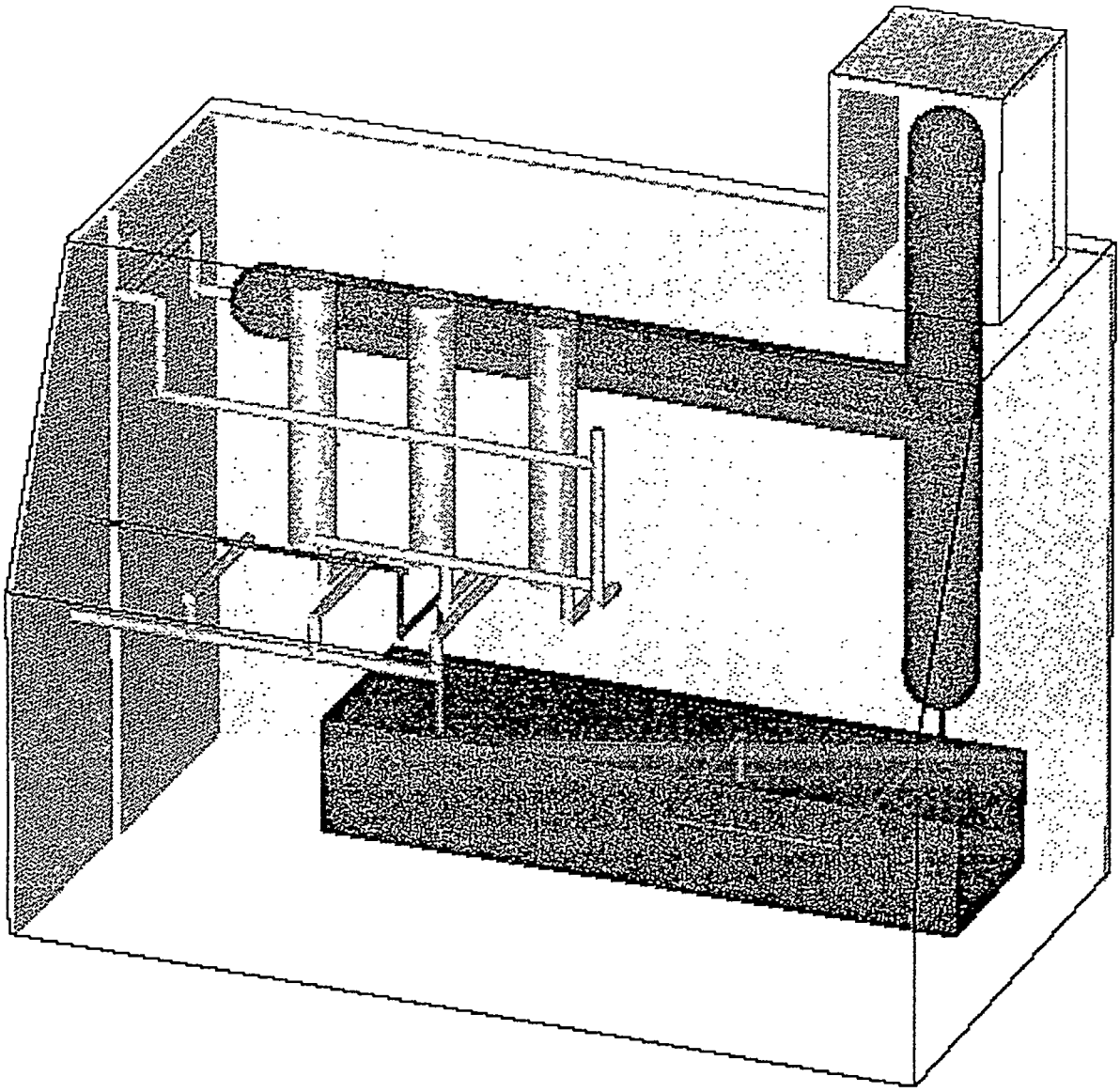
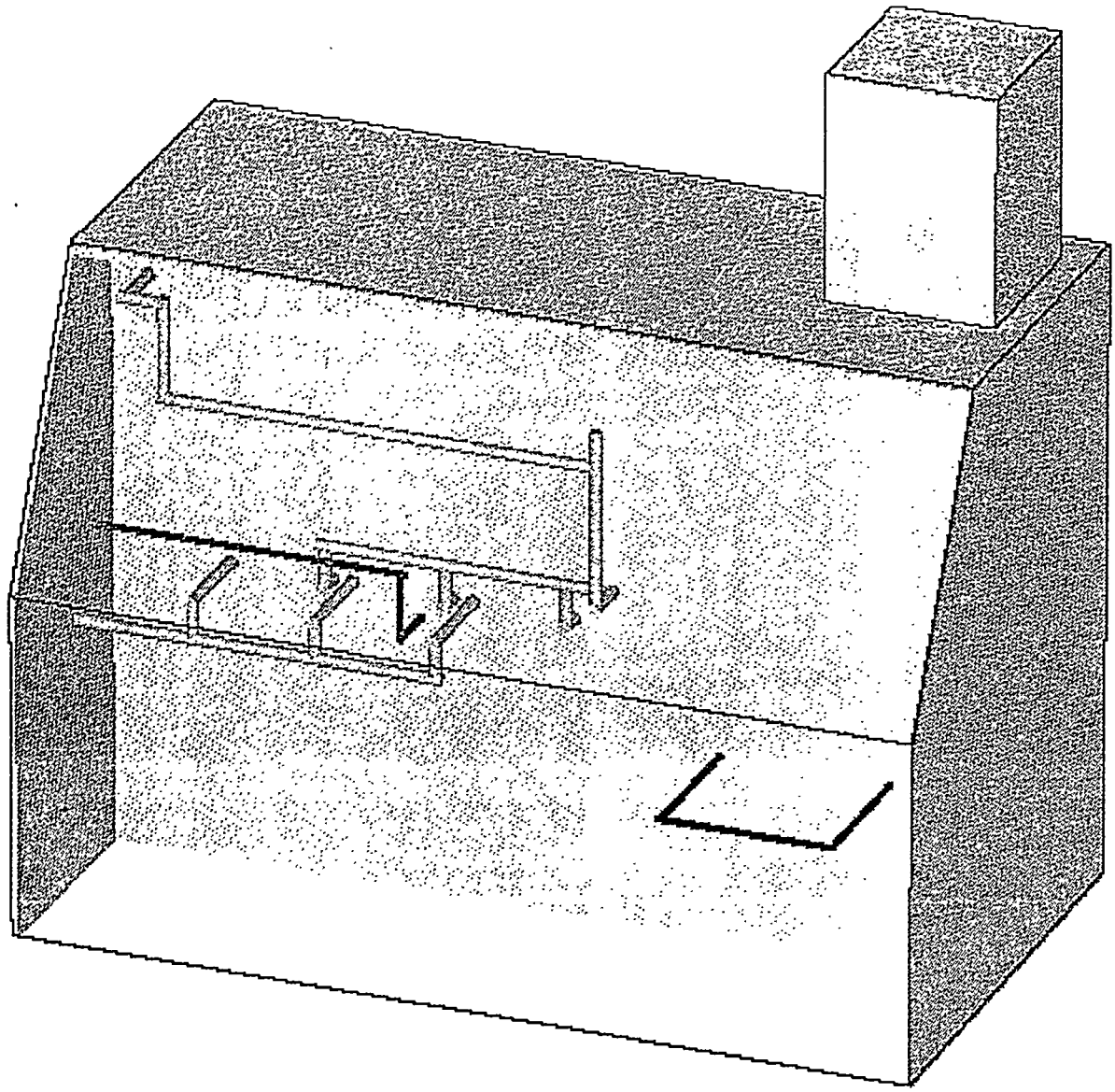


Figure B1
Plot Showing MCNP Geometry for the Enclosure Box with the Interior Shield Wall Removed



Plot Showing MCNP Geometry for the Enclosure Box with the Interior Shield Wall in Place



Plot Showing close up of the MCNP Geometry for the Filters and Piping with the Interior Shield Wall Removed

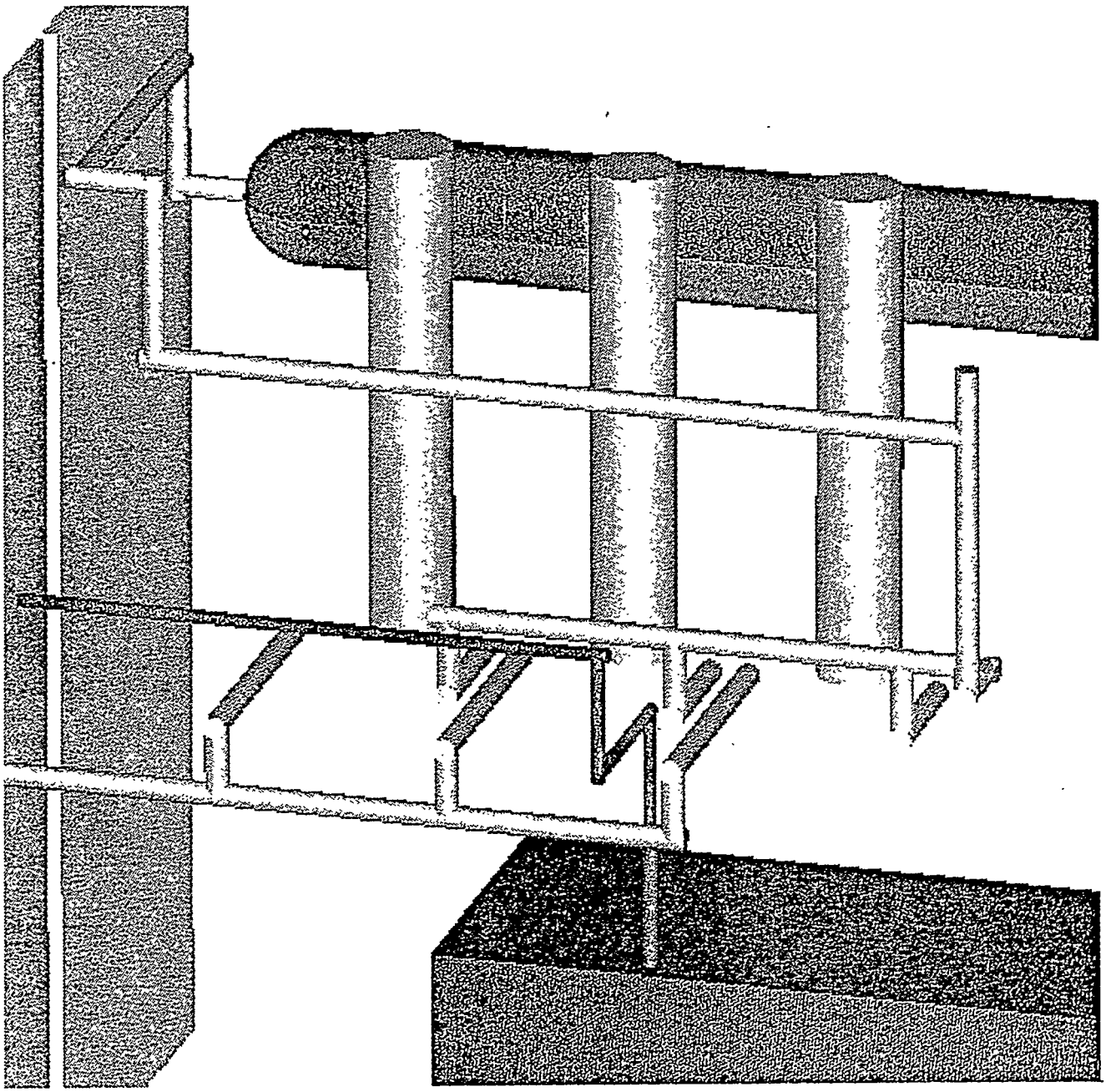
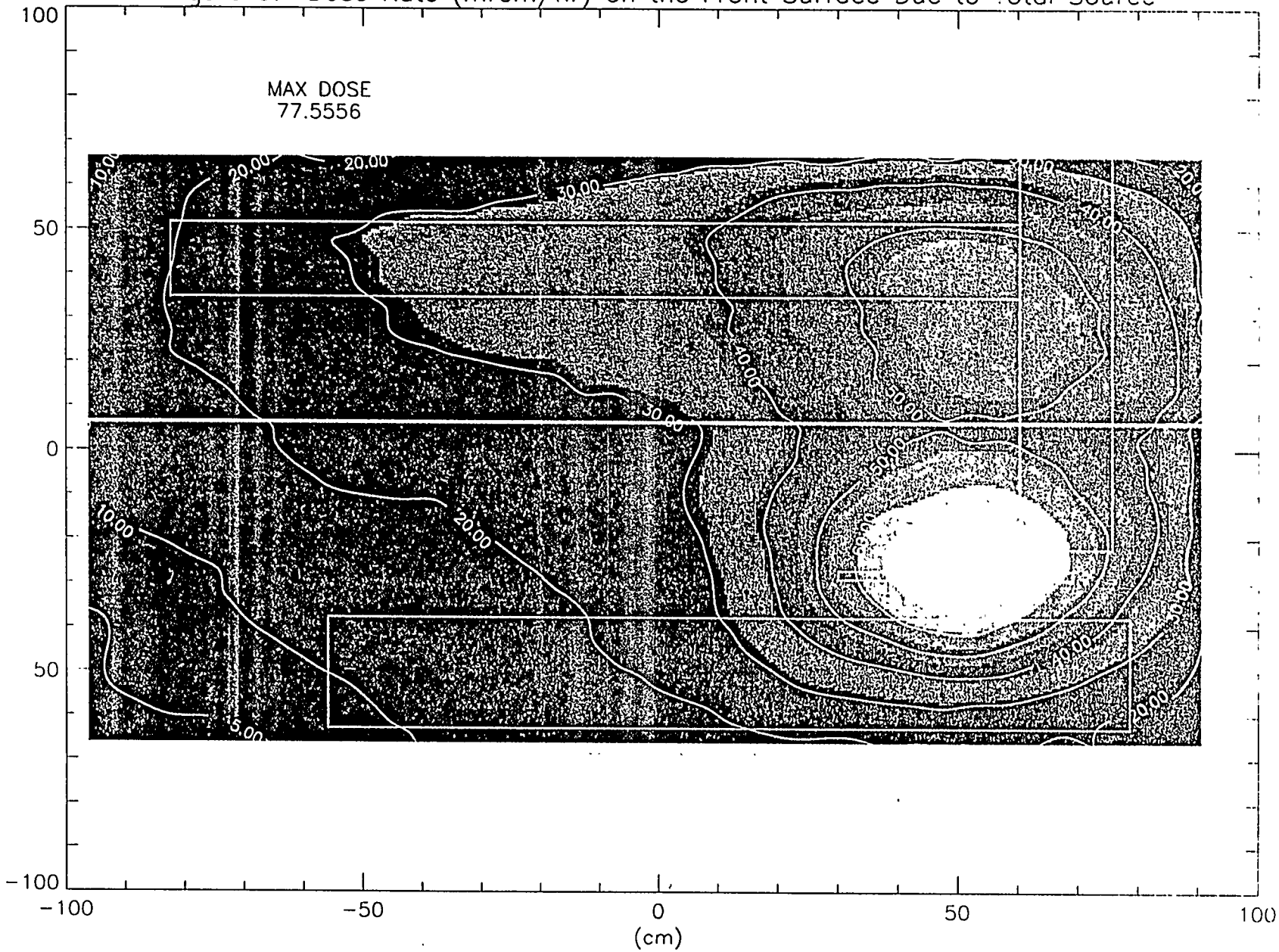


Figure 5. Dose Rate (mrem/hr) on the Front Surface Due to Total Source



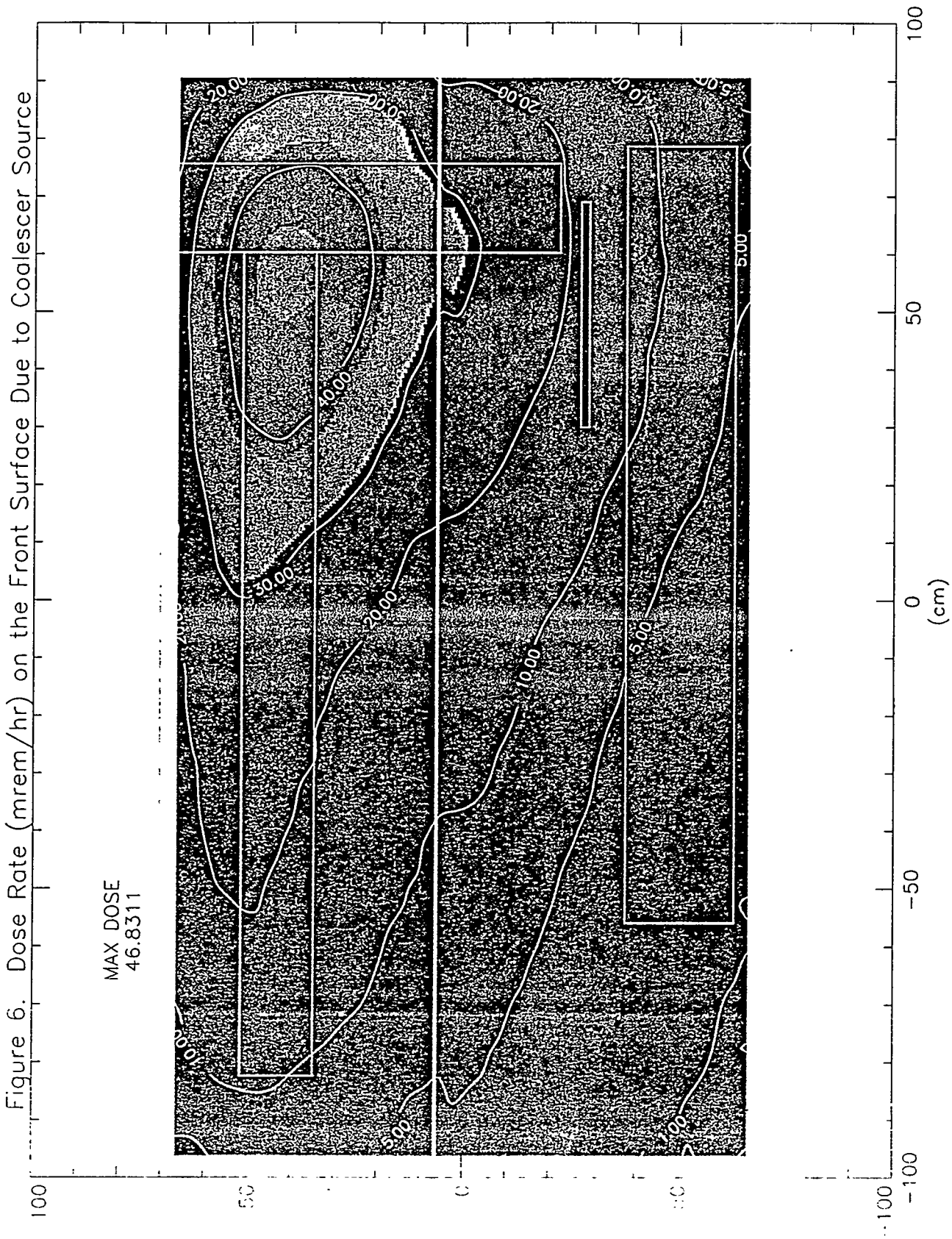


Figure 6. Dose Rate (mrem/hr) on the Front Surface Due to Coalescer Source

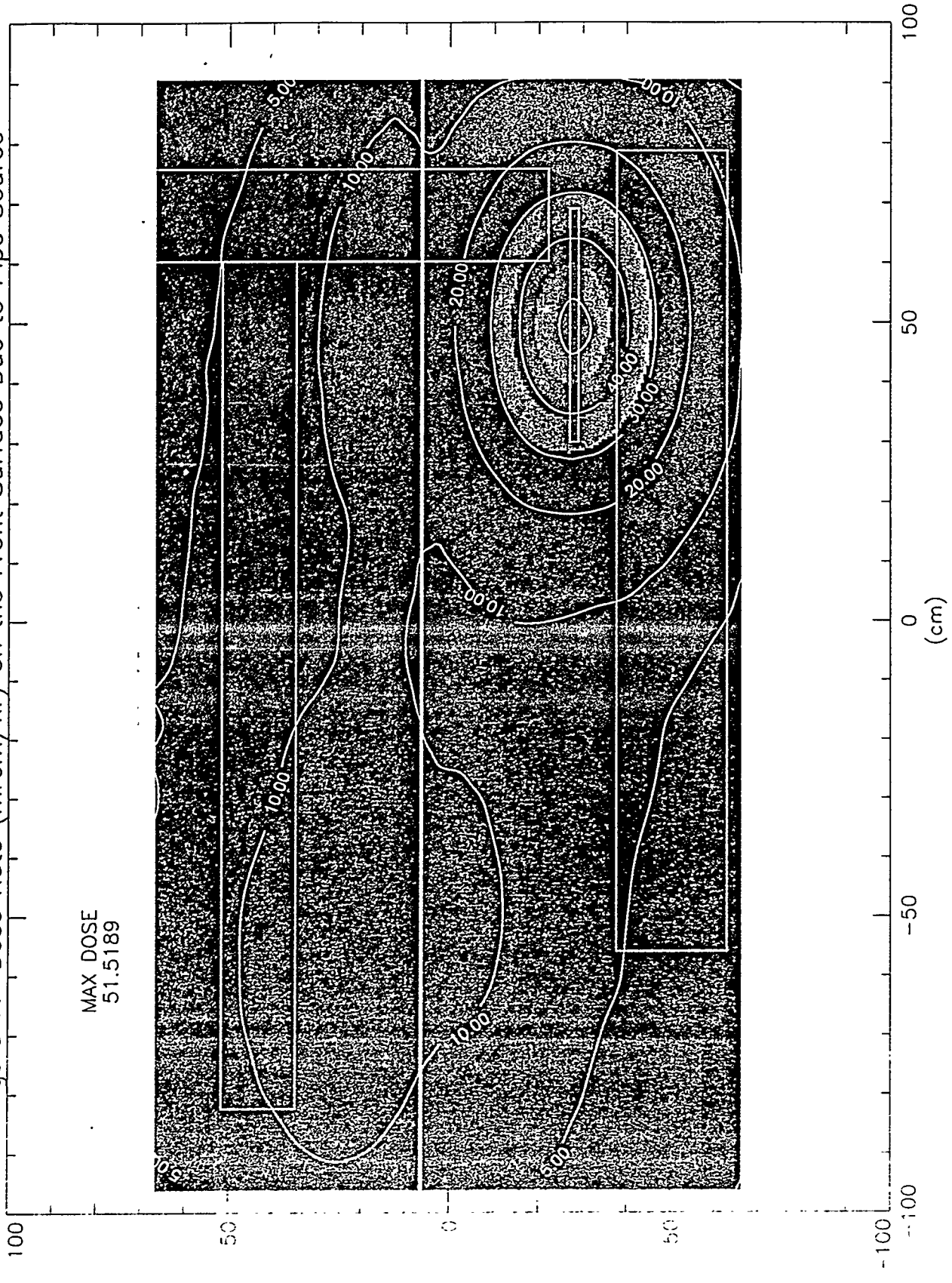


Figure 7. Dose Rate (mrem/hr) on the Front Surface Due to Pipe Source

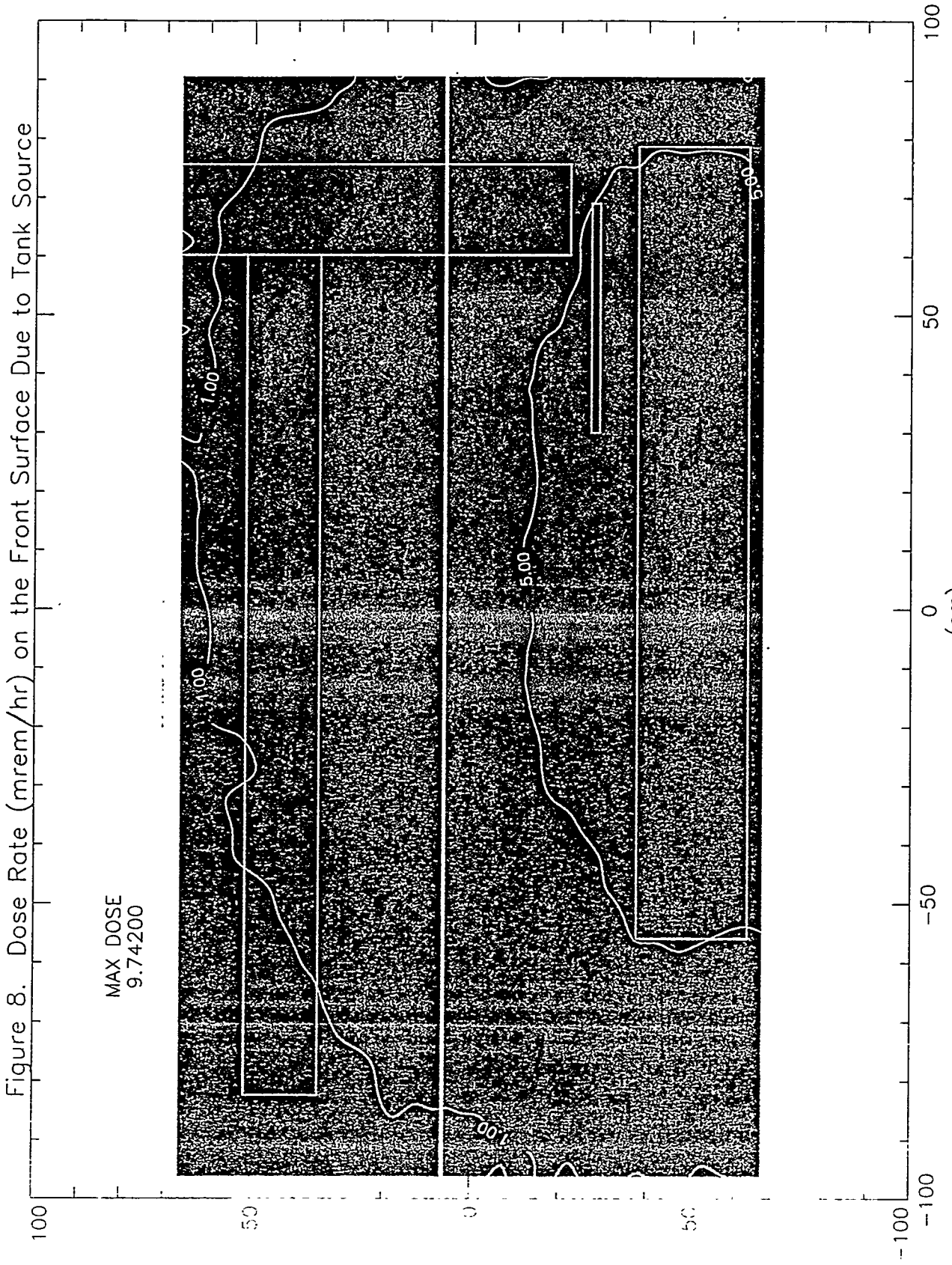
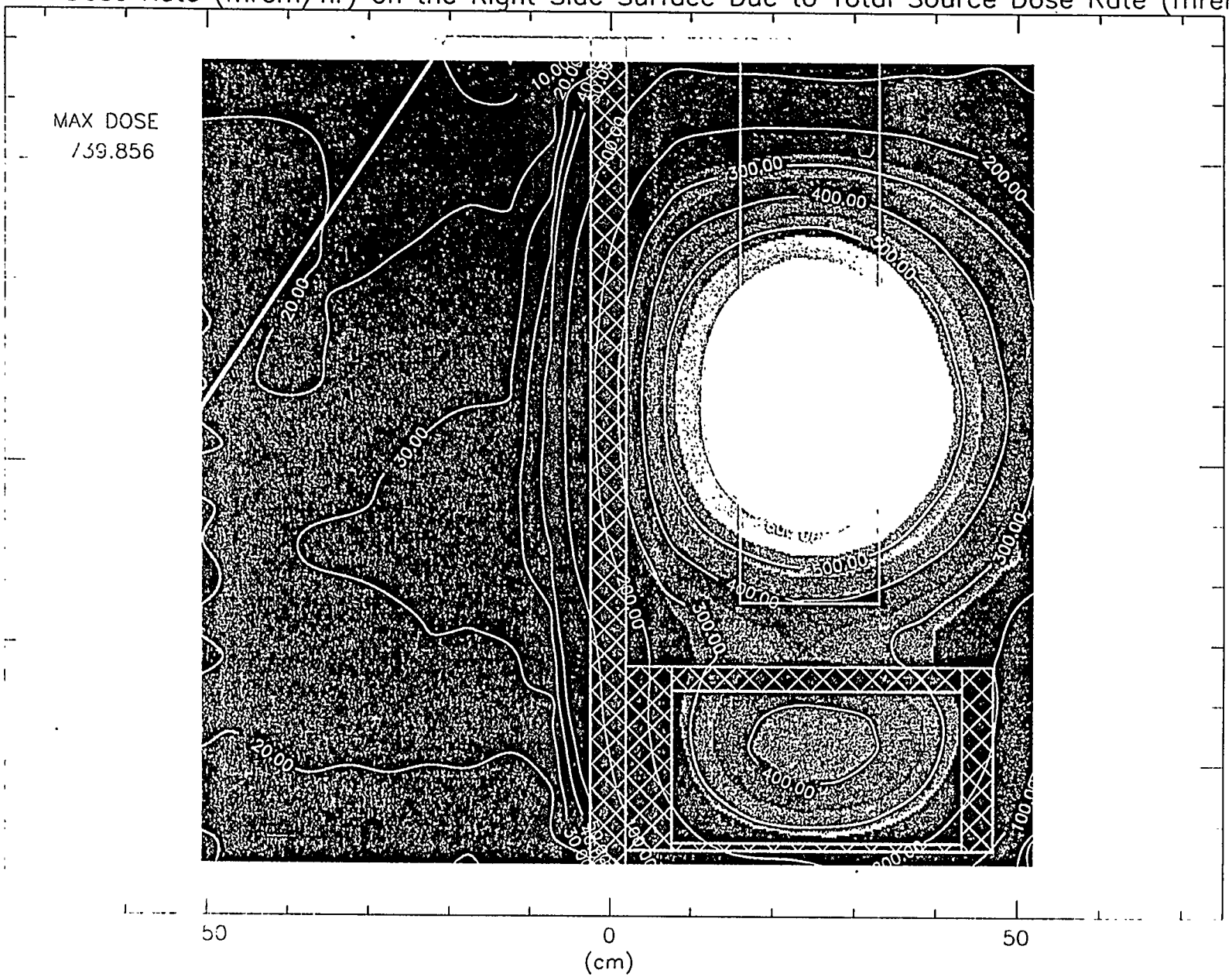


Figure 8. Dose Rate (mrem/hr) on the Front Surface Due to Tank Source

Figure 9. Dose Rate (mrem/hr) on the Right Side Surface Due to Total Source Dose Rate (mrem/hr)



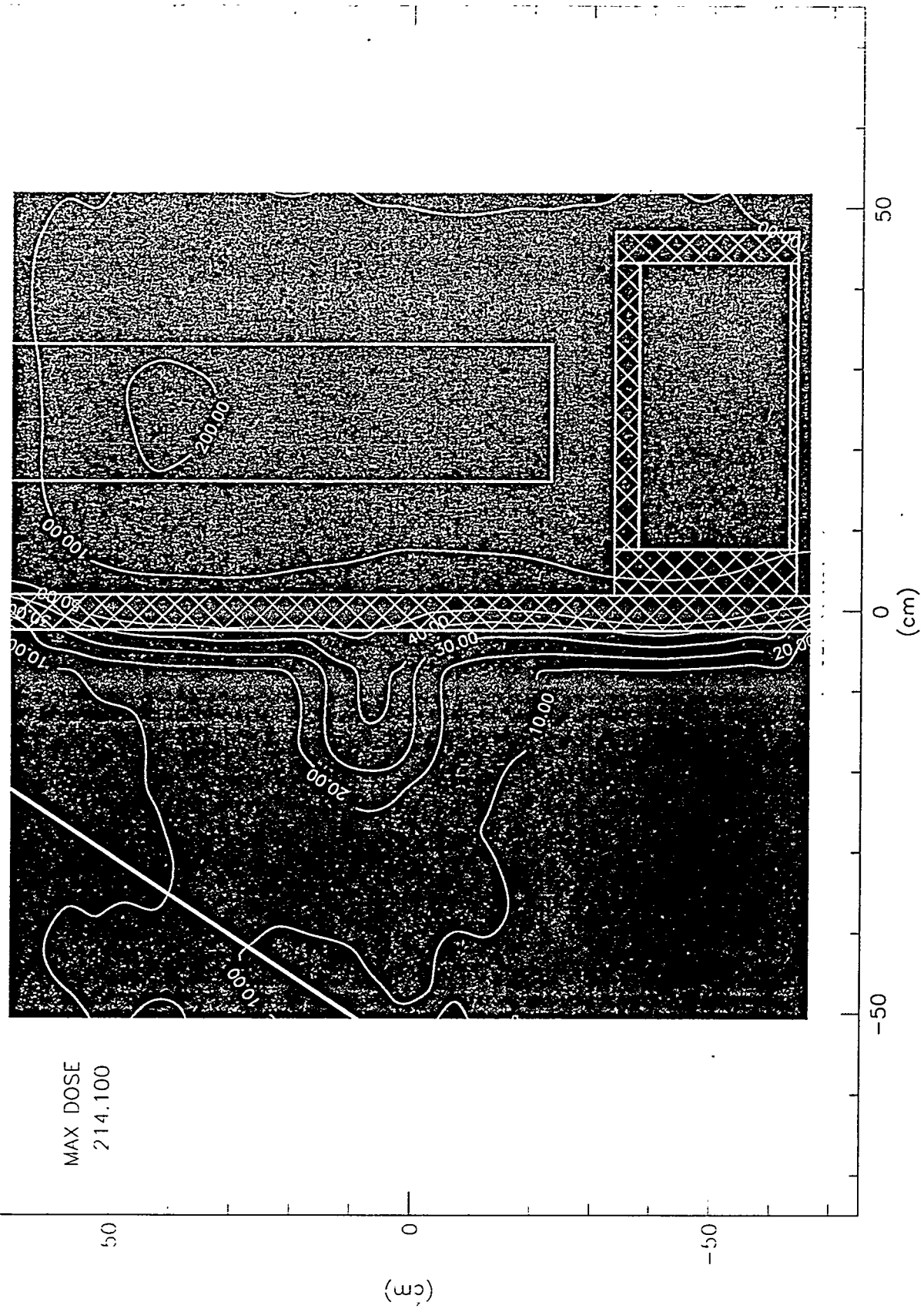
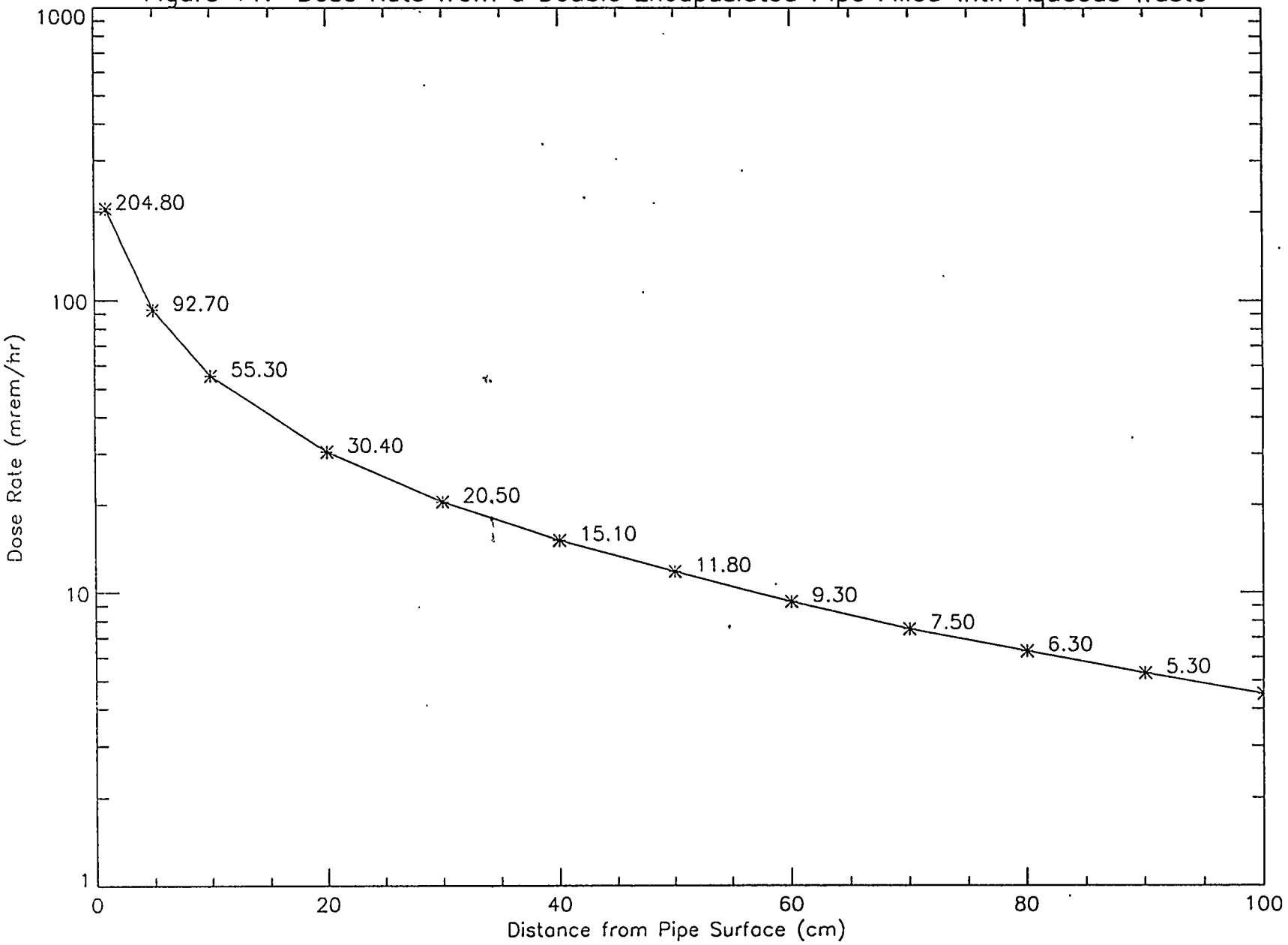


Figure 10. Dise Rate (mrem/hr) on the Left Side Surface Due to Total Source Dose Rate (mrem/

Figure 11. Dose Rate from a Double Encapuslated Pipe Filled with Aqueous Waste



T. R. Wilson
Page 21
September 26, 1994

Appendix A. MCNP Input File

```
Filter source and 1 in. piping removed Tank Shield Thicker
c     Filter shield Removed (den = 0 for cell 46)
c     1.75 in. shield wall
c     Front shield = 1/2 in.
  1    3 -7.8600  3 -7 2 -1 -5 6
  2    3 -7.8600  ((((((((((10 -8 2 -1 -5 6 )(90 ))(83 ))(104 ))(126 ))
       (179 ))(181 ))(185 ))(162 ))(184 ))(187 )
  3    3 -7.8600  -11 2 -5 6 8 -3
  4    3 -7.8600  12 -1 -3 8 -5 6
  5    3 -7.8600  (18 2 -7 -1 5 -13 )(-15 :16 :-17 :14 )
  6    3 -7.8600  -15 21 -19 20 13 -23
  7    3 -7.8600  14 -22 -19 20 -23 13
  8    3 -7.8600  16 -19 15 -14 -23 13
  9    3 -7.8600  20 -17 15 -14 13 -23
 10    3 -7.8600  21 -19 -22 20 23 -24
 11    3 -7.8600  4 -26 2 -1 -25 6
 12    3 -7.8600  -30 4 -13 29 -18 25 2 -1
 13    3 -7.8600  -29 -5 -10 26 6 2 -27
 14    3 -7.8600  -5 -29 26 6 -10 28 -1
 16    3 -7.8600  (-43 44 -31 32 )(34 :39 )
 17    3 -7.8600  -35 36 43
 18    3 -7.8600  (-37 38 -44 )(113 )
 19    3 -7.8600  (34 -33 42 31 -39 )
 20    3 -7.8600  (41 -40 -42 )(172 )
 21    0  ((-16 15 -14 17 -23 5 )(35 :-43 ))(43 :31 )
 22    4 -1.0800  -197 -41 -42
 23    4 -1.0800  -197 42 -34 -39 32
 24    4 -1.0800  -32 -197 44
 25    4 -1.0800  -44 -38
 26    5 -0.868   -41 197 -42
 27    5 -0.868   -34 42 32 32 197 -39
 28    3 -7.8600  (((53 8 -56 -52 -60 57 )(55 :-50 :-54 :51 :59 :-58 ))
       (109 :-55 ))(117 :-55 )
 29    0  (11 -56 -12 6 8 -3 )(60 :-53 :-57 :52 )
 30    5 -0.868   -32 -43 197
 31    5 -0.868   -36 43
 37    4 -1.0800  -55 50 -51 54 58 -59
 38    0  ((-61 )(22 :24 :-21 :19 :-20 :-5 ))(-6 :30 :-4 :7 :13 :-2 :1 )
 39    0- 61
 40    6 -1.0800  -74 -77 78
 41    3 -7.8600  (-70 71 -68 )(74 :77 :-78 )
 42    6 -1.0800  -75 78 -77
 43    3 -7.8600  (-72 71 -70 )(75 :77 :-78 )
 44    6 -1.0800  -76 -77 78
 45    3 -7.8600  (-73 71 -70 )(76 :77 :-78 )
 46    0          (((((81 -82 -79 80 -69 8)(126))(179))(185))(184))(187)
 47    4 -1.0800  (-115 85 -86 )(113 :-114 )
 48    3 -7.8600  ((-84 -83 85 87 )(-114 :113 ))(86 :115 )
 49    4 -1.0800  (-95 85 -94 )(117 :114 )
 50    3 -7.8600  (-90 94 -95 85 87 )(117 :114 )
 51    4 -1.0800  (((-91 -92 89 )(-85 .94 )))(-85 :86 )
 52    3 -7.8600  ((((-87 93 -88 )(92 :91 :-89 ))(-85 :94 )))(-85 :86 )
 53    4 -1.0800  (-97 27 -98 )(102 :144 )
 54    3 -7.8600  ((-96 -103 27 )(144 :102 ))(97 :98 )
 55    4 -1.0800  (-102 -144 107 )(105 :-106 )
 56    3 -7.8600  ((-144 100 -101 96 )(-106 :105 ))(102 :-107 )
 57    4 -1.0800  (-105 106 -111 )(110 :109 )
 58    3 -7.8600  ((106 101 -104 -95 )(110 :109 ))(105 :111 )
 59    4 -1.0800  -110 -109 55
 60    3 -7.8600  -110 104 109 -108 56
 61    4 -1.0800  114 -113 -44 38
 62    3 -7.8600  113 -112 37 -44 114 83
 63    4 -1.0800  -114 -117 55
 64    3 -7.8600  -114 90 56 117 -116
 65    6 -1.0800  (((-119 27 -125 )(122 :-123 ))(-123 :178 ))(-123 :175 )
 66    3 -7.8600  ((((-118 27 -120 )(119 -125 ))(-123 :122 ))(178 :-123 ))
       (-123 -175 )
```

B-3-24

```
 67   6 -1.0800  -124 123 -122
 68   3 -7.8600  123 118 -121 -124 126 122
 69   6 -1.0800  (130 -127 -128 )(124 :122.)
 70   3 -7.8600  ((-126 129 -128 )(122 :124 ))(127 :-130 )
 71   6 -1.0800  ((((-132 133 -134 )(139 :138 ))(144 :190 ))(194 :144 ))
      (144 :195 )
 72   3 -7.8600  (((((-136 -131 135 )(132 :-133 :134 ))(139 :138 ))
      (190 :144 ))(194 :144 ))(144 :195 )
 73   6 -1.0800  (-139 140 -138 )(-144 :143 )
 74   3 -7.8600  ((141 -137 -137 131 -139 )(138 :-140 ))(-144 :143 )
 75   6 -1.0800  (144 -143 -145 )(148 :150 )
 76   3 -7.8600  ((137 144 -142 -146 )(143 :145 ))(148 :150 )
 77   6 -1.0800  (-148 -150 149 )(-154 :153 )
 78   3 -7.8600  ((-147 151 -147 142 -150 )(148 :-149 ))(-154 :153 )
 79   6 -1.0800  (154 -153 -156 )(158 :160 )
 80   3 -7.8600  ((-155 -152 147 154 )(156 :153 ))(158 :160 )
 81   6 -1.0800  (-158 -160 161 )(-165 :163 )
 82   3 -7.8600  ((152 -158 157 -159 )(160 :-161 ))(163 :-165 )
 83   6 -1.0800  (165 -163 -164 )(168 :169 )
 84   3 -7.8600  ((165 159 -162 -166 )(164 :163 ))(169 :168 )
 85   6 -1.0800  (-169 -168 171 )(173 :-174 )
 86   3 -7.8600  ((170 -167 162 -169 )(168 :-171 ))(173 :-174 )
 87   6 -1.0800  -173 174 -42 41
 88   3 -7.8600  (174 167 -42 41 -172 )(173 )
 89   6 -1.0800  123 -178 -124
 90   3 -7.8600  (118 123 -177 -124 179 )(178 )
 91   6 -1.0800  123 -175 -124
 92   3 -7.8600  (181 118 123 -124 -176 )(175 )
 93   6 -1.0800  (-182 130 -128 )(175 :124 )
 94   3 -7.8600  ((-181 129 -128 )(182 :-130 ))(175 :124 )
 95   6 -1.0800  (130 -128 -180 )(124 :178 )
 96   3 -7.8600  ((-179 129 -128 )(180 :-130 ))(124 :178 )
 97   6 -1.0800  -144 -190 124
 98   3 -7.8600  (131 -144 124 187 -189 )(190 )
 99   6 -1.0800  (-188 192 -128 )(-124 :190 )
100   3 -7.8600  ((191 -128 -187 )(188 :-192 ))(-124 :190 )
101   6 -1.0800  124 -144 -194
102   3 -7.8600  (131 -144 124 185 -193 )(194 )
103   6 -1.0800  (192 -128 -186 )(-124 :194 )
104   3 -7.8600  ((191 -185 -128 )(186 :-192 ))(194 :-124 )
105   6 -1.0800  -144 124 -195
106   3 -7.8600  (131 -144 124 184 -196 )(195 )
107   6 -1.0800  (-183 192 -128 )(-124 :195 )
108   3 -7.8600  ((191 -128 -184 )(183 :-192 ))(195 :-124 )
109   0  (((((((((198 -3 11 -12 56 -5 )(40 ))(33 :-42 :39 ))(31 :-44 ))
      (37 ))(44 :112 :-114 ))(83 :84 ))(-174 :172 :42 ))(-170 :169 :167 ))
      (162 :166 )
110   0  ((((((((((-198 8 11 -12 199 -5 )(70 :68 :-71 ))(70 :72 :-71 ))
      (70 :73 :-71 ))(162 ))(181 :128 ))(128 :184 ))(128 :179 ))
      (128 :185 ))(126 :128 ))(187 :128 ))(-81 :79 :82 :-80 :69 )
111   0  (((((8 -198 11 -12 -199 56 )(83 ))(90 :95 ))(114 :116 ))(104 :95 ))
      (110 :108 )
112   0  ((((((((((((((200 -10 27 -28 -5 6 )(162 ))(181 ))(-191 :184 ))
      (179 ))(185 :-191 ))(126 ))(187 :-191 ))(144 :-124 :196 ))
      (193 :144 :-124 ))(-124 :189 :144 ))(-135 :131 :136 ))(139 :137 ))
      (104 ))(90 ))(83 )
113   0  ((((((((((((((27 -28 -200 201 -5 6 )(103 :96 ))(144 :101 :-100 ))
      (104 :-106 ))(137 :-141 ))(146 :142 :-144 ))(150 :147 :-151 ))
      (-154 :152 :155 ))(158 :159 :-157 ))(162 :-165 ))(181 ))(179 ))
      (126 ))(90 ))(83 )
114   0  ((((((((((((-201 26 27 -28 -5 -29 6 )(90 :-85 ))(87 :-93 :88 ))
      (83 :-85 ))(181 :-129 ))(179 :-129 ))(126 :-129 ))(124 :176 :-123 ))
      (124 :177 :-123 ))(124 :121 :-123 ))(181 :-129 ))(-129 :179 ))
      (-129 :126 ))(118 :120 )

  1    px 92.075
  2    px -98.485
  3    py  52 07
  4    py -52.07
```

B-3-25

```
5     pz  68.58
6     pz -68.58
7     py 53.975
8     py  1.90
10    py -2.54
11    px -96.58
12    px  90.17
13    pz 70.485
14    px  83.82
15    px  52.07
16    py 41.275
17    py  9.525
18    py -20.32
19    py  43.18
20    py  7.62
21    px 50.165
22    px 85.725
23    pz 117.475
24    pz 119.38
25    pz  6.35
26    py -50.8
27    px -97.216
28    px 90.805
29     p 0.0000 -50.80 6.3500 10.0000 -50.80 6.35 0 -20.32 68.58
30     p 0.0000 -52.07 6.3500 10.0000 -52.07 6.35 0 -20.32 70.485
31    c/z 67.9450 24.5000 8.4137
32    c/z 67.9450 24.5000 7.7025
33    c/x 24.5000 43.1800 8.4137
34    c/x 24.5000 43.1800 7.7025
35     s 67.9450 24.5000 100.8063 8.4137
36     s 67.9450 24.5000 100.8063 7.7025
37     s 67.9450 24.5000 -14.4463 8.4137
38     s 67.9450 24.5000 -14.4463 7.7025
39    px 67.9450
40     s -74.4000 24.5000 43.1800 8.4137
41     s -74.4000 24.5000 43.1800 7.7025
42    px -74.4000
43    pz 100.8063
44    pz -14.4463
50    py 7.62
51    py 43.1800
52    py 46.9900
53    pz -64.1350
54    pz -62.8650
55    pz -37.7190
56    pz -33.6550
57    px -59.6900
58    px -55.8800
59    px 78.7400
60    px 82.5500
61    so 200.0000
68    c/z -8.2550 9.5000 5.0800
69    py 3.81
70    pz 56.5000
71    pz -1.2850
72    c/z -33.6550 9.5000 5.0800
73    c/z -59.0550 9.5000 5.0800
74    c/z -8.2550 9.5000 4.7800
75    c/z -33.6550 9.5000 4.7800
76    c/z -59.0550 9.5000 4.7800
77    pz 56.2000
78    pz -0.9850
79    pz 57.5000
80    pz -2.2850
81    px -65.1350
82    px 80
83    c/y 67.9450 -27 9400 1.0668
84    py 25.5700
85    py -32.1030
```

```
 86    c/y  67.9450 -27.9400 0.7900
 87    c/x -32.1030 -27.9400 1.0668
 88     px  69.0150
 89     px  30.5700
 90    c/y  31.6400 -27.9400 1.0668
 91     px  68.7380
 92    c/x -32.1030 -27.9400 0.7900
 93     px  30.2930
 94    c/y  31.6400 -27.9400 0.7900
 95     py  9.8100
 96    c/x -11.4300 6.3500 1.0668
 97    c/x -11.4300 6.3500 0.7900
 98     px -30.4775
100     pz -8.8900
101    c/z -31.8100 -11.4300 1.0668
102    c/z -31.8100 -11.4300 0.7900
103     px -30.1400
104    c/y -31.8100 -7.8200 1.0668
105    c/y -31.8100 -7.8200 0.7900
106     py -11.4300
107     pz -8.6130
108    c/z -31.8100 8.7400 1.0668
109    c/z -31.8100 8.7400 0.7900
110     pz -7.8200
111     py 9.5330
112    c/z 67.9450 24.5000 1.0668
113    c/z 67.9450 24.5000 0.7900
114     pz -27.9400
115     py 25.2930
116    c/z 31.6400 8.7400 1.0668
117    c/z 31.6400 8.7400 0.7900
118    c/x -20.3200 -10.7950 1.6700
119    c/x -20.3200 -10.7950 1.3322
120     px -19.1100
121    c/z -20.7800 -20.3200 1.6700
122    c/z -20.7800 -20.3200 1.3322
123     pz -10.7950
124     pz -2.5400
125     px -19.4478
126    c/y -20.7800 -2.5400 1.6700
127    c/y -20.7800 -2.5400 1.3322
128     py 9.5000
129     py -21.9900
130     py -21.6523
131    c/x -4.4450 6.3500 1.6700
132    c/x -4.4450 6.3500 1.3322
133     px -52.7474
134     px 11.3497
135     px -53.0852
136     px 11.6875
137    c/y 10.0175 6.3500 1.6700
138    c/y 10.0175 6.3500 1.3322
139     py -4.4450
140     py -13.8744
141     py -14.2120
142    c/z 10.0175 -12.5420 1.6700
143    c/z 10.0175 -12.5420 1.3322
144     pz 6.3500
145     pz 44.6100
146     pz 44.8869
147    c/x -12.4520 36.8300 1.6700
148    c/x -12.4520 36.8300 1.3322
149     px -83.0247
150     px 10.0175
151     px -83.3625
152    c/z -81.6925 -12.4520 1.6700
153    c/z -81.6925 -12.4520 1.3322
154     pz 36.8300
155     pz 59.0200
```

```
156     pz 58.6822
157     px -91.5000
158     px -81.6925
159     c/x -12.4520 57.3500 1.6700
160     c/x -12.4520 57.3500 1.3322
161     px -91.1622
162     c/y -89.8300 57.3500 1.6700
163     c/y -89.8300 57.3500 1.3322
164     py 26.1700
165     py -12.4520
166     py 26.5078
167     c/z -89.8300 24.5000 1.6700
168     c/z -89.8300 24.5000 1.3322
169     pz 57.3500
170     pz 41.5100
171     pz 41.8478
172     c/x 24.5000 43.1800 1.6700
173     c/x 24.5000 43.1800 1.3322
174     px -89.8300
175     c/z -72.4500 -20.3200 1.3322
176     c/z -72.4500 -20.3200 1.6700
177     c/z -46.4150 -20.3200 1.6700
178     c/z -46.4150 -20.3200 1.3322
179     c/y -46.4150 -2.5400 1.6700
180     c/y -46.4150 -2.5400 1.3322
181     c/y -72.4500 -2.5400 1.6700
182     c/y -72.4500 -2.5400 1.3322
183     c/y -50.7550 -2.5400 1.3322
184     c/y -50.7550 -2.5400 1.6700
185     c/y -25.1200 -2.5400 1.6700
186     c/y -25.1200 -2.5400 1.3322
187     c/y 0.5150 -2.5400 1.6700
188     c/y 0.5150 -2.5400 1.3322
189     c/z 0.5150 -4.4450 1.6700
190     c/z 0.5150 -4.4450 1.3322
191     py -6.1150
192     py -5.7773
193     c/z -25.1200 -4.4450 1.6700
194     c/z -25.1200 -4.4450 1.3322
195     c/z -50.7550 -4.4450 1.3322
196     c/z -50.7550 -4.4450 1.6700
197     pz 43.1800
198     py 15.0000
199     pz -5.0000
200     py -8.0000
201     py -15.0000
202     pz -65.0000
203     pz -60.0000
204     pz -55.0000
205     pz -50.0000
206     pz -45.0000
207     pz -40.0000
208     pz -35.0000
209     pz -30.0000
210     pz -25.0000
211     pz -20.0000
212     pz -15.0000
213     pz -10.0000
214     pz -5.0000
215     pz 0.0000
216     pz 5.0000
217     pz 10.0000
218     pz 15.0000
219     pz 20.0000
220     pz 25.0000
221     pz 30.0000
222     pz 35.0000
223     pz 40.0000
224     pz 45.0000
```

```
 225      pz 50.0000
 226      pz 55.0000
 227      pz 60.0000
 228      pz 65.0000
 229      px -95.0000
 230      px -90.0000
 231      px -85.0000
 232      px -80.0000
 233      px -75.0000
 234      px -70.0000
 235      px -65.0000
 236      px -60.0000
 237      px -55.0000
 238      px -50.0000
 239      px -45.0000
 240      px -40.0000
 241      px -35.0000
 242      px -30.0000
 243      px -25.0000
 244      px -20.0000
 245      px -15.0000
 246      px -10.0000
 247      px -5.0000
 248      px 0.0000
 249      px 5.0000
 250      px 10.0000
 251      px 15.0000
 252      px 20.0000
 253      px 25.0000
 254      px 30.0000
 255      px 35.0000
 256      px 40.0000
 257      px 45.0000
 258      px 50.0000
 259      px 55.0000
 260      px 60.0000
 261      px 65.0000
 262      px 70.0000
 263      px 75.0000
 264      px 80.0000
 265      px 85.0000
 266      px 90.0000

imp:p 1 8 1 7r 16 16 1 19r 0     $cell 33
     1 5r 4 1 67r
mode p
c    wgt = volume * photons/sec/gram * density
sdef cel=d1 erg fcel d2 pos fcel d3 rad fcel d4 ext fcel d5 axs fcel d6
      x fcel d7 y fcel d8 z fcel d9
      wgt = 3.6964E+11
#       si1     sp1
        I       d
         22 1.1456E+09
         23 3.1758E+10
         24 2.5713E+10
         25 2.2913E+09
         26 1.5713E+06
         27 4.3559E+07
         30 3.5269E+07
         31 3.1427E+06
         37 3.0671E+11
         40 0
         42 0
         44 0
         47 2.6941E+08
         49 1.9673E+08
         51 4.6612E+08
         53 3.1475E+08
         55 7.0234E+07
```

```
      57 9.8397E+07
      59 1.4034E+08
      61 2.7278E+07
      63 4.5901E+07
      65 0
      67 0
      69 0
      71 0
      73 0
      75 0
      77 0
      79 0
      81 0
      83 0
      85 2.0692E+08
      87 1.0391E+08
      89 0
      91 0
      93 0
      95 0
      97 0
      99 0
      101 0
      103 0
      105 0
      107 0
c        3.6964E+11
sc2 Energy from ISOSHLD
c     22 23 24 25 26 27 30 31 37 40 42 44
ds2   s 35 35 35 35 36 36 36 36 35 35 35 35
c     47 49 51 53 55 57 59 61 63 65
      35 35 35 35 35 35 35 35 35 35
c     67 69 71 73 75 77 79 81 83 85
      35 35 35 35 35 35 35 35 35 35
c     87 89 91 93 95 97 99 101 103 105
      35 35 35 35 35 35 35 35 35 35
c     107
      35
sc35  Energy from ISOSHLD AQUEOUS
#       si35    sp35
        l     d
     0.015 8.5890E+04
     0.025 4.7970E+04
     0.035 1.8480E+05
     0.045 1.9670E+04
     0.055 1.4160E+04
     0.065 1.2010E+04
     0.075 1.0810E+04
     0.085 0.9711E+04
     0.095 0.8683E+04
     0.150 3.9420E+04
     0.250 1.2960E+04
     0.350 6.3370E+03
     0.475 4.7440E+03
     0.650 1.9300E+06
     0.825 1.0430E+03
     1.000 7.0280E+02
     1.225 4.1390E+03
     1.475 1.1710E+02
     1.700 1.1560E+02
     1.900 5.5970E+00
     2.100 3.9830E+00
c     TOTALS 2.3940E+06
sc36  Energy from ISOSHLD
#       si36    sp36
        l     d
     0.015 5.2991E+02
     0.025 2.9069E+02
     0.035 2.7333E+02
```

T. R. Wilson
Page 28
September 26, 1994


```
     0.045 1.2386E+02
     0.055 8.9838E+01
     0.065 7.5507E+01
     0.075 6.8477E+01
     0.085 6.5465E+01
     0.095 5.6029E+01
     0.150 2.6292E+02
     0.250 8.6123E+01
     0.350 4.2098E+01
     0.475 3.1708E+01
     0.650 1.2152E+03
     0.825 8.6531E+00
     1.000 7.8424E+00
     1.225 5.4146E+01
     1.475 8.5767E-01
     1.700 9.5306E-01
     1.900 3.7567E-02
     2.100 2.6734E-02
c    TOTALS 3.2836E+03
sc3  POSITION
ds3  l -74.4   24.5    43.18    $22
       0      24.5    43.18    $23
       67.945 24.5    0        $24
       67.945 24.5    -14.4463 $25
       -74.4  24.5    43.18    $26
       0      24.5    43.18    $27
       67.945 24.5    0        $30
       67.945 24.5    100.8063 $31
       0      0       0        $37
       -8.255 9.5     0        $40
       -33.655 9.5    0        $42
       -59.055 9.5    0        $44
       67.945 0       -27.94   $47
       31.64  0       -27.94   $49
       0      -32.103 -27.94   $51
       0      -11.43  6.35     $53
       -31.81 -11.43  0        $55
       -31.81 0       -7.82    $57
       -31.81 8.74    0        $59
       67.945 24.5    0        $61
       31.64  8.74    0        $63
       0      -20.32  -10.795  $65
       -20.78 -20.32  0        $67
       -20.78 0       -2.54    $69
       0      -4.445  6.35     $71
       10.0175 0      6.35     $73
       10.0175 -12.542 0       $75
       0      -12.542 36.83    $77
       -81.6925 -12.542 0      $79
       0      -12.542 57.35    $81
       -89.83 0       57.35    $83
       -89.83 24.5    0        $85
       0      24.5    43.18    $87
       -46.415 -20.32 0        $89
       -72.45 -20.32  0        $91
       -72.45 0       -2.54    $93
       -46.415 0      -2.54    $95
       0.5150 -4.445  0        $97
       0.5150 0       -2.54    $99
       -25.12 -4.445  0        $101
       -25.12 0       -2.54    $103
       -50.755 -4.445 0        $105
       -50.755 0      -2.54    $107
sc4  RADIUS
c    22 23 24 25 26 27 30 31 37 40 42 44
ds4  s 10 11 11 10 10 11 11 10 0 12 12 12
c    47 49 51 53 55 57 59 61 63.65
     13 13 13 13 13 13 13 13 13 14
c    67 69 71 73 75 77 79 81 83 85
```

T. R. Wilson
Page 29
September 26, 1994


```
      14 14 14 14 14 14 14 14 14 14
c     87 89 91 93 95 97 99 101 103 105
      14 14 14 14 14 14 14 14 14 14
c     107
      14
sc5   EXTENT
c      22 23 24 25 26 27 30 31 37 40 42 44
ds5   s 0  20 21 0  0  20 22  0 0  23 23 23
c      47 49 51 53 55 57 59 61 63 65
       47 49 51 53 55 57 59 61 63 65
c      67 69 71 73 75 77 79 81 83 85
       67 69 71 73 75 77 79 81 83 85
c      87 89 91 93 95 97 99 101 103 105
       87 67 67 69 69 97 99 97  99  97
c      107
       99
sc6   AXIS
c      22 23 24 25 26 27 30 31 37 40 42 44
ds6   s 0  30 31 0  0  30 31  0 0  31 31 31
c      47 49 51 53 55 57 59 61 63 65
       32 32 30 30 31 32 31 31 31 30
c      67 69 71 73 75 77 79 81 83 85
       31 32 30 32 31 30 31 30 32 31
c      87 89 91 93 95 97 99 101 103 105
       30 31 31 32 32 31 32 31  32  31
c      107
       32
sc7   X extent
ds7   s 0 0 0 0 0 0 0 0 0 41 0 0 0
       0 0 0 0 0 0 0 0 0 0
       0 0 0 0 0 0 0 0 0 0
       0 0 0 0 0 0 0 0 0 0
       0
sc8   Y extent
ds8   s 0 0 0 0 0 0 0 0 0 42 0 0 0
       0 0 0 0 0 0 0 0 0 0
       0 0 0 0 0 0 0 0 0 0
       0 0 0 0 0 0 0 0 0 0
       0
sc9   Z extent
ds9   s 0 0 0 0 0 0 0 0 0 43 0 0 0
       0 0 0 0 0 0 0 0 0 0
       0 0 0 0 0 0 0 0 0 0
       0 0 0 0 0 0 0 0 0 0
       0
sc10  RADIUS for Spherical cell - COALESCER
si10  0  7.7025
sp10    -21      2
sc11  RADIUS for Cylindrical cell - COALESCER
si11  0  7.7025
sp11    -21      1
sc12  RADIUS for Cylindrical cell - FILTER
si12  0  4.78
sp12    -21      1
sc13  RADIUS for Cylindrical cell - OUTPUT AQUEOUS LINE
si13  0  0.79
sp13    -21      1
sc14  RADIUS for Cylindrical cell - INPUT LINE
si14  0  1.3322
sp14    -21      1
sc20  EXTENT for Cylindrical cell
si20  -74.4  67.945
sp20    -21      0
sc21  EXTENT for Cylindrical cell
si21  -14.4463  43.18
sp21    -21      0
sc22  EXTENT for Cylindrical cell
si22  43.18  100 8063
sp22    -21      0
```

```
sc23  EXTENT for Cylindrical cell
si23  -0.985  56.2
sp23   -21     0
sc47  EXTENT for Cylindrical cell - AQUEOUS
si47  -32.103  25.293
sp47   -21     0
sc49  EXTENT for Cylindrical cell - AQUEOUS
si49  -32.103  9.81
sp49   -21     0
sc51  EXTENT for Cylindrical cell - AQUEOUS
si51  30.57  68.735
sp51   -21     0
sc53  EXTENT for Cylindrical cell - AQUEOUS
si53  -97.5325  -30.4775
sp53   -21     0
sc55  EXTENT for Cylindrical cell - AQUEOUS
si55  -8.613  6.35
sp55   -21     0
sc57  EXTENT for Cylindrical cell - AQUEOUS
si57  -11.43  9.533
sp57   -21     0
sc59  EXTENT for Cylindrical cell - AQUEOUS
si59  -37.719  -7.82
sp59   -21     0
sc61  EXTENT for Cylindrical cell - AQUEOUS
si61  -27.94  -14.446
sp61   -21     0
sc63  EXTENT for Cylindrical cell - AQUEOUS
si63  -37.719  -27.94
sp63   -21     0
sc65  EXTENT for Cylindrical cell - INPUT
si65  -97.5325  -19.4478
sp65   -21     0
sc67  EXTENT for Cylindrical cell - INPUT
si67  -10.795  -2.54
sp67   -21     0
sc69  EXTENT for Cylindrical cell - INPUT
si69  -21.6523  9.5
sp69   -21     0
sc71  EXTENT for Cylindrical cell - INPUT
si71  -52.7474  11.3497
sp71   -21     0
sc73  EXTENT for Cylindrical cell - INPUT
si73  -13.8744  -4.445
sp73   -21     0
sc75  EXTENT for Cylindrical cell - INPUT
si75  6.35  44.61
sp75   -21     0
sc77  EXTENT for Cylindrical cell - INPUT
si77  -83.0247  10.0175
sp77   -21     0
sc79  EXTENT for Cylindrical cell - INPUT
si79  36.83  58.6822
sp79   -21     0
sc81  EXTENT for Cylindrical cell - INPUT
si81  -91.1622  -81.6925
sp81   -21     0
sc83  EXTENT for Cylindrical cell - INPUT
si83  -12.452  26.17
sp83   -21     0
sc85  EXTENT for Cylindrical cell - INPUT
si85  41.8478  57.35
sp85   -21     0
sc87  EXTENT for Cylindrical cell - INPUT
si87  -89.83  -74.4
sp87   -21     0
sc97  EXTENT for Cylindrical cell - INPUT
si97  -2.54  6 35
sp97   -21     0
```

T. R. Wilson


```
sc99  EXTENT for Cylindrical cell - INPUT
si99  -5.7773  9.5
sp99   -21     0
sc30  AXIS for Cylindrical cell
si30  l 1 0 0
sp30  1
sc31  AXIS for Cylindrical cell
si31  l 0 0 1
sp31  1
sc32  AXIS for Cylindrical cell
si32  l 0 1 0
sp32  1
sc41  X extent for rectangular solid cell
si41  -55.88 78.74
sp41  0    1
sc42  Y extent for rectangular solid cell
si42  7.62 43.18
sp42  0    1
sc43  Z extent for rectangular solid cell
si43  -62.865 -37.719
sp43  0    1
m1     1001.50 .4372     $H 101 SY Slurry
       6000.50 .0170     $C
       7014.50 .0579     $N
       8016.50 .3725     $O
      11023.50 .0975     $Na
      13027.50 .0113     $Al
      15031.50 .0011     $P
      17000.50 .0029     $Cl
      19000.50 .0026     $K
m2     8016.50  .21      $O air number fraction
       7014.50  .79     $N
m3   26000.01 -.58845  6000.01 -.0008  25000.01 -.020      $ 304 SST
    28000.01 -.190   24000.01 -.190   14000.01 -.010
    15000.01 -.00045 16000.01 -.00030
m4     1001.50 .4372     $H AQUEOUS
       6000.50 .0170     $C
       7014.50 .0579     $N
       8016.50 .3725     $O
      11023.50 .0975     $Na
      13027.50 .0113     $Al
      15031.50 .0011     $P
      17000.50 .0029     $Cl
      19000.50 .0026     $K
m5     1001.50 .4372     $H ORGANIC
       6000.50 .0170     $C
       7014.50 .0579     $N
       8016.50 .3725     $O
      11023.50 .0975     $Na
      13027.50 .0113     $Al
      15031.50 .0011     $P
      17000.50 .0029     $Cl
      19000.50 .0026     $K
m6     1001.50 .4372     $H FROM TANK
       6000.50 .0170     $C
       7014.50 .0579     $N
       8016.50 .3725     $O
      11023.50 .0975     $Na
      13027.50 .0113     $Al
      15031.50 .0011     $P
      17000.50 .0029     $Cl
      19000.50 .0026     $K
c     FLUX TO DOSE CONVERSION FACTORS ANSI/ANS-6.1.1-1991 (Column AP)*3600E-07
de0   log  .01 .015 .02 .03 .04 .05
        .06  08 .10 .15  20  30
        .40 .50 .60  80 1.0 1 5
        2.0 3.0 4.0 5.0 6.0 8.0
        10. 12.
df0   log  2.232e-5 5 652e-5 8 568e-5 1.184e-4 1 314e-4 1 382e-4
```

```
        1.440e-4 1.624e-4 1.919e-4 2.797e-4 3.708e-4 5.616e-4
        7.416e-4 9.144e-4 1.076e-3 1.379e-3 1.656e-3 2.246e-3
        2.758e-3 3.672e-3 4.500e-3 5.292e-3 6.012e-3 7.488e-3
        8.892e-3 1.040e-2
e0    .5 .67 1. 1.5 2.5 20.
fc2    slanted surface
f2:p   30
fs2   -228 -229 -230 -231 -232 -233 -234 -235 -236 -237 -238 -239
      -240 -241 -242 -243 -244 -245 -246 -247 -248 -249
      -250 -251 -252 -253 -254 -255 -256 -257 -258 -259
      -260 -261 -262 -263 -264 -265 -266
fc12   slanted surface
f12:p  30
fs12  -227  228 -229 -230 -231 -232 -233 -234 -235 -236 -237 -238 -239
      -240 -241 -242 -243 -244 -245 -246 -247 -248 -249
      -250 -251 -252 -253 -254 -255 -256 -257 -258 -259
      -260 -261 -262 -263 -264 -265 -266
fc22   slanted surface
f22:p  30
fs22  -226  227 -229 -230 -231 -232 -233 -234 -235 -236 -237 -238 -239
      -240 -241 -242 -243 -244 -245 -246 -247 -248 -249
      -250 -251 -252 -253 -254 -255 -256 -257 -258 -259
      -260 -261 -262 -263 -264 -265 -266
fc32   slanted surface
f32:p  30
fs32  -225  226 -229 -230 -231 -232 -233 -234 -235 -236 -237 -238 -239
      -240 -241 -242 -243 -244 -245 -246 -247 -248 -249
      -250 -251 -252 -253 -254 -255 -256 -257 -258 -259
      -260 -261 -262 -263 -264 -265 -266
fc42   slanted surface
f42:p  30
fs42  -224  225 -229 -230 -231 -232 -233 -234 -235 -236 -237 -238 -239
      -240 -241 -242 -243 -244 -245 -246 -247 -248 -249
      -250 -251 -252 -253 -254 -255 -256 -257 -258 -259
      -260 -261 -262 -263 -264 -265 -266
fc52   slanted surface
f52:p  30
fs52  -223  224 -229 -230 -231 -232 -233 -234 -235 -236 -237 -238 -239
      -240 -241 -242 -243 -244 -245 -246 -247 -248 -249
      -250 -251 -252 -253 -254 -255 -256 -257 -258 -259
      -260 -261 -262 -263 -264 -265 -266
fc62   slanted surface
f62:p  30
fs62  -222  223 -229 -230 -231 -232 -233 -234 -235 -236 -237 -238 -239
      -240 -241 -242 -243 -244 -245 -246 -247 -248 -249
      -250 -251 -252 -253 -254 -255 -256 -257 -258 -259
      -260 -261 -262 -263 -264 -265 -266
fc72   slanted surface
f72:p  30
fs72  -221  222 -229 -230 -231 -232 -233 -234 -235 -236 -237 -238 -239
      -240 -241 -242 -243 -244 -245 -246 -247 -248 -249
      -250 -251 -252 -253 -254 -255 -256 -257 -258 -259
      -260 -261 -262 -263 -264 -265 -266
fc82   slanted surface
f82:p  30
fs82  -220  221 -229 -230 -231 -232 -233 -234 -235 -236 -237 -238 -239
      -240 -241 -242 -243 -244 -245 -246 -247 -248 -249
      -250 -251 -252 -253 -254 -255 -256 -257 -258 -259
      -260 -261 -262 -263 -264 -265 -266
fc92   slanted surface
f92:p  30
fs92  -219  220 -229 -230 -231 -232 -233 -234 -235 -236 -237 -238 -239
      -240 -241 -242 -243 -244 -245 -246 -247 -248 -249
      -250 -251 -252 -253 -254 -255 -256 -257 -258 -259
      -260 -261 -262 -263 -264 -265 -266
fc102  slanted surface
f102:p 30
fs102 -218  219 -229 -230 -231 -232 -233 -234 -235 -236 -237 -238 -239
      -240 -241 -242 -243 -244 -245 -246 -247 -248 -249
```

-250 -251 -252 -253 -254 -255 -256 -257 -258 -259
-260 -261 -262 -263 -264 -265 -266
fc112 slanted surface
f112:p 30
fs112 -217 218 -229 -230 -231 -232 -233 -234 -235 -236 -237 -238 -239
-240 -241 -242 -243 -244 -245 -246 -247 -248 -249
-250 -251 -252 -253 -254 -255 -256 -257 -258 -259
-260 -261 -262 -263 -264 -265 -266
fc122 slanted surface
f122:p 30
fs122 217 -229 -230 -231 -232 -233 -234 -235 -236 -237 -238 -239
-240 -241 -242 -243 -244 -245 -246 -247 -248 -249
-250 -251 -252 -253 -254 -255 -256 -257 -258 -259
-260 -261 -262 -263 -264 -265 -266
fc132 front surface
f132:p 4
fs132 -216 -229 -230 -231 -232 -233 -234 -235 -236 -237 -238 -239
-240 -241 -242 -243 -244 -245 -246 -247 -248 -249
-250 -251 -252 -253 -254 -255 -256 -257 -258 -259
-260 -261 -262 -263 -264 -265 -266
fc142 front surface
f142:p 4
fs142 -215 216 -229 -230 -231 -232 -233 -234 -235 -236 -237 -238 -239
-240 -241 -242 -243 -244 -245 -246 -247 -248 -249
-250 -251 -252 -253 -254 -255 -256 -257 -258 -259
-260 -261 -262 -263 -264 -265 -266
fc152 front surface
f152:p 4
fs152 -214 215 -229 -230 -231 -232 -233 -234 -235 -236 -237 -238 -239
-240 -241 -242 -243 -244 -245 -246 -247 -248 -249
-250 -251 -252 -253 -254 -255 -256 -257 -258 -259
-260 -261 -262 -263 -264 -265 -266
fc162 front surface
f162:p 4
fs162 -213 214 -229 -230 -231 -232 -233 -234 -235 -236 -237 -238 -239
-240 -241 -242 -243 -244 -245 -246 -247 -248 -249
-250 -251 -252 -253 -254 -255 -256 -257 -258 -259
-260 -261 -262 -263 -264 -265 -266
fc172 front surface
f172:p 4
fs172 -212 213 -229 -230 -231 -232 -233 -234 -235 -236 -237 -238 -239
-240 -241 -242 -243 -244 -245 -246 -247 -248 -249
-250 -251 -252 -253 -254 -255 -256 -257 -258 -259
-260 -261 -262 -263 -264 -265 -266
fc182 front surface
f182:p 4
fs182 -211 212 -229 -230 -231 -232 -233 -234 -235 -236 -237 -238 -239
-240 -241 -242 -243 -244 -245 -246 -247 -248 -249
-250 -251 -252 -253 -254 -255 -256 -257 -258 -259
-260 -261 -262 -263 -264 -265 -266
fc192 front surface
f192:p 4
fs192 -210 211 -229 -230 -231 -232 -233 -234 -235 -236 -237 -238 -239
-240 -241 -242 -243 -244 -245 -246 -247 -248 -249
-250 -251 -252 -253 -254 -255 -256 -257 -258 -259
-260 -261 -262 -263 -264 -265 -266
fc202 front surface
f202:p 4
fs202 -209 210 -229 -230 -231 -232 -233 -234 -235 -236 -237 -238 -239
-240 -241 -242 -243 -244 -245 -246 -247 -248 -249
-250 -251 -252 -253 -254 -255 -256 -257 -258 -259
-260 -261 -262 -263 -264 -265 -266
fc212 front surface
f212:p 4
fs212 -208 209 -229 -230 -231 -232 -233 -234 -235 -236 -237 -238 -239
-240 -241 -242 -243 -244 -245 -246 -247 -248 -249
-250 -251 -252 -253 -254 -255 -256 -257 -258 -259
-260 -261 -262 -263 -264 -265 -266
fc222 front surface

```
f222:p  4
fs222 -207  208 -229 -230 -231 -232 -233 -234 -235 -236 -237 -238 -239
     -240 -241 -242 -243 -244 -245 -246 -247 -248 -249
     -250 -251 -252 -253 -254 -255 -256 -257 -258 -259
     -260 -261 -262 -263 -264 -265 -266
fc232   front surface
f232:p  4
fs232 -206  207 -229 -230 -231 -232 -233 -234 -235 -236 -237 -238 -239
     -240 -241 -242 -243 -244 -245 -246 -247 -248 -249
     -250 -251 -252 -253 -254 -255 -256 -257 -258 -259
     -260 -261 -262 -263 -264 -265 -266
fc242   front surface
f242:p  4
fs242 -205  206 -229 -230 -231 -232 -233 -234 -235 -236 -237 -238 -239
     -240 -241 -242 -243 -244 -245 -246 -247 -248 -249
     -250 -251 -252 -253 -254 -255 -256 -257 -258 -259
     -260 -261 -262 -263 -264 -265 -266
fc252   front surface
f252:p  4
fs252 -204  205 -229 -230 -231 -232 -233 -234 -235 -236 -237 -238 -239
     -240 -241 -242 -243 -244 -245 -246 -247 -248 -249
     -250 -251 -252 -253 -254 -255 -256 -257 -258 -259
     -260 -261 -262 -263 -264 -265 -266
fc262   front surface
f262:p  4
fs262 -203  204 -229 -230 -231 -232 -233 -234 -235 -236 -237 -238 -239
     -240 -241 -242 -243 -244 -245 -246 -247 -248 -249
     -250 -251 -252 -253 -254 -255 -256 -257 -258 -259
     -260 -261 -262 -263 -264 -265 -266
fc272   front surface
f272:p  4
fs272 -202  203 -229 -230 -231 -232 -233 -234 -235 -236 -237 -238 -239
     -240 -241 -242 -243 -244 -245 -246 -247 -248 -249
     -250 -251 -252 -253 -254 -255 -256 -257 -258 -259
     -260 -261 -262 -263 -264 -265 -266
fc282   front surface
f282:p  4
fs282  202 -229 -230 -231 -232 -233 -234 -235 -236 -237 -238 -239
     -240 -241 -242 -243 -244 -245 -246 -247 -248 -249
     -250 -251 -252 -253 -254 -255 -256 -257 -258 -259
     -260 -261 -262 -263 -264 -265 -266
ctme  3600.0
print  10 40 50 126 130 170
prdmp  2j 1
```

ATTACHMENT
C-1

Westinghouse Hanford Company | **Internal Memo**

MIT94-2136

From: TWRS Project Support
Phone: 376-2478 H5-68
Date: August 30, 1994
Subject: PRELIMINARY WASTE HANDLING PLAN FOR THE ORGANIC REMOVAL EQUIPMENT PROPOSED FOR TANK 241-C-103

To:

R. F. Carlstrom	S2-54	D. C. Hetzer	S6-31
M. W. Cline	H6-24	D. A. Koehler	H5-70
S. R. Crow	G2-03	A. G. Miskho	H6-20
G. T. Dukelow	S7-15	K. E. Myers	S7-01
K. L. Engelhardt	S6-31	R. J. Parazin	H5-49
P. A. Gagnon	S6-30	R. A. Schwarz	H0-35
C. E. Hanson	H5-09	T. R. Wilson	H5-09
D. W. Hendrickson	L5-31	C. M. Winkler	S5-07

cc: MJO File/LB

Attached, is an informational memo outlining the current waste handling proposal for the 103-C Organic Removal Equipment. The original intent of the attached memo, was to gain consensus from operations, engineering and the program office on how to proceed. Since the initiation of the planning effort, the project has been put on hold and a new TPA agreement is being negotiated.

If the decision is made to remove the organic layer, then the attached memo will provide the basis for continued planning for this project.

If you have any questions about the attached, please contact M. J. Ostrom.

Mike J. Ostrom

M. J. Ostrom, Principal Engineer
TWRS Engineering Support

kdp

Attachment

Hanford Operations and Engineering Contractor for the US Department of Energy

Attachment to MIT94-2136

PRELIMINARY WASTE HANDLING PLAN FOR THE ORGANIC REMOVAL EQUIPMENT PROPOSED FOR TANK 241-C-103

Westinghouse Hanford Company — **Internal Memo**

From: TWRS Engineering Support Services C10394-11
Phone: 376-2478
Date: September 6, 1994
Subject: PRELIMINARY WASTE HANDLING PLAN FOR THE ORGANIC REMOVAL EQUIPMENT PROPOSED FOR TANK 241-C-103

To: R. Ni S5-07

cc:

G. T. Dukelow	S7-15	C. E. Hanson	H5-09
R. F. Carlstrom	G2-02	D. W. Hendrickson	L5-31
M. W. Cline	H6-24	D. C. Hetzer	S6-30
S. R. Crow	G2-30	D. A. Koehler	H5-70
K. L. Engelhardt	S6-30	A. G. Miskho	H6-30
P. A. Gagnon	S6-30	K. E. Myers	S7-01
R. J. Parazin	H5-49	R. A. Schwartz	H0-35
Project Files	H5-09	C. M. Winkler	S5-07

The attached *Preliminary Waste Handling Plan For The Organic Removal Equipment Proposed For Tank 241-C-103* has factored in guidance from the key contributors who will be involved in the equipment removal, waste handling, packaging, characterization, storage and disposal activities.

The intent of this letter is to document discussions that have been ongoing with your staff for waste characterization and disposal activities for the C-103 organic removal program. As you know, the program to remove the floating organic layer has been put on hold and a new TPA agreement is being negotiated. That agreement sets a goal of making a decision by March 1995 as to the disposition of the organic. If a decision is reached that the organic must be separately removed, this letter would provide the basis for continuing planning for the disposal of the operating equipment used for the removal of the organic.

In working with your staff, a preliminary conclusion has been reached that there are no requirements that mandate fabrication of disposal equipment parallel to the fabrication of the organic removal system. The conclusion of the attached plan documents that rationale, therefore, the organic removal and disposal work could be scheduled in series.

The proposed waste-handling strategy is driven by tank farm operations. They request that the removal and packaging process should begin as soon as the organic removal task has been completed. From a regulatory standpoint, this is not required. (Section 3.0 of attachment)

It should be understood that this is a preliminary proposal based on limited information. The plan also suggests that other options be considered as additional funding becomes available to do an in-depth review. Other technologies and life-cycle cost options should be evaluated before the final decision is made on how to proceed (see flow chart 1 and discussion in Section 4.0 of attachment).

C-1-3

With limited resources available, the preliminary proposal attached is the foundation of the waste plan for the organic removal equipment proposed for 241-C-103 tank and gives a better understanding of what the project entails.

All questions and comments should be directed to M. J. Ostrom at 376-2478.

M. J. Ostrom, Principal Engineer
TWRS Engineering Support Services

Attachments (5)

C-1-4

REMOVAL EQUIPMENT PROPOSED FOR TANK 241-C-103

1.0 SCOPE

This document outlines a plan for handling the solid waste generated during the removal of the floating organic waste layer from tank 241-C-103. Its scope includes the disassembly and handling of the above-ground piping, the separations enclosure equipment, the specially designed shielding enclosures, and the pump mast and skimmer equipment inside tank C-103. It does not include plans for dismantling the loading station or handling the tanker truck or its contents. (Refer to Figure 1)

2.0 PROPOSED WASTE-HANDLING APPROACH

2.1 ASSUMPTIONS/REQUIREMENTS

Even though the project will back-flush all piping and associated equipment with hot water, provide decontamination spray system for in tank equipment, and use compressed air to blow down the system before the organic removal task is complete, additional treatment and inspection is assumed to be required before removal to meet the performance criteria of the debris rule.

Even with the most reasonable results, the process cannot decontaminate the system completely. Therefore, for this discussion, all the components will be considered to be mixed waste.

Programmatically, there appears to be no future use for this equipment; therefore all equipment will be treated as waste in this proposal.

Current direction from Operations dictates that equipment removal will begin as soon as the organic removal process is considered a success.

Preliminary calculations summarized in the tabele (Schwarz 1994) are based on limited data to support realistic estimates of residual film thicknesses.

TABLE 1. DOSE RATES AT 1CM FROM TANK C-103 EQUIPMENT

EQUIPMENT	SOURCE	DOSE RATE (mrem /hr)
Inside the tank there is a 1/2-inch schedule 40 pipe that is not enclosed.	Organic	0.09
	Aqueous	125
There will be a doubly contained pipe between the tank, the enclosure, and the tank car. For calculating dose rates outside this pipe a geometry was created consisting of a 1/2-inch schedule 40 pipe enclosed in a 1 1/2-inch schedule 40 pipe with a hollow region between the two pipes. The pipe was modeled as a thin film inside the 1/2-inch pipe. The pipe was modeled as 200 cm. long to simulate an infinitely long pipe.	Organic	0.04
	Aqueous	59
The overall dimensions of the skimmer are 8 inches by 16 inches with a depth of 4.5 inches. No shielding from the steel structure of the skimmer is accounted for in this model; it is assumed that there is a 0.05-inch layer of film on all the sides of the box. It is assumed that there is no waste on the inside of the hollow collar. For some of the surfaces, such as the bottom of the skimmer, the thin film was modeled on both the top and bottom of the surface resulting in a total film thickness of 0.1 inch.	Organic	0.8
	Aqueous	1,100
The pump will be located inside the waste tank and will be used to pump the waste out of the tank to the enclosure. To estimate dose rates from the pump, a model was created that neglected the presence of any steel shielding. The assumption of a 0.05-inch thin film of waste on both the inside and outside surface of the pump results in a total film thickness on 0.1-inch when the steel shielding is neglected. An estimate of the dimensions of the pump was obtained from vendor data as 10.3-inch wide by 21-inches high and 26.3-inches long.	Organic	1
	Aqueous	1,300
If it is assumed that the coalescer is coated with 0.05 inch of waste, and dose measurement taken outside coalescer, the maximum dose rate outside the enclosure box because of the presence of the coalescer is 42 mrem/hr for aqueous and 2 mrem/hr for organic waste. This maximum dose point occurs in front of the enclosure shield wall.	Organic	0.21
	Aqueous	300
It is assumed that the coalescer is coated with 0.05-inches of waste and dose measurement is taken outside enclosure with coalescer inside.	Organic	0.03
	Aqueous	42
The tank in the separation enclosure will be assumed to have a 0.05-inch thin film of waste, and measurements will be taken outside of tank.	Organic	0.05
	Aqueous	51
Measurement taken outside enclosure box with tank containing a 0.05-inch thin film of waste.	Organic	0.02
	Aqueous	22

Dose rates should reflect the organic results more than the aqueous results. Reason for this assumption is due to the functionality of the coalescer. If the coalescer function as designed, very little aqueous waste solution will get through, leaving organic waste and traces of aqueous solution.

It is assumed that a special receiver will be designed to accommodate the removal of the shielding enclosure, pump mast, pull rod, piping, pump and skimmer. It is assumed accommodations for interface will be made during definitive design. The special receiver instrumentation would provide radiation characterization data as the equipment is pulled from the tank. The instrumentation also supports conclusions regarding ALARA and pre-job planning.

Direct burial of the mixed waste was considered, but does not appear to be an option because the criteria have not yet been determined for the RCRA trench. The CERCLA trench is in the early planning stages; its completion date is TBD.

2.2 EQUIPMENT REMOVAL AND PACKAGING PROCESS

When the floating organic layer has been removed and it is judged that the equipment has completed its required mission, preparations then will be initiated to begin the process of procuring the containers and removing, storing, and disposing of the equipment.

The transfer piping radiation levels will be characterized by taking radiation readings with existing onsite hand-held instrumentation. The residual radiation readings for the separations enclosure components will be provided by the internal instrumentation. Radiation Engineering (Jess Greenborg's organization) and Waste Tank Characterization and Preplanning (Dave Hetzer's organization) should participate in the design process so the proper information can be provided to support the packaging and disposal activities.

The residual radiation information will be provided to Packaging Design Engineering and Packaging Safety Engineering to assist in the definition of the packaging requirements. Packaging will be designed for these components through radiation assumptions.

It is believed that onsite low-level metal boxes (LMB's) can be used for the piping since the radiation activity levels should be low. The piping will be sectioned in the field in portable contamination tents.

Fabrication of custom LMB's are anticipated for the shielding enclosure/mast assembly (e.g., rigid pump support mast, skimmer, pump) and separations enclosure.

The custom containers can be built to existing specifications and delivered in approximately 12 weeks after the purchase requisition is issued. They can be used to ship and store contaminated equipment classified as low-level or mixed waste. Both the onsite and custom LMB's take advantage of an existing safety analysis report for packaging (SARP).

The LMB's will be stored on the future container storage pad (see Figure 1) in C Farm to await shipment to T Plant for treatment, decontamination, and disposal. T Plant is expected to be capable of handling mixed waste in early 1996. The containers will be staged on the C Farm loading pad, after the trailer has been removed for approximately six months. The Part A permit makes this procedure possible (Cline 1994).

Routine maintenance is required for storage on future container pad in C Farm. This maintenance will encompass weekly inspections of container and containment for integrity. If puddles appear, lab samples will be taken and analyzed. Inspections are expected to require 8 hours every 3 weeks at $55.00 per person for two people. Lab work cost will depend on the nature of the test. This approach avoids the high costs of storage at the Central Waste Complex (CWC) (See Table 2).

The Waste Characterization and Preplanning Organization will prepare the appropriate paper work to transport the containers to T Plant once T Plant is ready to receive and treat waste.

3.0 REGULATORY ISSUES

From a regulatory standpoint, the equipment inside tank C-103 and the ancillary equipment is addressed in the current revision to the Single Shell Tank (SST) Part A Permit (tank storage). The pending revision to the Part A will expand the appended ancillary equipment to include the organic removal and separations system. Once this is approved the equipment could remain indefinitely.

Once the equipment is disassembled and removed from tank C-103, or from the SST system for that matter, the accumulation period (90-day clock) begins. All waste equipment must be containerized and moved to permitted container storage within this time frame, but storage on loading pad is permitted through the Part A revision (Cline 1994).

4.0 ADDITIONAL STUDIES

A cost study is recommended at a later date when more details and funding is available from the Programs Office to evaluate this proposal. Operations has indicated that it would consider different logic if it were cost effective and did not cause significant problems with daily operations. Additionally, other options such as waste minimization should be considered, e.g., CO_2 treatment of the contaminated piping, instrument enclosure, and mast. CO_2 treatment has been successfully done onsite by vendors who have equipment available and a market for free releasable scrap, making this process more cost efficient.

A second study is recommended to determine whether any of the equipment used in the removal of organic waste at tank 241-C-103 can be reused elsewhere. Equipment designated as reusable is not regulated as waste equipment, it is desirable to reuse as much equipment as possible.

FLOW CHART STEP DESCRIPTION

POSSIBLE WASTE HANDLING APPROACHES (Flow Chart 1)

Step	Description
A	The floating organic layer has been successfully removed and it is judged that the removal equipment will no longer be needed at tank 241-C-103. All piping used for waste transfer has been flushed with water and/or air to remove as much waste residue as possible.
B	The aboveground and in-tank equipment is removed within a reasonable amount of time (within 90 days) after the completion of Step A. All major disassembly of equipment is conducted inside the farm by Tank Farm Operations personnel. The disassembled equipment and piping is sorted into waste classification (e.g., low-level and mixed waste) and put into containers approved for storage, transportation, and burial (e.g., low-level metal boxes for low-level waste).
C	The aboveground and/or in-tank equipment is adequately decontaminated (i.e., piping flushed with water and/or air) and left in place until it can be accepted by T Plant for decontamination. The purpose of this step is to avoid substantial storage costs at the CWC in the event that the storage pad in C Farm is not available. The decision to leave any equipment in place should be made jointly with Tank Farm Operations and should be based primarily (but not completely) on comprehensive studies of the costs of storage, decontamination, and burial. When the equipment is eventually removed, it should be disassembled and packaged as described in Step B.
D	The waste containers are buried as either low-level or mixed waste (Trench 31). Mixed waste may have to be repacked before burial and must meet the land disposal restrictions (LDR). The mixed waste may require some treatment before it can be buried.
E	The containerized waste is shipped to the CWC for interim storage.
F	The low-level and/or mixed waste is shipped to T Plant for decontamination. The purpose of decontamination is to allow all equipment to be either buried as low-level waste or scrapped.
G	The containerized mixed waste is stored on the future container storage pad in C Farm. This pad will be approved for container storage and may store containers longer than 90 days.

5.0 REFERENCES

Anderson, T. M., "Waste-Generating Policy for Westinghouse Hanford Company Employees," Letter from T.M. Anderson to J. D. Wagoner, December 9, 1992.

Cline, M. W., "Part A Permit Information," cc:Mail from M. W. Cline to M.J. Ostrom, July 25, 1994, Westinghouse Hanford Co.

Enserch Environmental Corporation, ICF KH, Science Applications International Corporation, and Westinghouse Hanford Company. "Preliminary Design Report, Removal and Separation of the Floating Organic Layer in Tank 241-C-103," May 9, 1994,

Miskho, A. G., "Equipment Information," CC:mail from A. G. Miskho to D. A. Koehler, June 22, 1994.

Schwarz, R. A., "Dose Rate Calculations Organic Waste from Tank C-103," DSI to D. A. Koehler et al., July 19, 1994.

Thornton, J. W., "Statement of Work for 103C Equipment Removal and Disposal Project," Internal memo from Packaging Design Engineering to D. A. Koehler et. al., June 10, 1994.

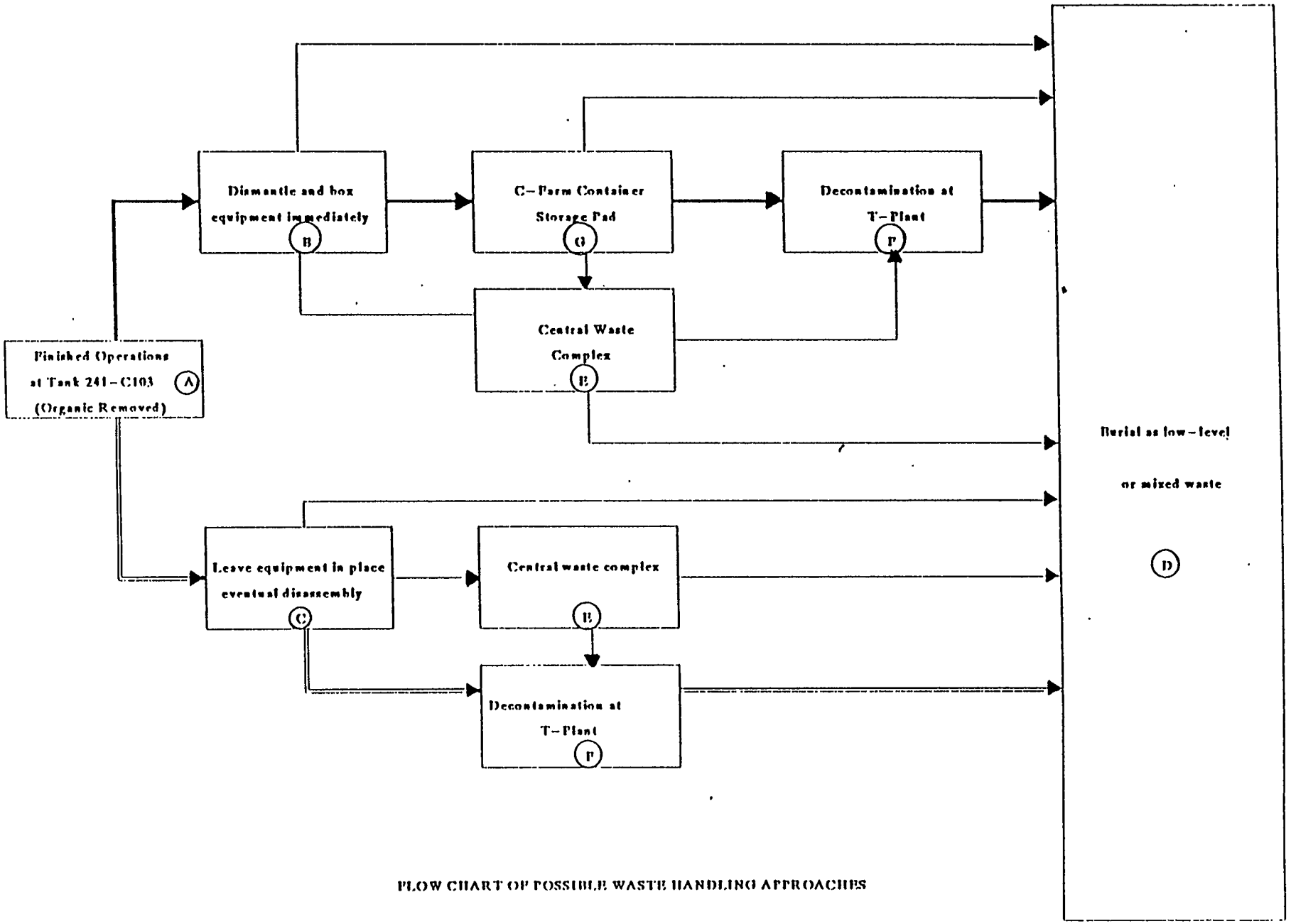
Table 2. Storage and Disposal Rates[a]

Waste Type	FY94	FY95	FY96	FY97	FY98
LLW ($/ft^3)[b] (trench burial)	50	60	72	86	104
RMW ($/ft^3)[b] (storage @ CWC)	144	173	207	249	299
RMW (trench burial)	Not available at this time[c]				

[a] For additional information regarding storage and disposal fees, contact R. A. Barcot at 373-0321.

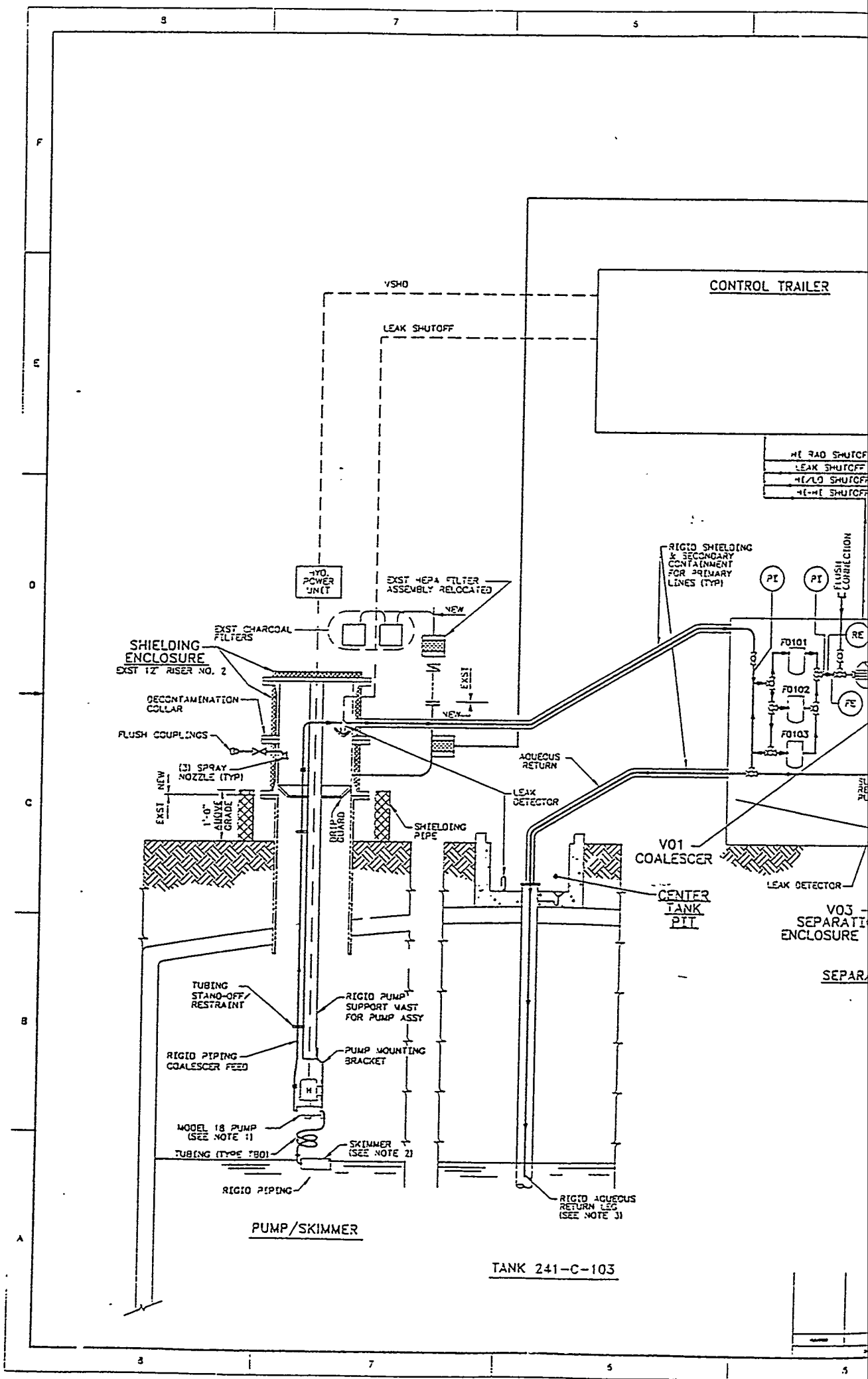
[b] The storage and disposal rates are based on the volume of the container, not on the actual waste volume.

[c] For additional information regarding burial in the mixed waste trench, contact D. W. Carlyle at 373-4222.



PLOW CHART OF POSSIBLE WASTE HANDLING APPROACHES

C-1-12

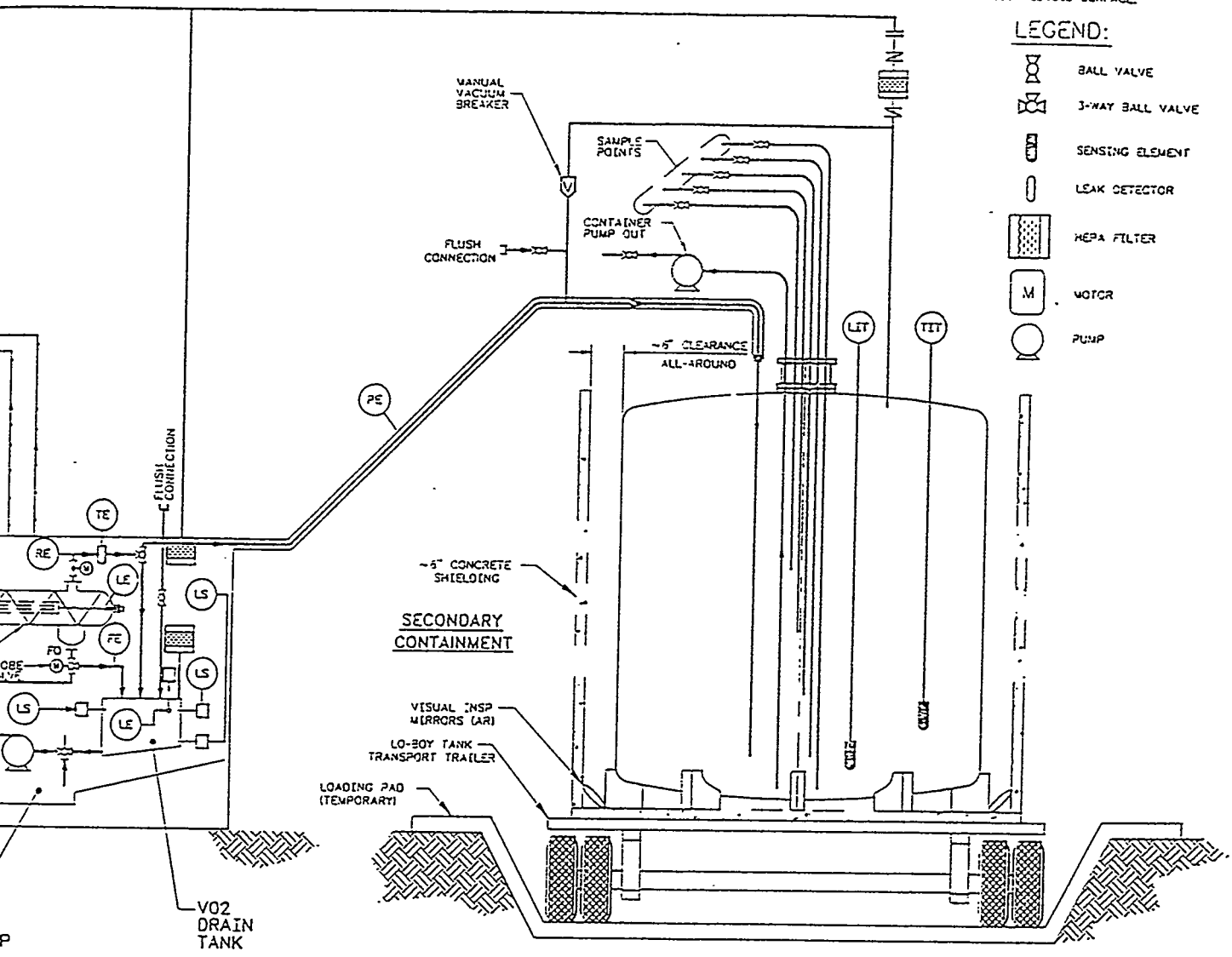

CONTROL TRAILER
VSHO
LEAK SHUTOFF
HYD POWER UNIT
EXST HEPA FILTER ASSEMBLY RELOCATED
NEW
EXST CHARCOAL FILTERS
SHIELDING ENCLOSURE
EXST 12" RISER NO. 2
DECONTAMINATION COLLAR
FLUSH COUPLINGS
(3) SPRAY NOZZLE (TYP)
EXST
NEW
1'-0" ABOVE GRADE
DRIP GUARD
SHIELDING PIPE
RIGID SHIELDING & SECONDARY CONTAINMENT FOR PRIMARY LINES (TYP)
PI
FLUSH CONNECTION
FD101
FD102
FD103
AQUEOUS RETURN
LEAK DETECTOR
V01 COALESCER
CENTER TANK PIT
V03 SEPARATI ENCLOSURE
SEPARA
TUBING STAND-OFF/ RESTRAINT
RIGID PUMP SUPPORT MAST FOR PUMP ASSY
RIGID PIPING COALESCER FEED
PUMP MOUNTING BRACKET
MODEL 18 PUMP (SEE NOTE 1)
TUBING (TYPE TBD)
SKIMMER (SEE NOTE 2)
RIGID PIPING
RIGID AQUEOUS RETURN LEG (SEE NOTE 3)
PUMP/SKIMMER
TANK 241-C-103

WHC-SD-WM-PLN-092

REV 0

NOTES:

1. THE RECOVERY PUMP, WAUKESHA MODEL 18 IS A REVERSIBLE VARIABLE SPEED, HYDRAULICALLY DRIVEN, PRESSURE COMPENSATING, POSITIVE DISPLACEMENT PUMP. THE PUMP SHOULD BE LOCATED 2-5 FEET ABOVE LIQUID LEVEL.
2. THE SKIMMER IS A SELF-ADJUSTING FLOATING WEIR TYPE, WITH AN ATTACHMENT (TO BE DETERMINED) TO THE RECOVERY PUMP, MODEL 18.
3. AQUEOUS RETURN LEG OUTLET SHOULD BE LOCATED ~ 1 FOOT BELOW LIQUID SURFACE.



LOADING STATION

C-1-13

CONCEPTUAL	
CR WILLIAMS	3
SEE DR/AT FORM	U.S. DEPARTMENT OF ENERGY RICHLAND OPERATIONS OFFICE ICF KAISER HANFORD COMPANY
SEE DR/AT FORM	TK-C-103 ORGANIC RECOVERY SYSTEM
SEE DR/AT FORM	
2	NA
F 241-C NA	X 0
CRW103M2	28:IBM-AC02:12.0:NN
WHC	SHOWN X

ATTACHMENT
D-1

STATEMENT OF WORK

C-103 FLOATING ORGANIC LAYER REMOVAL DEFINITIVE DESIGN

CLIENT: WESTINGHOUSE HANFORD CO.
PREPARED BY: ICF KAISER HANFORD
WORK ORDER:
DATE:

1.0 SCOPE

Project C-103 is a task to provide a system for removing the floating organic layer in tank C-103. This task involves putting a skimmer and pump in the tank, routing the waste to a separation enclosure (which houses a coalescer), then routing the organic to a storage tanker.

In September 1994, the design was completed to 90%. The design was checked by each discipline and WHC and comments incorporated. The scope of this effort is to complete the design incorporating all known design changes. The design will be completed to 90% and then sent to the fabrication shops where it will be built under the development control procedure.

2.0 REFERENCES

2.1 Preliminary Design Report, "Removal and Separation of the Floating Organic Layer in Tank 241-C-103", dated May 9, 1994.

2.2 WHC Internal Memo No. C10394-16, "Removal, Radionuclide Separation and Storage of Floating Organic Layer in Tank 241-C-103, Letter of Instruction Number 4 - Supplemental Direction Regarding Definitive Design".

3.0 ENGINEERING DELIVERABLES

The following tasks will be performed by all disciplines at the re-start of the definitive design:

1. Review the approved PDR and all other design inputs.
2. Revise this SOW to spell out specific drawings to be modified and any new drawings required based on the review of all design requirements.
3. Review any waivers to DOE 6430.1A that have been granted.

The estimate for this SOW was based on the design inputs in the draft PDR, as modified by LOI #4, with the following additions/changes:

1. The filters in the separation enclosure will be removed.
2. The drain tank in the separations enclosure will be removed.

4.0 ASSUMPTIONS

The assumptions that were included in the Engineering Work Plan dated June 14, 1994 are still valid with the following additions/modifications:

4.1 The safety class for the complete task is safety class 3.

4.2 All requested waivers to DOE 6430.1A are granted.

4.3 The pump inside the tank will be a hydraulically driven pump.

4.4 No design will be provided for the storage tank trailer.

4.5 ICF KH will prepare an approved construction specification to accompany the approved drawings for field installation.

ATTACHMENT
D-2

PROJECT TITLE:

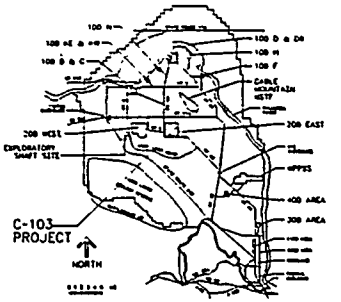
C-103 FLOATING ORGANIC REMOVAL SYSTEM

FOR:

WESTINGHOUSE HANFORD COMPANY

BY:

ICF KAISER HANFORD COMPANY



HANFORD AREA MAP

DRAWING LIST

DRAWING LIST

DRAWING NO.	INDEX NO.	TITLE
H-2-823452	0000, 0101	DRAWING LIST & AREA MAP

CIVIL

DRAWING NO	INDEX NO.	TITLE
H-2-823453	0110	CIVIL SITE PLAN 241-C-103
H-2-823454	0900, 0901	CIVIL/ENVIRONMENTAL PLAN & SECT

INSTRUMENTATION

DRAWING NO.	INDEX NO.	TITLE
H-2-823461 SH 1	7003	PUMP CONTROL LOGIC DIAGRAMS
H-2-823461 SH 2	7003	TOTALIZE & ANNUNCIATE LOGIC DIAGRAMS
H-2-823462 SH 1	7501	PLC CONTROL ENCLOSURE, CONTROL PANEL ASSEMBLY
H-2-823462 SH 2	7501	SEPARATION ENCLOSURES, DC AND AC T-BOX ASSEMBLYBLIES
H-2-823463 SH 1	5903	PLC ENCLOSURE, INTERCONNECTION DIAGRAM
H-2-823463 SH 2	5903	SEPARATION ENCL DC T-BOX, INTERCONNECTION DIAGRAM
H-2-823463 SH 3	5903	SEPARATION ENCL AC T-BOX, INTERCONNECTION DIAGRAM

PIPING & VESSELS

DRAWING NO	INDEX NO	TITLE
H-2-823465 SH 1	7001	P&ID, ORGANIC REMOVAL, TK-103 (RW)
H-2-823465 SH 2	7001	P&ID, ORGANIC REMOVAL, SEPARATIONS ENCLOSURE (RW)
H-2-823465 SH 3	7001	P&ID, ORGANIC REMOVAL, TANK TRUCK (RW)
H-2-823466 SH 1	8510	PIPING, PLAN & SECTIONS, TRANSFER PUMP AT RISER 2
H-2-823466 SH 2	8510	PIPING, PLAN & SECTIONS, TRANSFER PUMP AT RISER 2
H-2-823466 SH 3	8510	PIPING, SECTIONS & DETAILS, TRANSFER PUMP AT RISER 2
H-2-823466 SH 4	8510	PIPING, SECTIONS & DETAILS, TRANSFER PUMP AT RISER 2
H-2 823467 SH 1	8510	PIPING, PLAN, SECT & DETAILS SALT WELL PIT MODIFICATIONS
H-2-823468 SH 1	8510	PIPING, TANK 103, PLAN & SECTIONS
H-2-823468 SH 2	8510	PIPING, TANK 103 SECTIONS & DETAILS
H-2-823469 SH 1	8510	ASSEMBLY, SEPARATIONS ENCLOSURE, PLAN & ELEVATION
H-2-823469 SH 2	8510	ASSEMBLY, SEPARATIONS ENCLOSURE, INTERNAL PIPING
H-2-823469 SH 3	8510	ASSEMBLY, SEPARATIONS ENCLOSURE, INTERNAL PIPING DETAILS
H-2-823469 SH 4	8510	ASSEMBLY, SEPARATIONS ENCLOSURE, INTERNAL PIPING DETAILS
H-2-823470 SH 1	8510	ASSEMBLY, SEPARATIONS ENCLOSURE, BOX
H-2-823470 SH 2	8510	ASSEMBLY, SEPARATIONS ENCLOSURE, BOX
H-2-823471 SH 1	8510	ASSEMBLY, SEPARATIONS ENCLOSURE, COVER
H-2-823471 SH 2	8510	ASSEMBLY, SEPARATIONS ENCLOSURE, COVER
H-2-823471 SH 3	8510	ASSEMBLY, SEPARATIONS ENCLOSURE, COVER

ELECTRICAL

DRAWING NO.	INDEX NO.	TITLE
H-2-823455	6001	ELECTRICAL, SITE PLAN, 241-C-103
H-2-823456	7302	ONE AND THREE LINE DIAGRAMS, 241-C-103
H-2-823457	7301, 7401	CONTROL TRAILER, LIGHTING & ELECTRICAL EQUIPMENT LAYOUT, 241-C-103
H-2-823458	7505, 7301, 7304	MISC DETAILS & DISTRIBUTION PANEL SCHEDULES, 241-C-103

CONSTRUCTION SPECIFICATION

ER5922-C1 / ER5922-C2 — SHOP FABRICATION / CONSTRUCTION SPECIFICATION

HOLD #4
HOLD FOR SITE WORK SPECIFICATION CREATION

CALCULATION — TITLE

HOLD #3
HOLD FOR CALCULATION COMPLETION

* SEE E.D.T. # 609327
FOR RELEASED / RETRIEVABLE DWGS.

W.J. MAGRUDER, P.E.

DRAWN BY	R. VALMONT
CHECKED BY	SEE ORIG FORM
ENGINEER	SEE ORIG FORM
PROJECT ENGINEER	SEE ORIG FORM
PROJECT MANAGER	SEE ORIG FORM
DESIGN AUTHORITY	
DESIGN AGENT	
APPROVED FOR CONSTRUCTION	
AS-BUILT	
DATE	

PRELIMINARY

U.S. DEPARTMENT OF ENERGY
RICHLAND OPERATIONS OFFICE
ICF KAISER HANFORD COMPANY

DRAWING LIST & AREA MAP

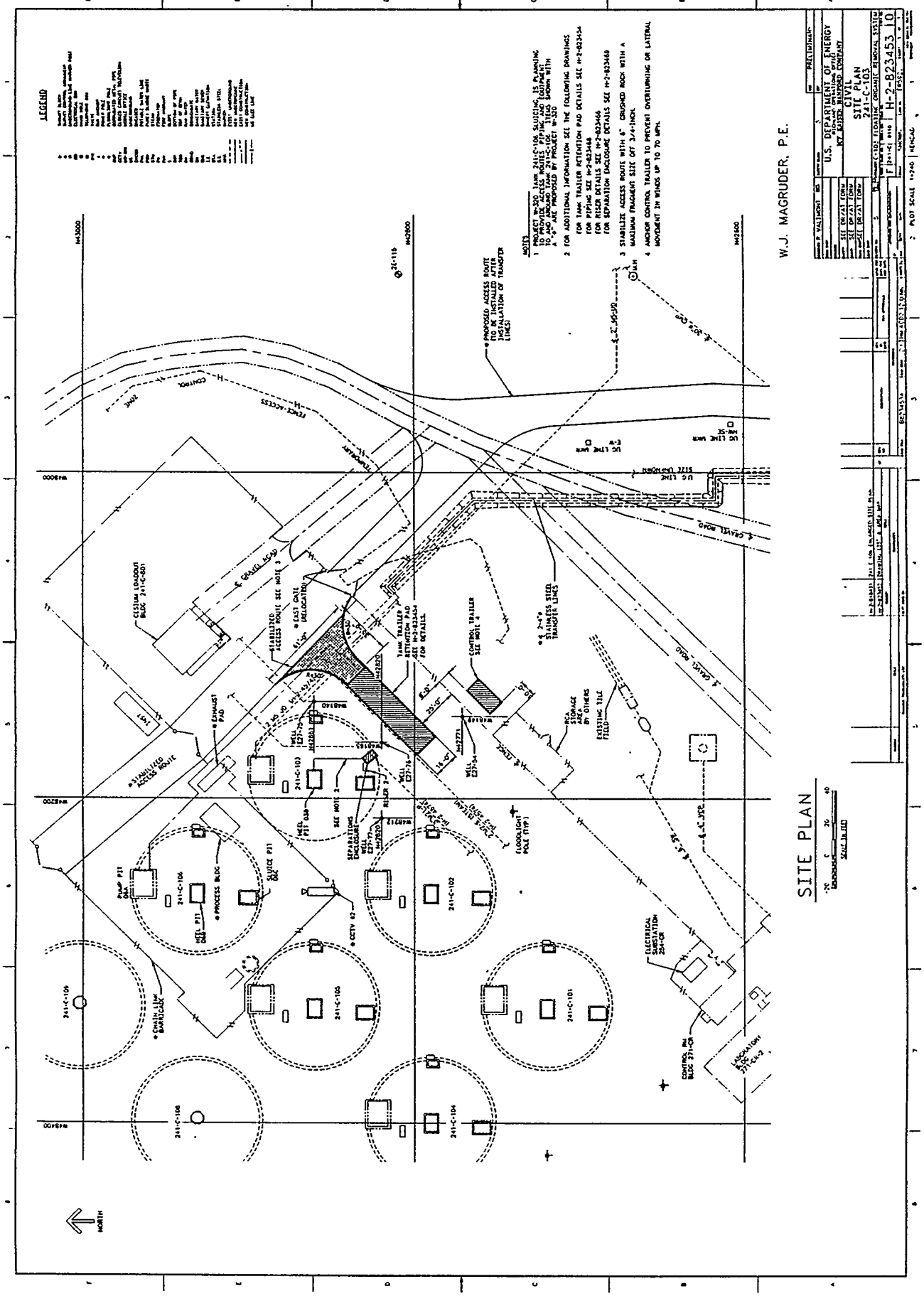
C-103 FLOATING ORGANIC REMOVAL SYSTEM

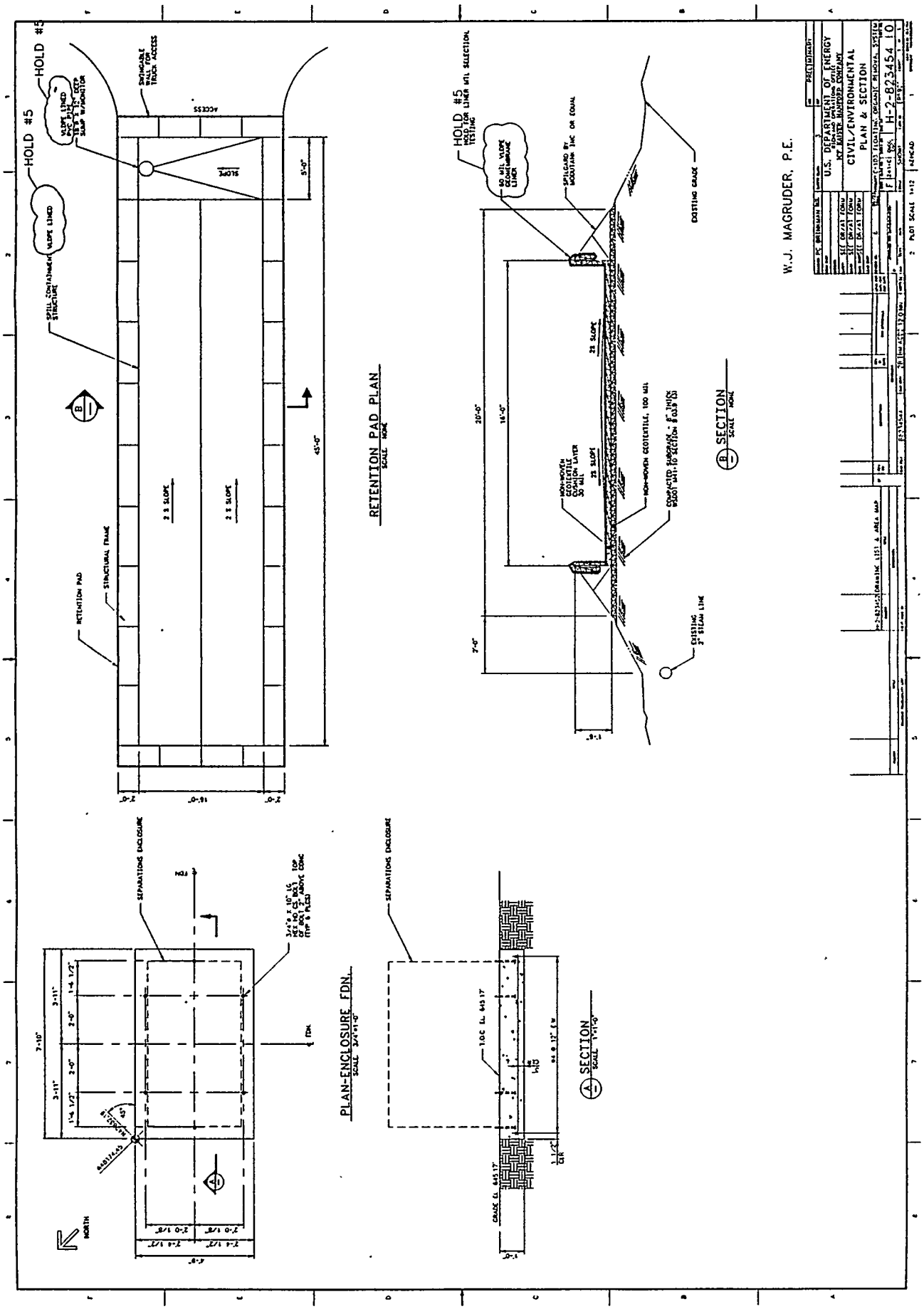
FIZ=1<C | 9823452 | 0

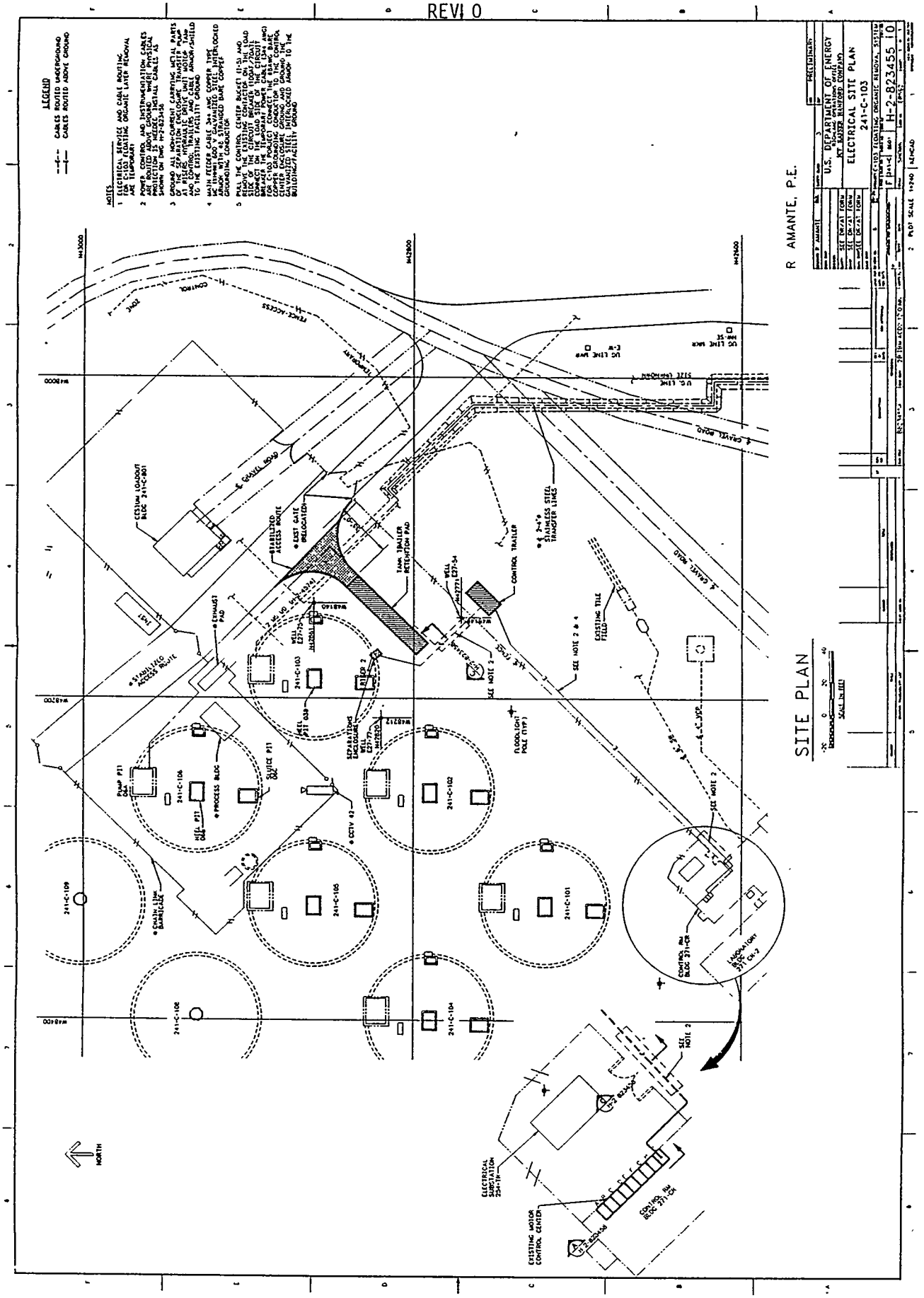
2 PLOT SCALE 1=1 | W.E.H.C.A.D

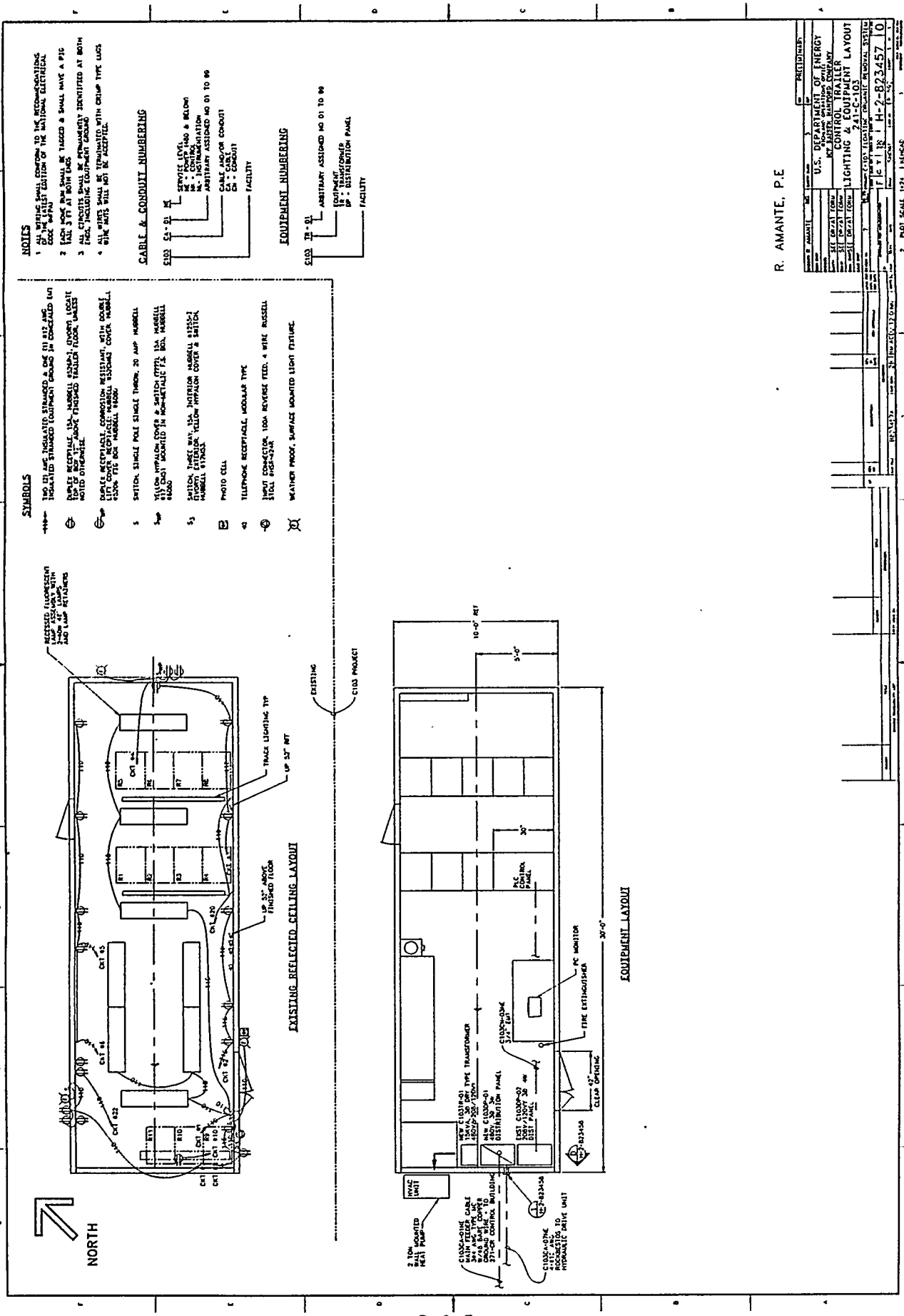
D-2-1

WHC-SD-WM-PLN-092
REV 0


SITE PLAN
W.J. MAGRUDER, P.E.
U.S. DEPARTMENT OF ENERGY
H-2-823453 10
241-C-103
NORTH


HOLD #5
RETENTION PAD PLAN
SECTION
PLAN-ENCLOSURE FDN.
SECTION
W.J. MAGRUDER, P.E.
U.S. DEPARTMENT OF ENERGY
CIVIL/ENVIRONMENTAL
PLAN & SECTION
H-2-823454


LEGEND
CABLES ROUTED UNDERGROUND
CABLES ROUTED ABOVE GROUND
NOTES
SITE PLAN
R AMANTE, P.E.
U.S. DEPARTMENT OF ENERGY
ELECTRICAL SITE PLAN
241-C-103
H-2-823455
NORTH
CESIUM LOADOUT BLDG 241-C-801
STABILIZED ACCESS ROUTE
EXHAUST PAD
TANK TRAILER RETENTION PAD
CONTROL TRAILER
EXISTING TILE FIELD
FLOODLIGHT POLE (TYP)
SEPARATIONS ENCLOSURE
PROCESS BLDG
CHAIN LINK BARRICADE
CONTROL RM BLDG 271-CR
LABORATORY BLDG 271-CN-2
ELECTRICAL SUBSTATION 254-TH
EXISTING MOTOR CONTROL CENTER
CONTROL RM BLDG 271-CK
241-C-101
241-C-102
241-C-103
241-C-104
241-C-105
241-C-106
241-C-108
241-C-109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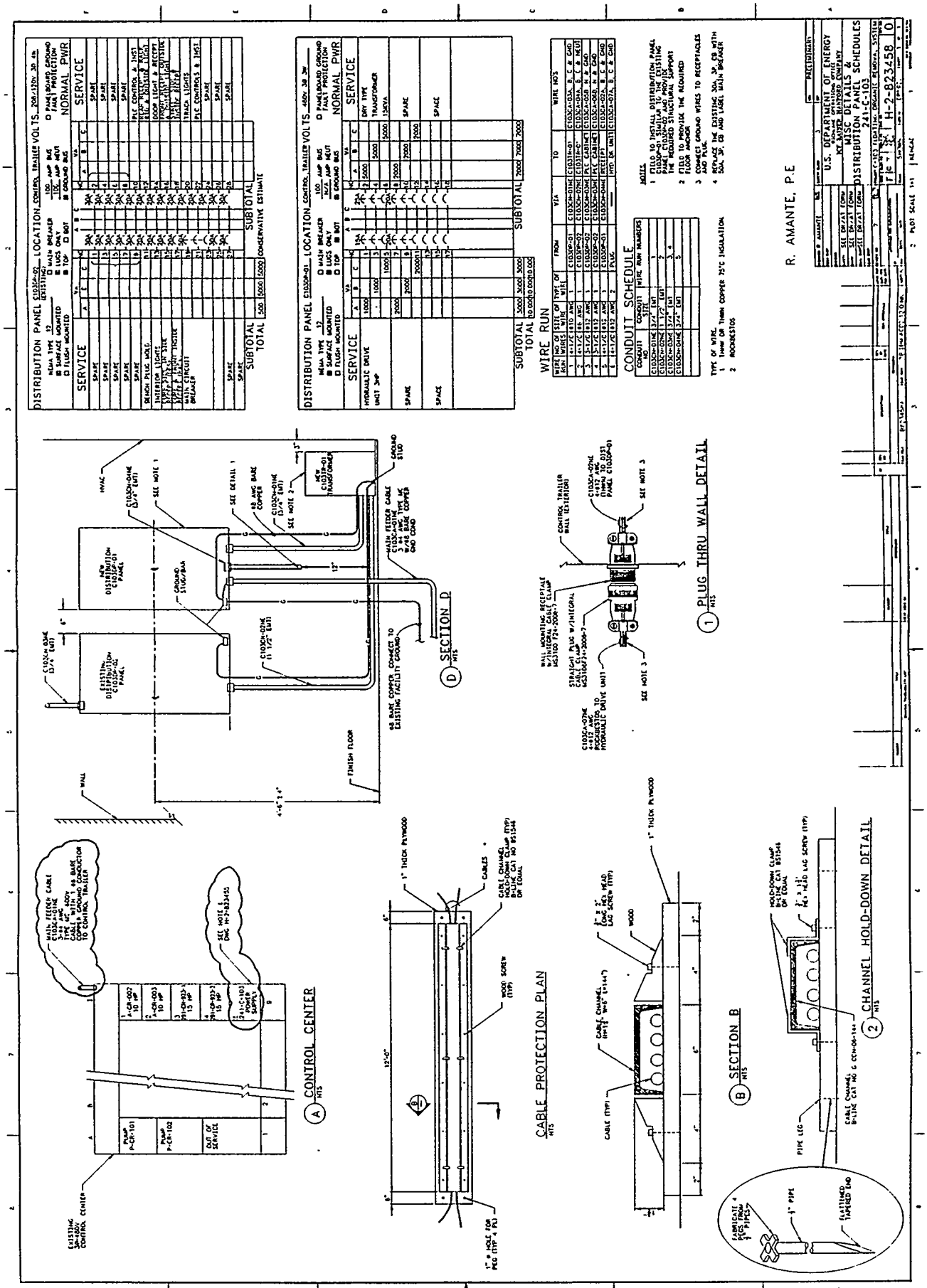
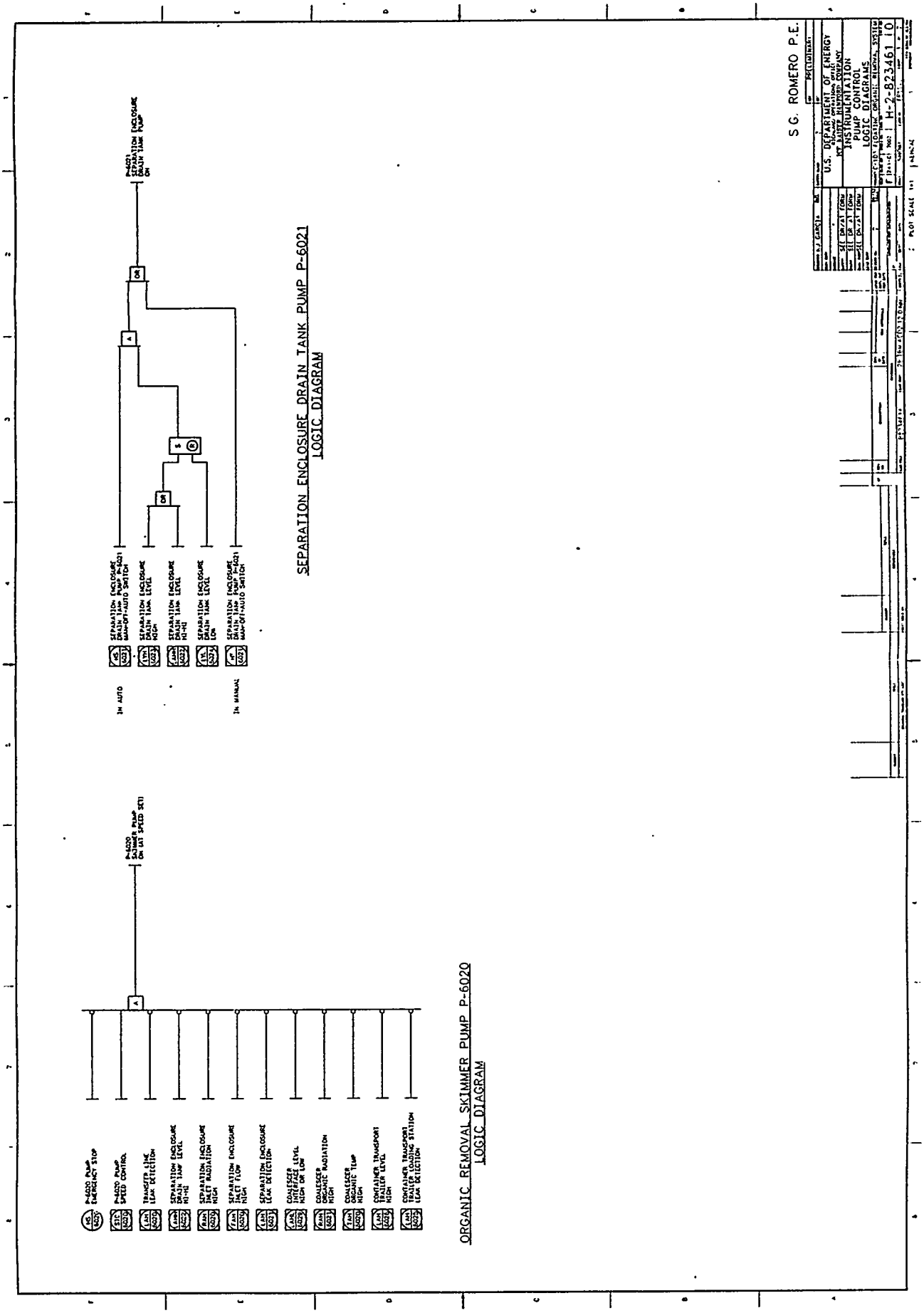
SYMBOLS
CABLE & CONDUIT NUMBERING
EQUIPMENT NUMBERING
EXISTING REFLECTED CEILING LAYOUT
EQUIPMENT LAYOUT
NORTH
R. AMANTE, P.E
U.S. DEPARTMENT OF ENERGY
CONTROL TRAILER
LIGHTING & EQUIPMENT LAYOUT
241-C-103
H-2-823457

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LOGIC DIAGRAM
ORGANIC REMOVAL SKIMMER PUMP P-6020
LOGIC DIAGRAM
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U.S. DEPARTMENT OF ENERGY
INSTRUMENTATION
PUMP CONTROL
LOGIC DIAGRAMS
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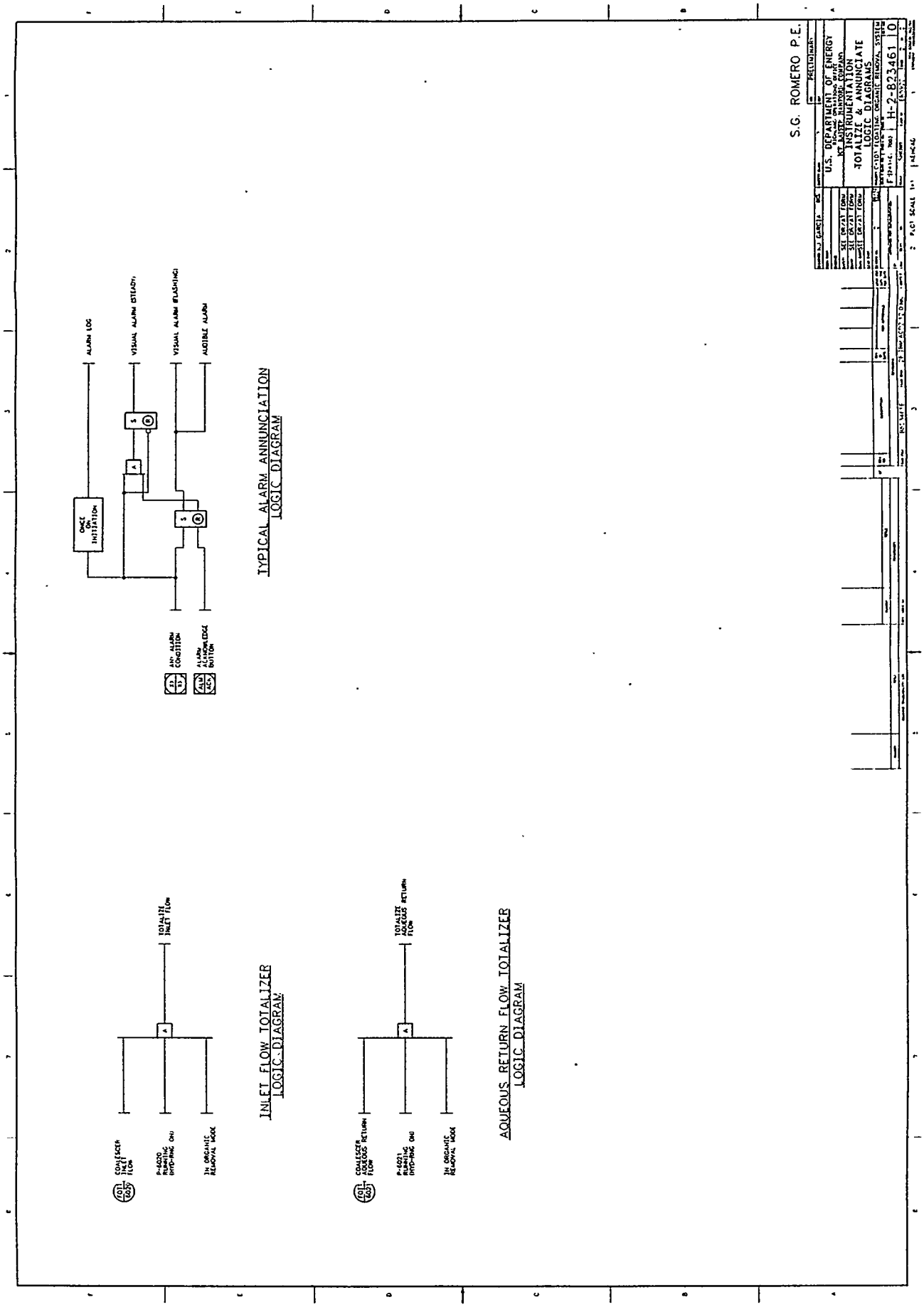
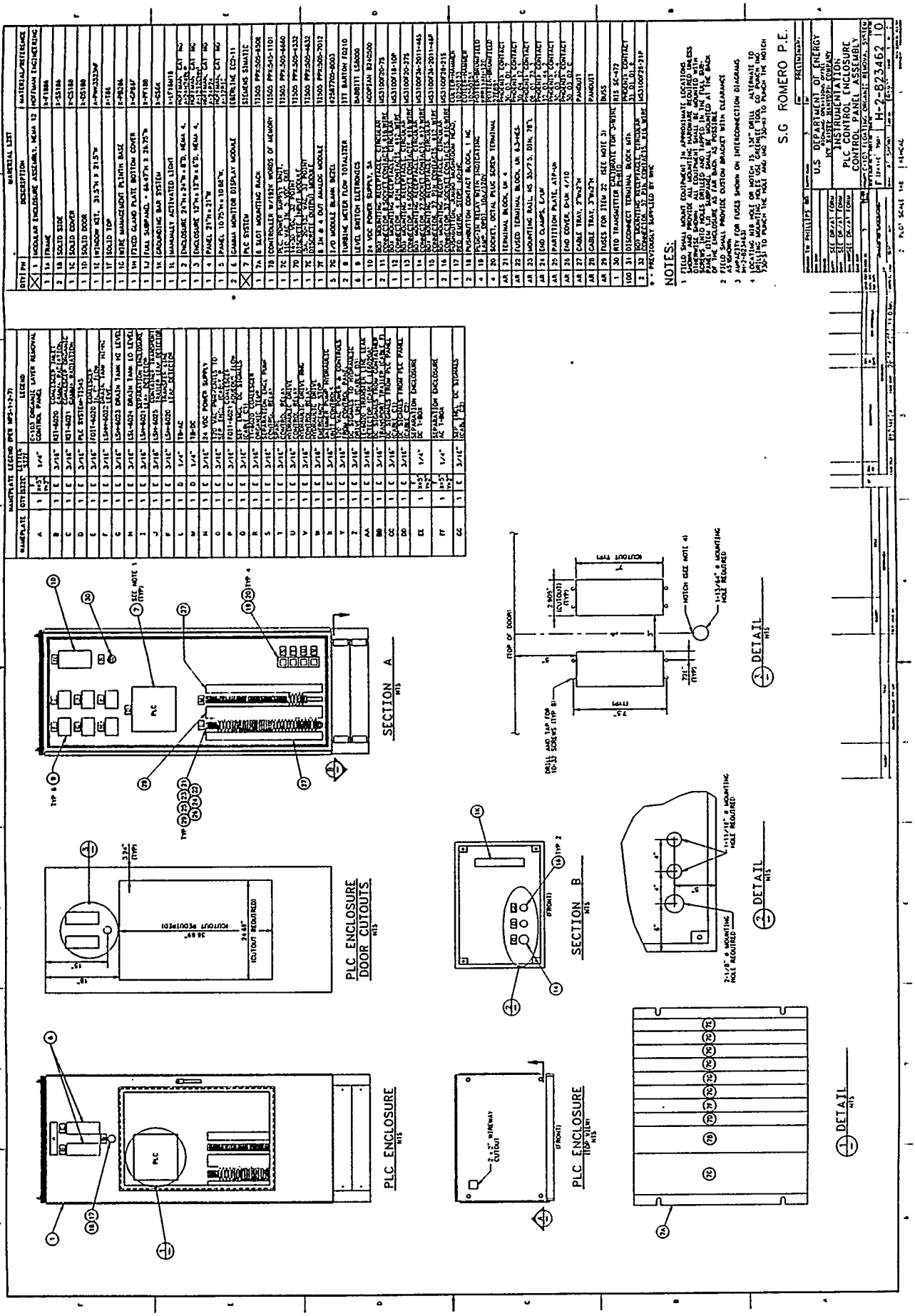


TYPICAL ALARM ANNUNCIATION LOGIC DIAGRAM

INLET FLOW TOTALIZER LOGIC DIAGRAM

AQUEOUS RETURN FLOW TOTALIZER LOGIC DIAGRAM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NAMEPLATE LEGEND PER WPS-11-2-71
LEGEND
NOTES:
SECTION A
PLC ENCLOSURE DOOR CUTOUTS
SECTION B
PLC ENCLOSURE
PLC ENCLOSURE TOP VIEW
DETAIL
U.S DEPARTMENT OF ENERGY
WESTINGHOUSE HANFORD COMPANY
INSTRUMENTATION
PLC CONTROL ENCLOSURE
CONTROL PANEL ASSEMBLY
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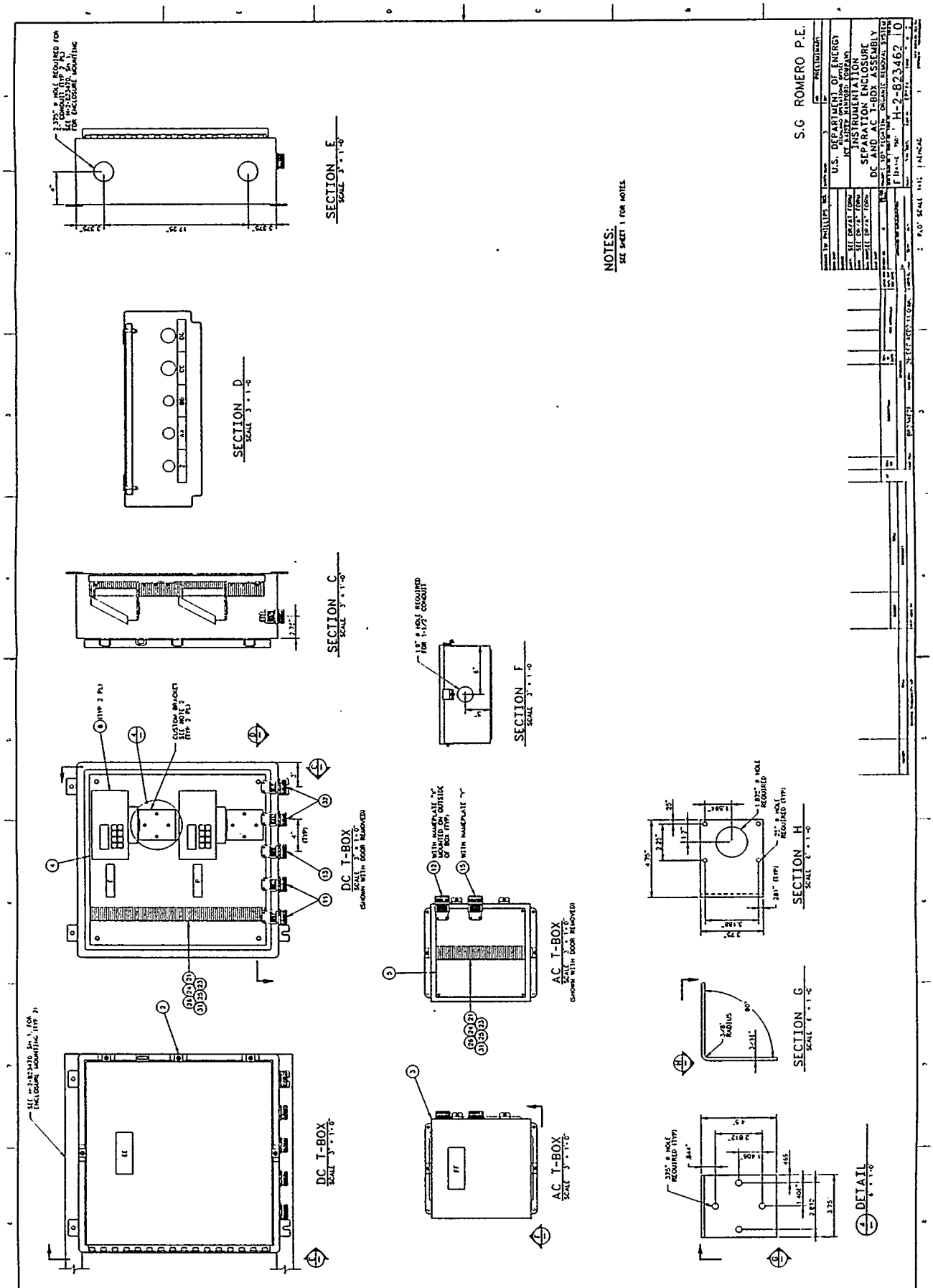
S.G ROMERO P.E.


S.G ROMERO P.E.
U.S. DEPARTMENT OF ENERGY
INSTRUMENTATION
SEPARATION ENCLOSURE
DC AND AC T-BOX ASSEMBLY
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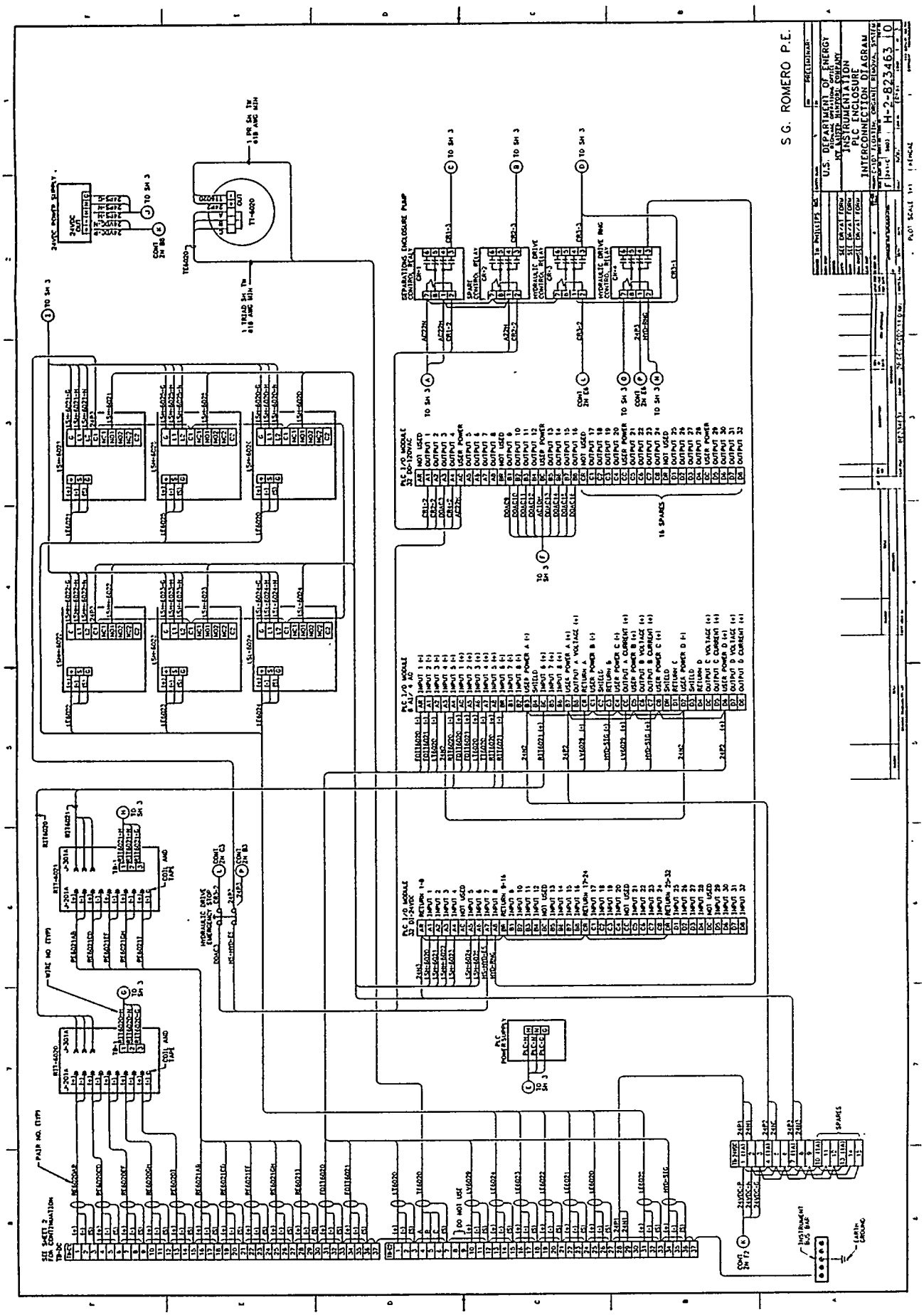
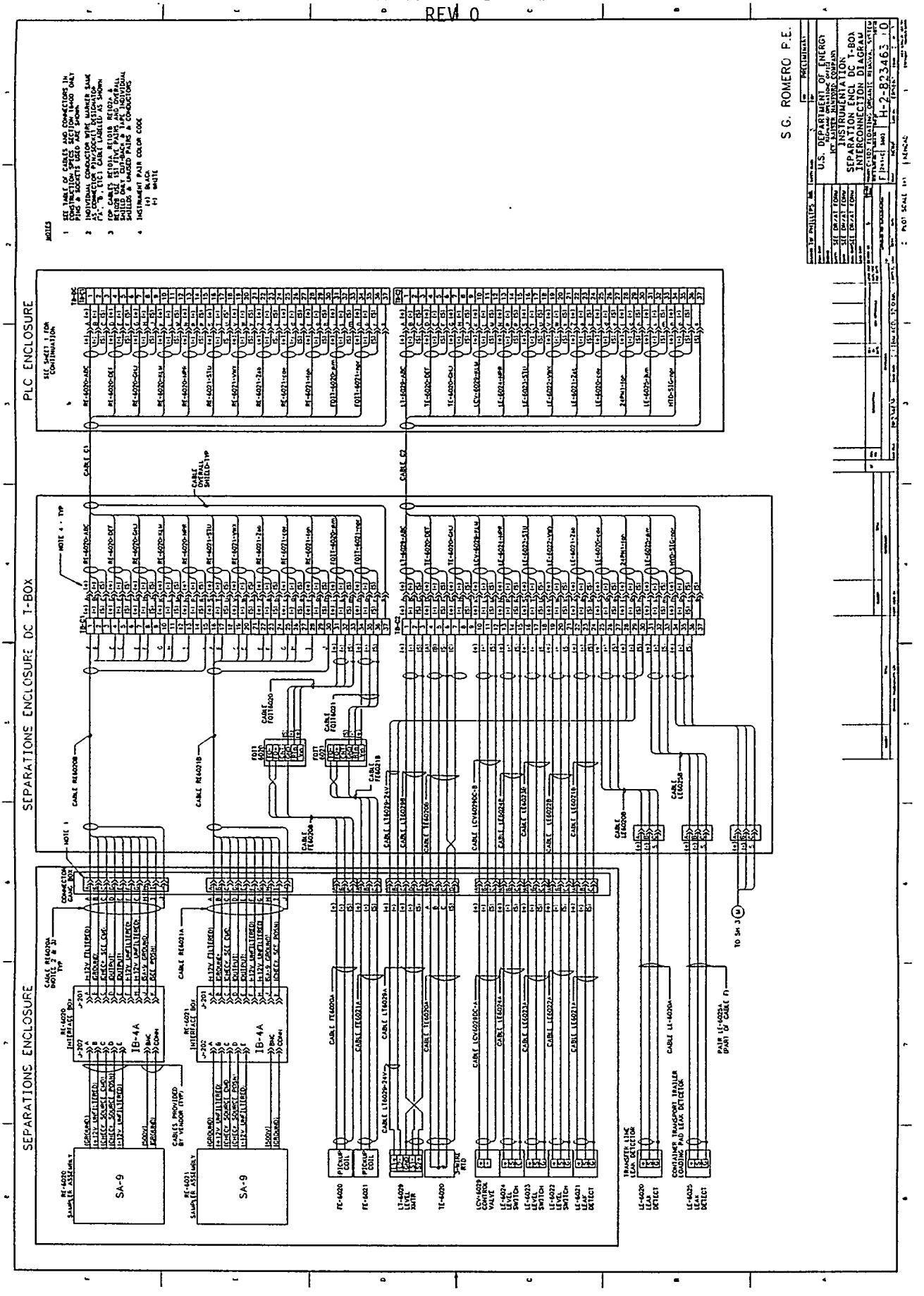
SECTION E
SECTION D
SECTION C
SECTION F
SECTION G
SECTION H
DC T-BOX
AC T-BOX
DETAIL

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SEPARATIONS ENCLOSURE DC T-BOX
SEPARATIONS ENCLOSURE
S.G. ROMERO P.E.
U.S. DEPARTMENT OF ENERGY
INSTRUMENTATION
SEPARATION ENCL DC T-BOX
INTERCONNECTION DIAGRAM
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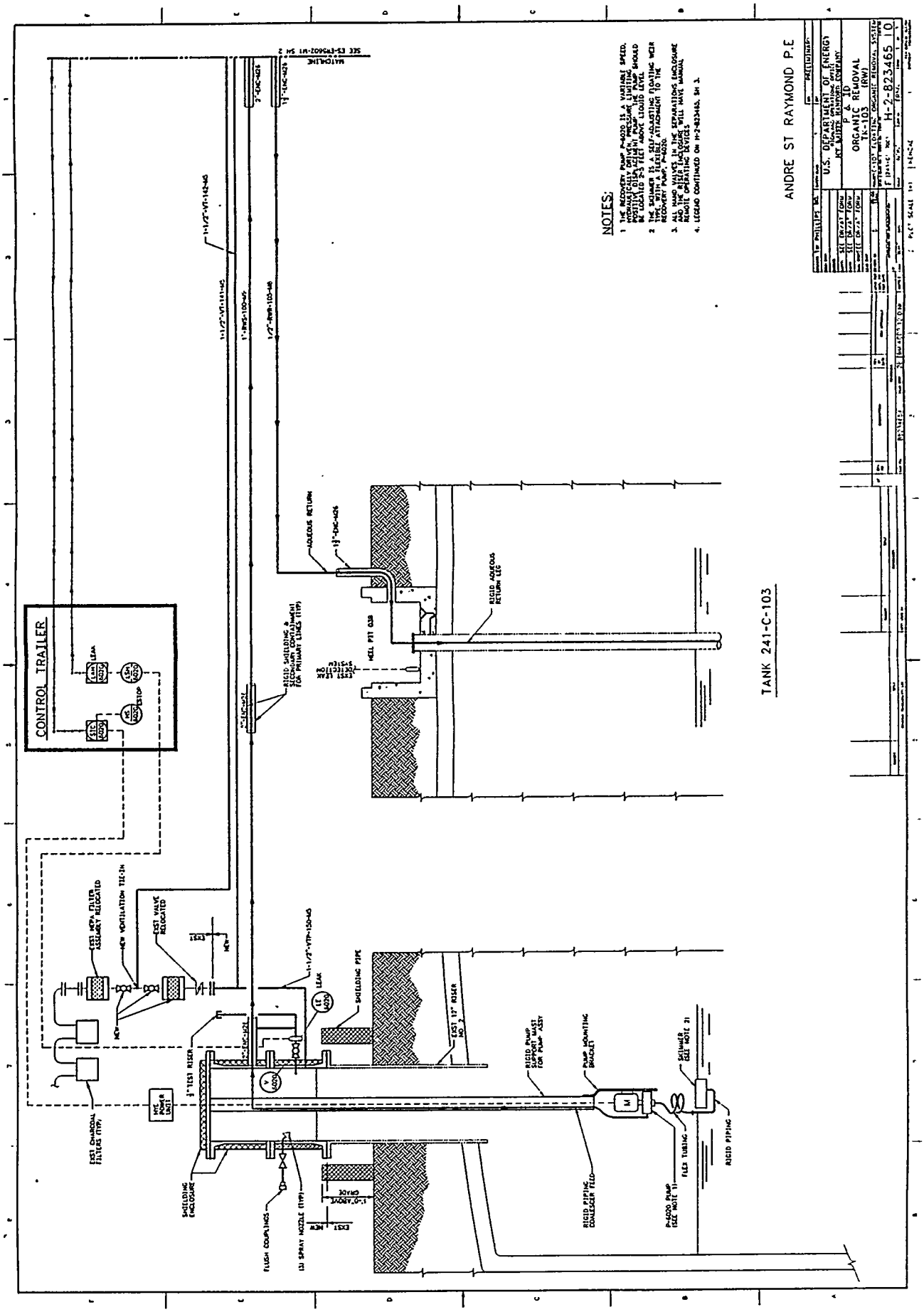
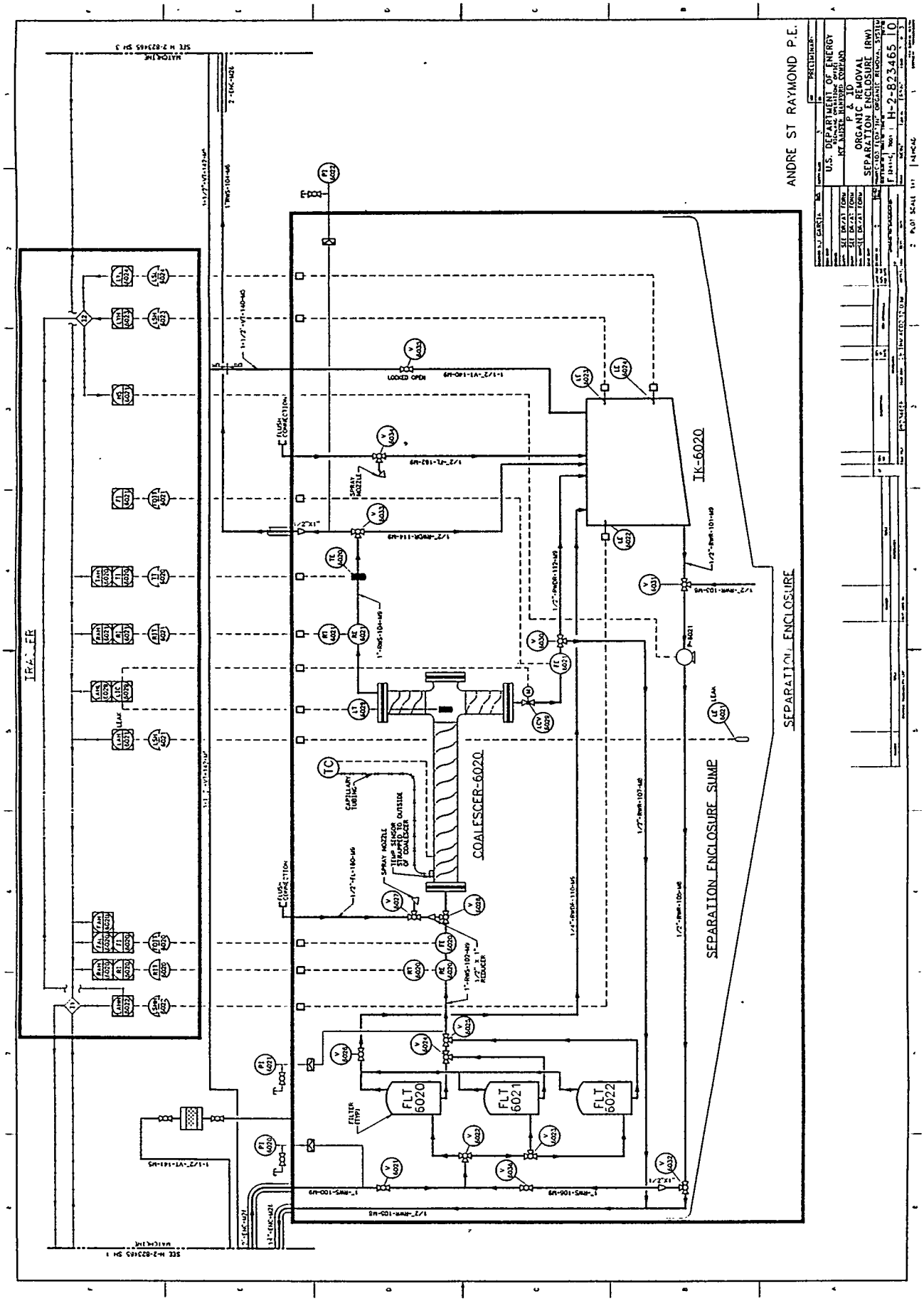

ANDRE ST RAYMOND P.E
U.S. DEPARTMENT OF ENERGY
P & ID
ORGANIC REMOVAL
TK-103
H-2-823465
NOTES:
CONTROL TRAILER
TANK 241-C-103
AQUEOUS RETURN
RIGID AQUEOUS RETURN LEG
HEEL PIT 030
SHIELDING PIPE
SHIELDING ENCLOSURE
FLUSH COUPLINGS
RIGID PIPING
FLEX TUBING
RIGID PIPING COALESCER FEED
PUMP MOUNTING BRACKET
EXST 12" RISER NO 2
EXST HEPA FILTER ASSEMBLY RELOCATED
NEW VENTILATION TIE-IN
EXST VALVE RELOCATED
EXST CHARCOAL FILTERS (TYP)
HYD POWER UNIT
EXST 12" RISER


ANDRE ST RAYMOND P.E.
U.S. DEPARTMENT OF ENERGY
P & ID
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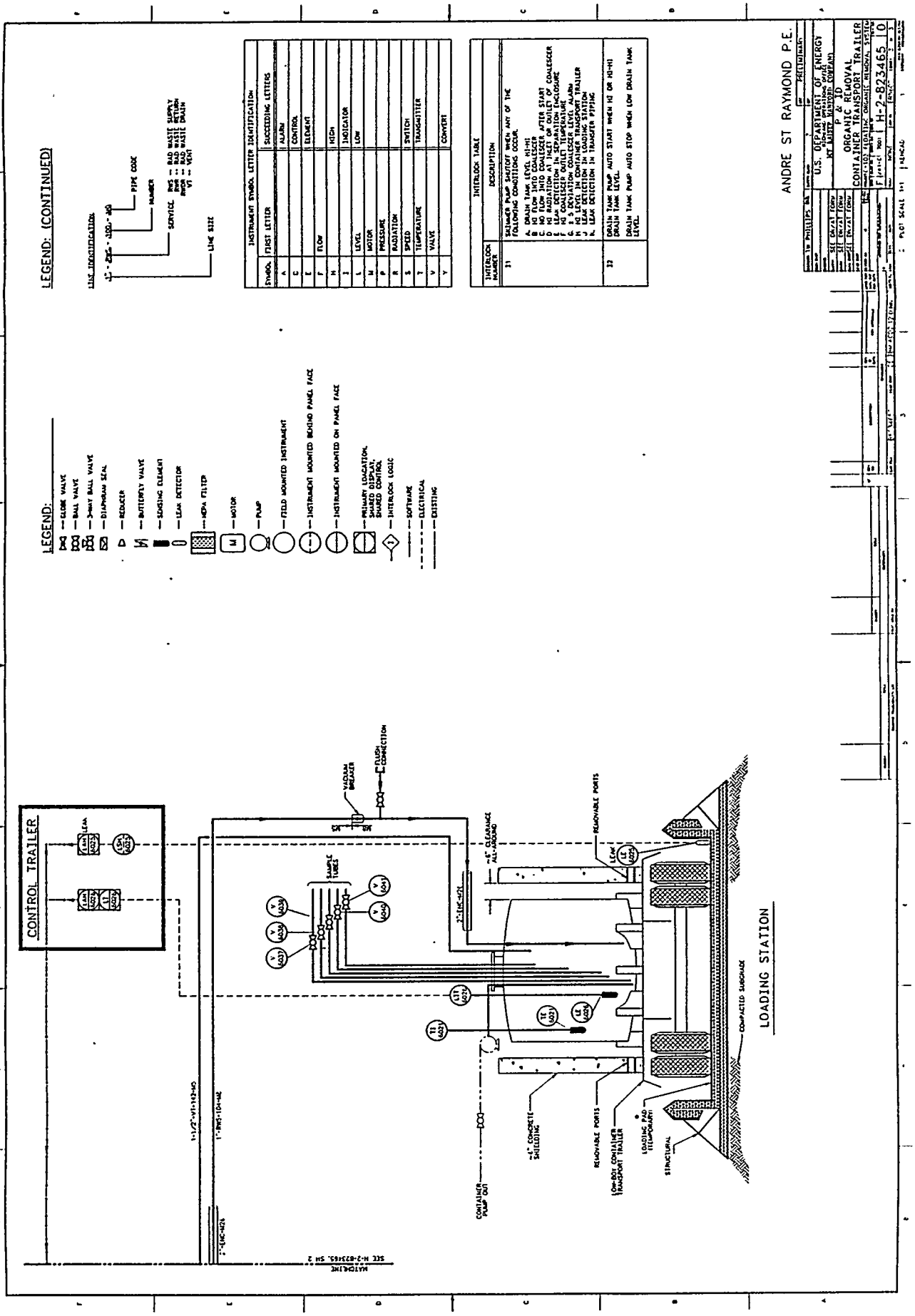
SEPARATION ENCLOSURE (RW)
H-2-823465 10
IK-6020
COALESCER-6020
SEPARATION ENCLOSURE
SEPARATION ENCLOSURE SUMP
FLT 6020
FLT 6021
FLT 6022
LOCKED OPEN
FLUSH CONNECTION
SPRAY NOZZLE
CAPILLARY TUBING
1/2" x 1" REDUCER


LEGEND: (CONTINUED)
LEGEND:
CONTROL TRAILER
LOADING STATION
U.S. DEPARTMENT OF ENERGY
P & ID
ORGANIC REMOVAL
CONTAINER TRANSPORT TRAILER
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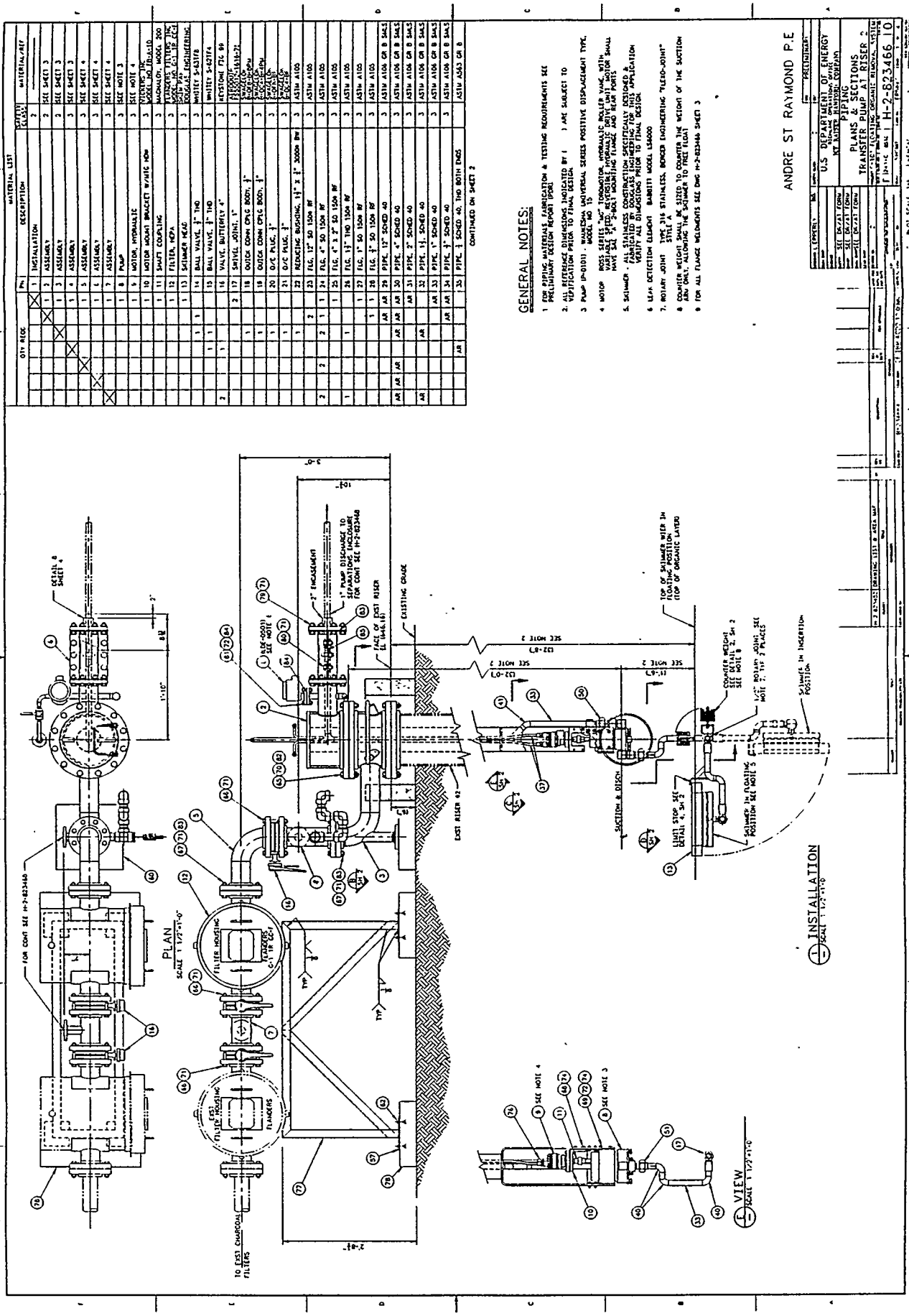
ANDRE ST RAYMOND P.E.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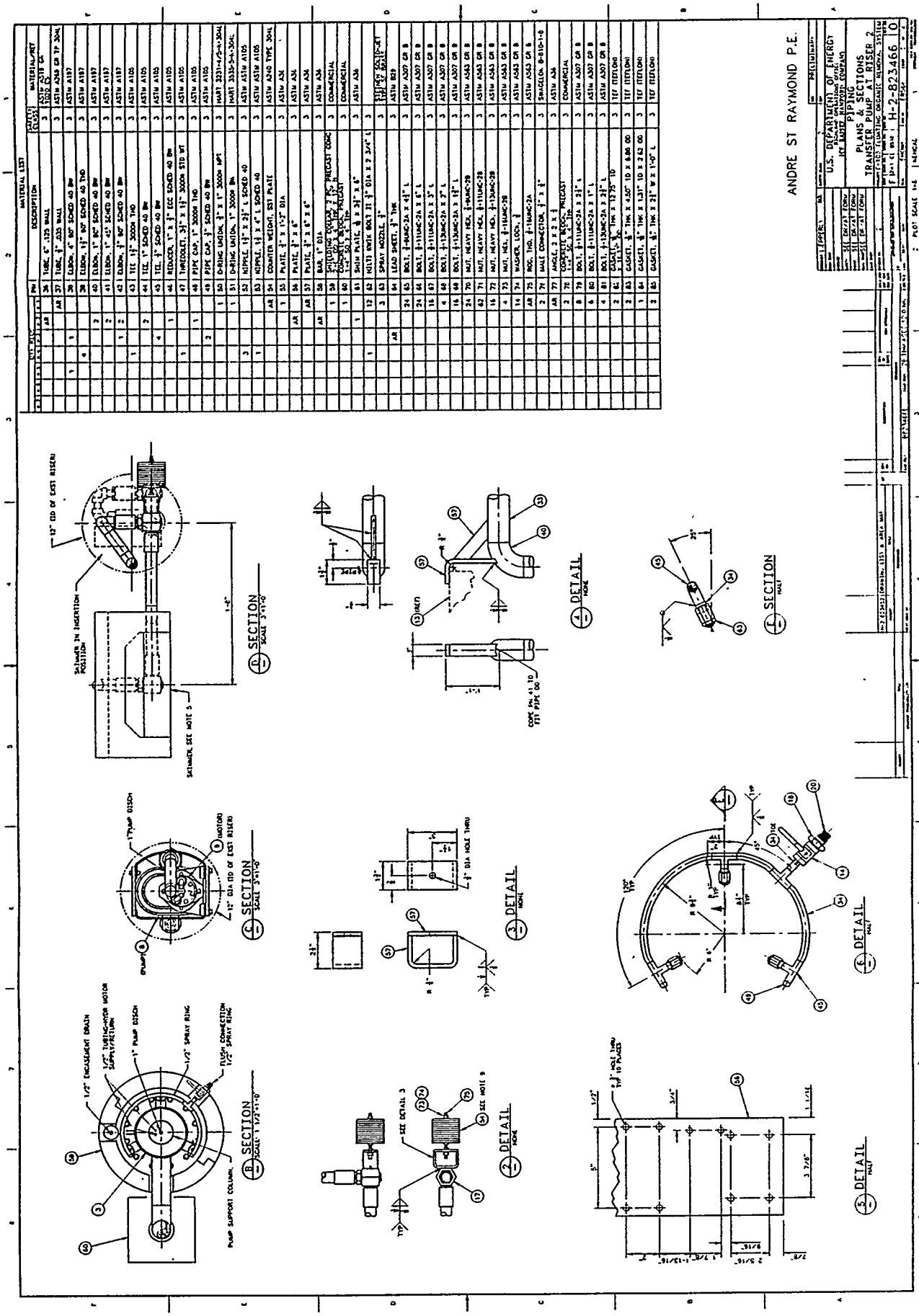
PLAN
SCALE 1 1/2"=1'-0"
INSTALLATION
SCALE 1 1/2"=1'-0"
VIEW
SCALE 1 1/2"=1'-0"
ANDRÉ ST RAYMOND P.E
U.S DEPARTMENT OF ENERGY
RICHLAND OPERATIONS OFFICE
RICHLAND, WASHINGTON
WESTINGHOUSE HANFORD COMPANY
PIPING
PLANS & SECTIONS
TRANSFER PUMP A1 RISER 2
H-2-823466 10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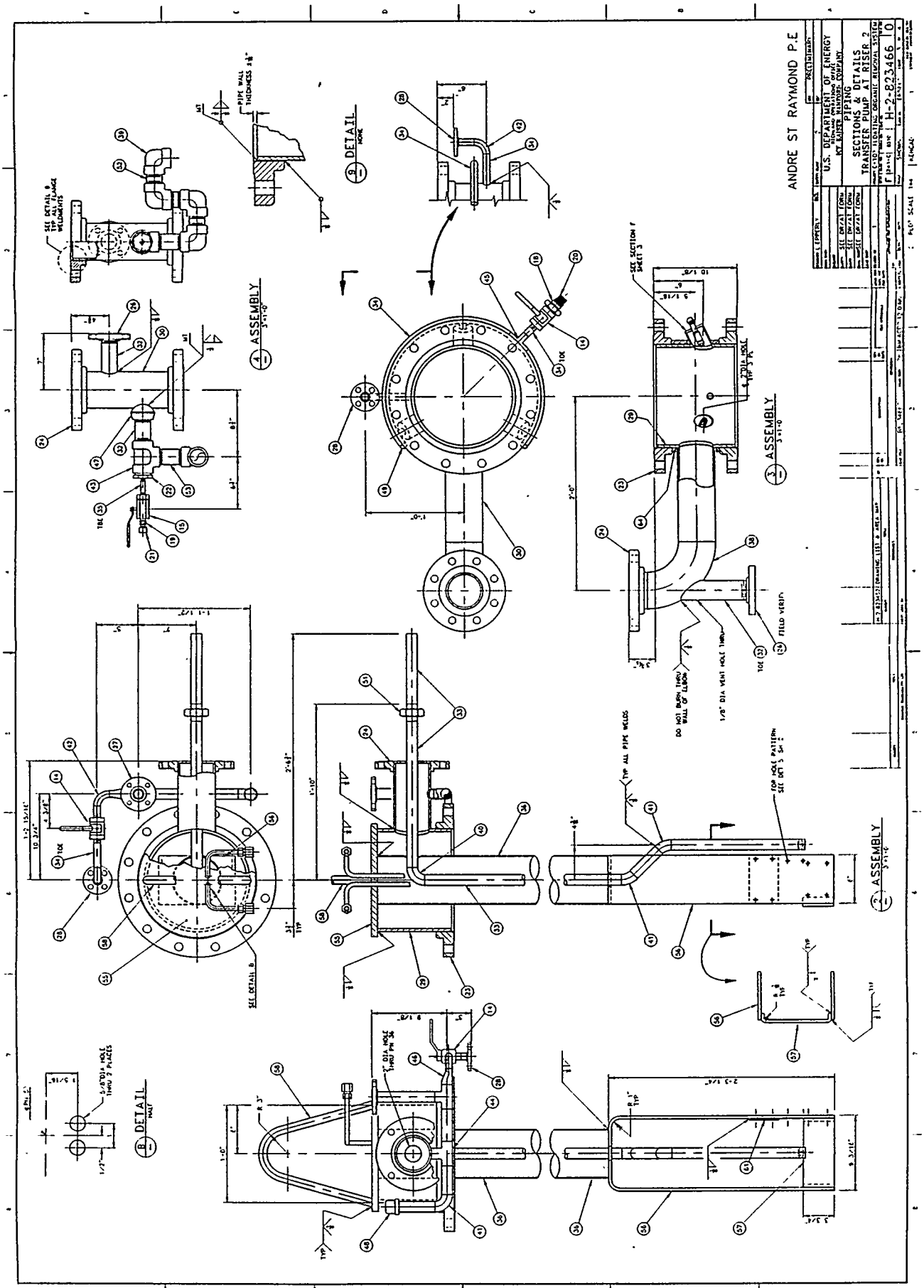
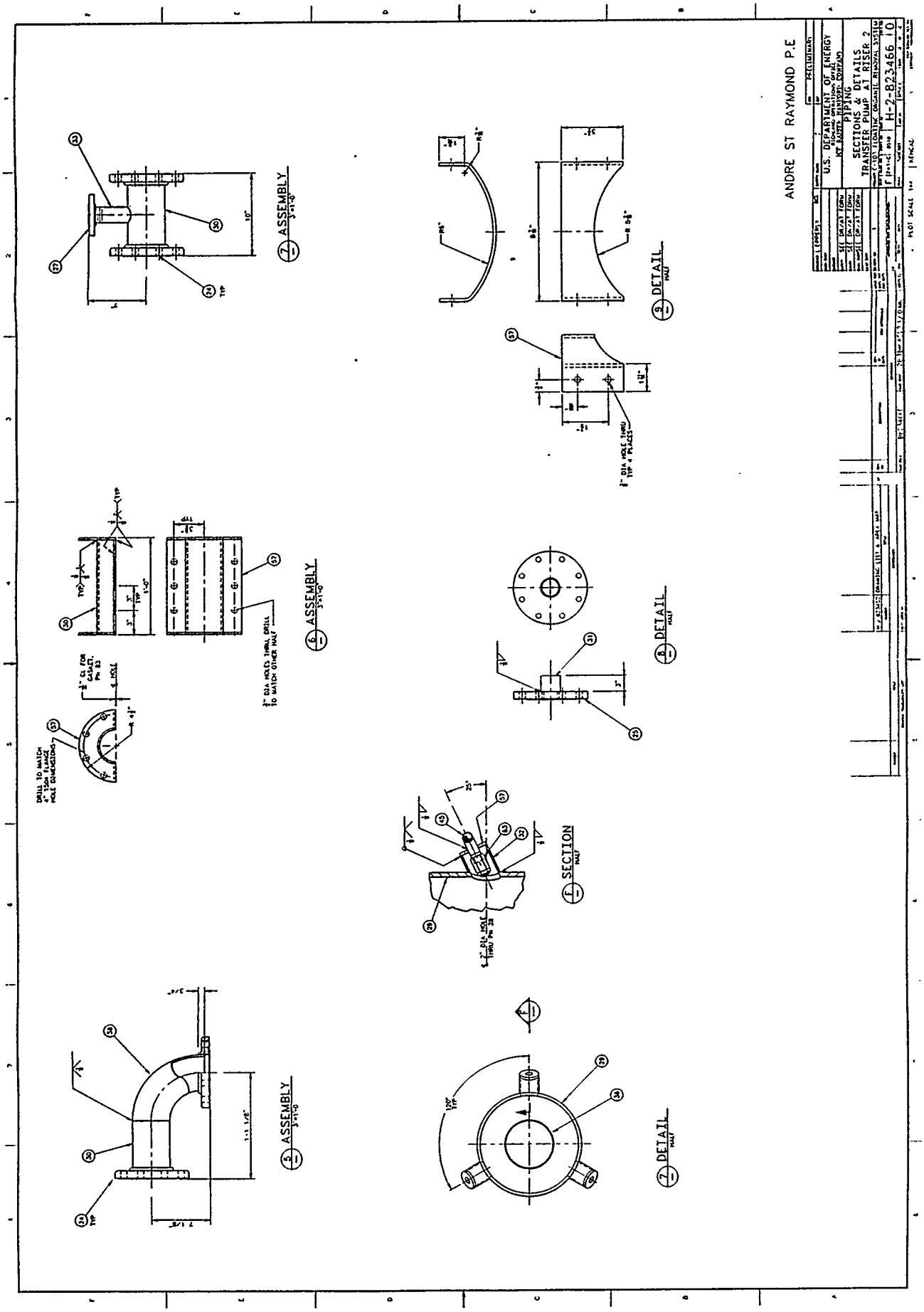
DESCRIPTION
MATERIAL/PART NUMBER
ANDRE ST RAYMOND P.E.
U.S. DEPARTMENT OF ENERGY
PIPING
PLANS & SECTIONS
TRANSFER PUMP A1 RISER 2
H-2-823466
SECTION
DETAIL
PLOT SCALE 1=6


ANDRE ST RAYMOND P.E
U.S. DEPARTMENT OF ENERGY
PIPING
SECTIONS & DETAILS
TRANSFER PUMP AT RISER 2
H-2-823466
DETAIL
ASSEMBLY
SEE DETAIL B
FIELD VERIFY
DO NOT BURN THRU WALL OF ELBOW
1/8" DIA VENT HOLE THRU
TYP ALL PIPE WELDS
FOR HOLE PATTERN SEE DET 5 SH 2
SEE SECTION F SHEET 3
PIPE WALL THICKNESS
SEE DETAIL B TYP ALL FLANGE WELDMENTS
5/8" DIA HOLE THRU 2 PLACES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U.S. DEPARTMENT OF ENERGY
PIPING
SECTIONS & DETAILS
TRANSFER PUMP AT RISER 2
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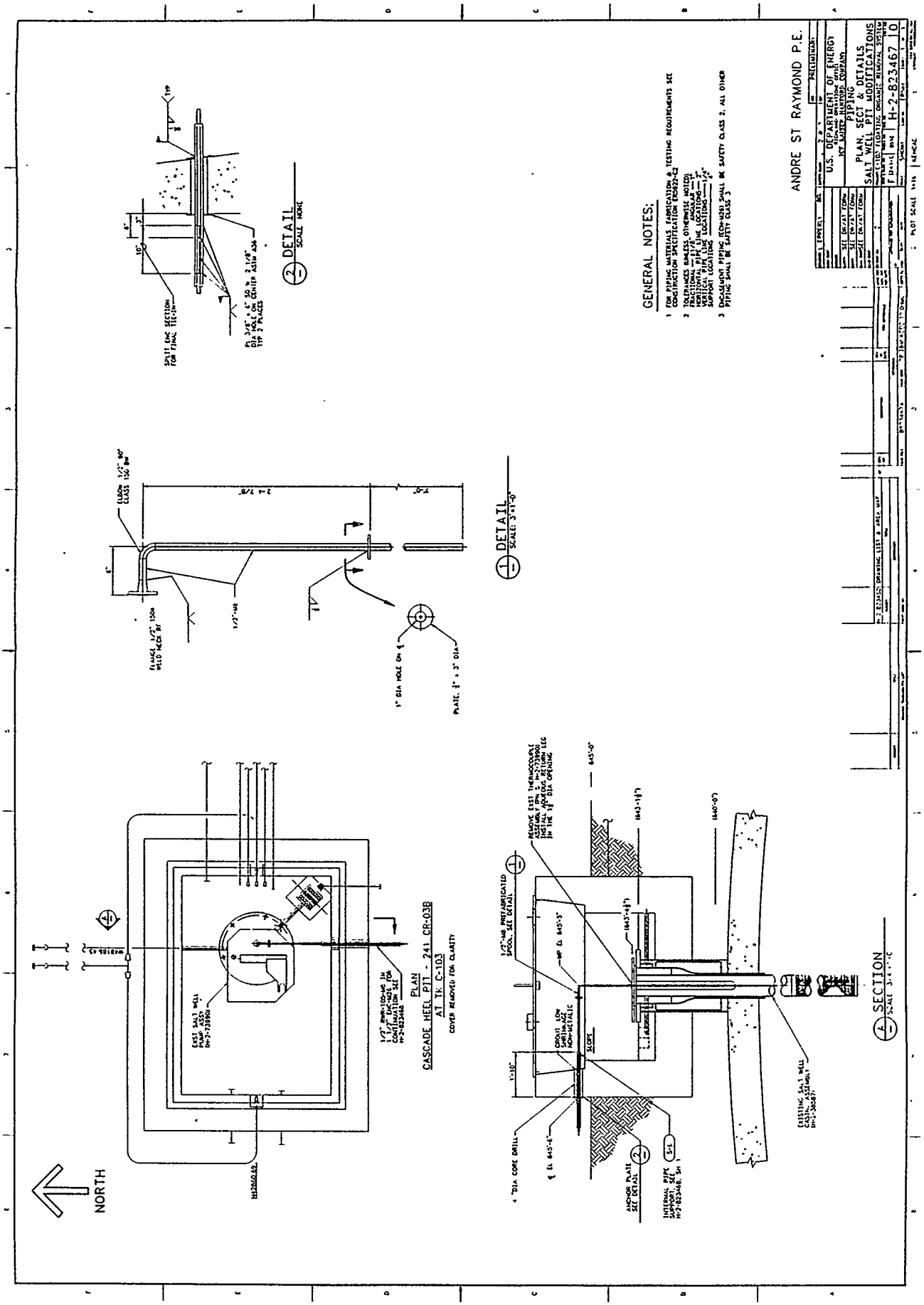
1 ASSEMBLY
2 DETAIL
3 ASSEMBLY
4 ASSEMBLY
5 DETAIL
6 SECTION
7 DETAIL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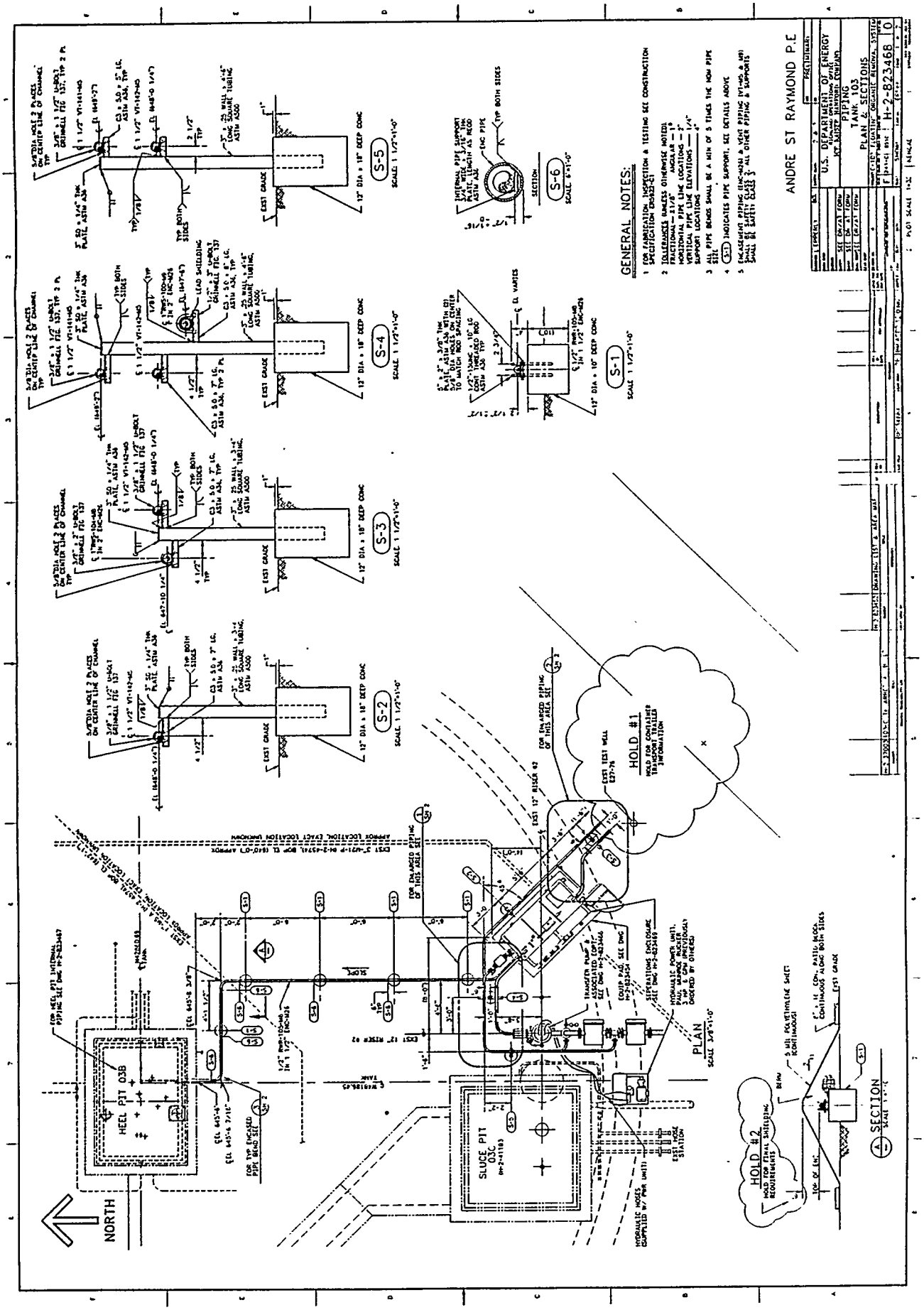
U.S. DEPARTMENT OF ENERGY
PIPING
PLAN, SECT & DETAILS
SALT WELL PIT MODIFICATIONS
H-2-823467
GENERAL NOTES:
DETAIL
SCALE NONE
DETAIL
SCALE: 3"=1'-0"
PLAN
CASCADE HEEL PIT - 241 CR-03B
AT TK C-103
COVER REMOVED FOR CLARITY
SECTION
NORTH


ANDRE ST RAYMOND P.E
U.S. DEPARTMENT OF ENERGY
PIPING
TANK 103
PLAN & SECTIONS
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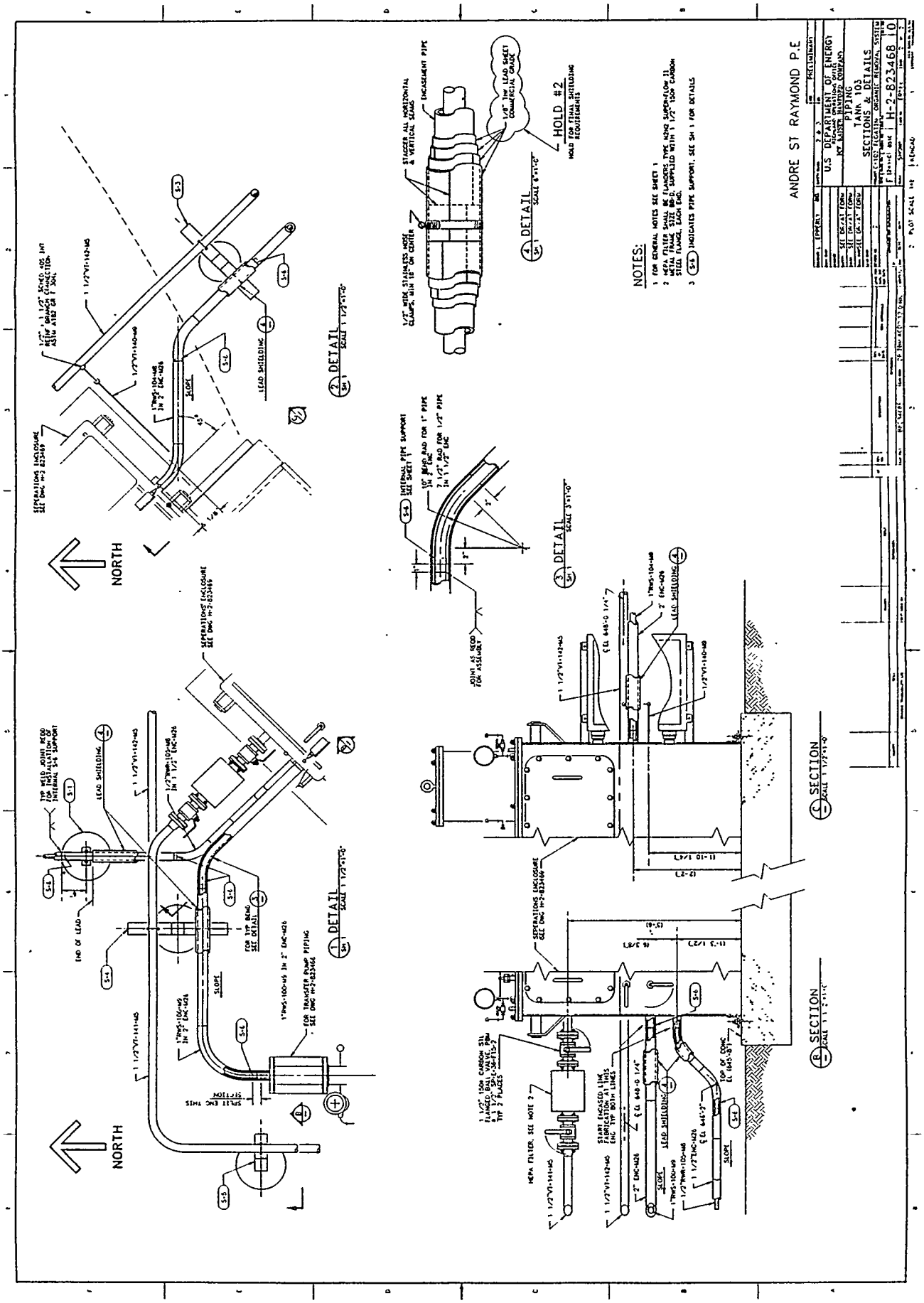
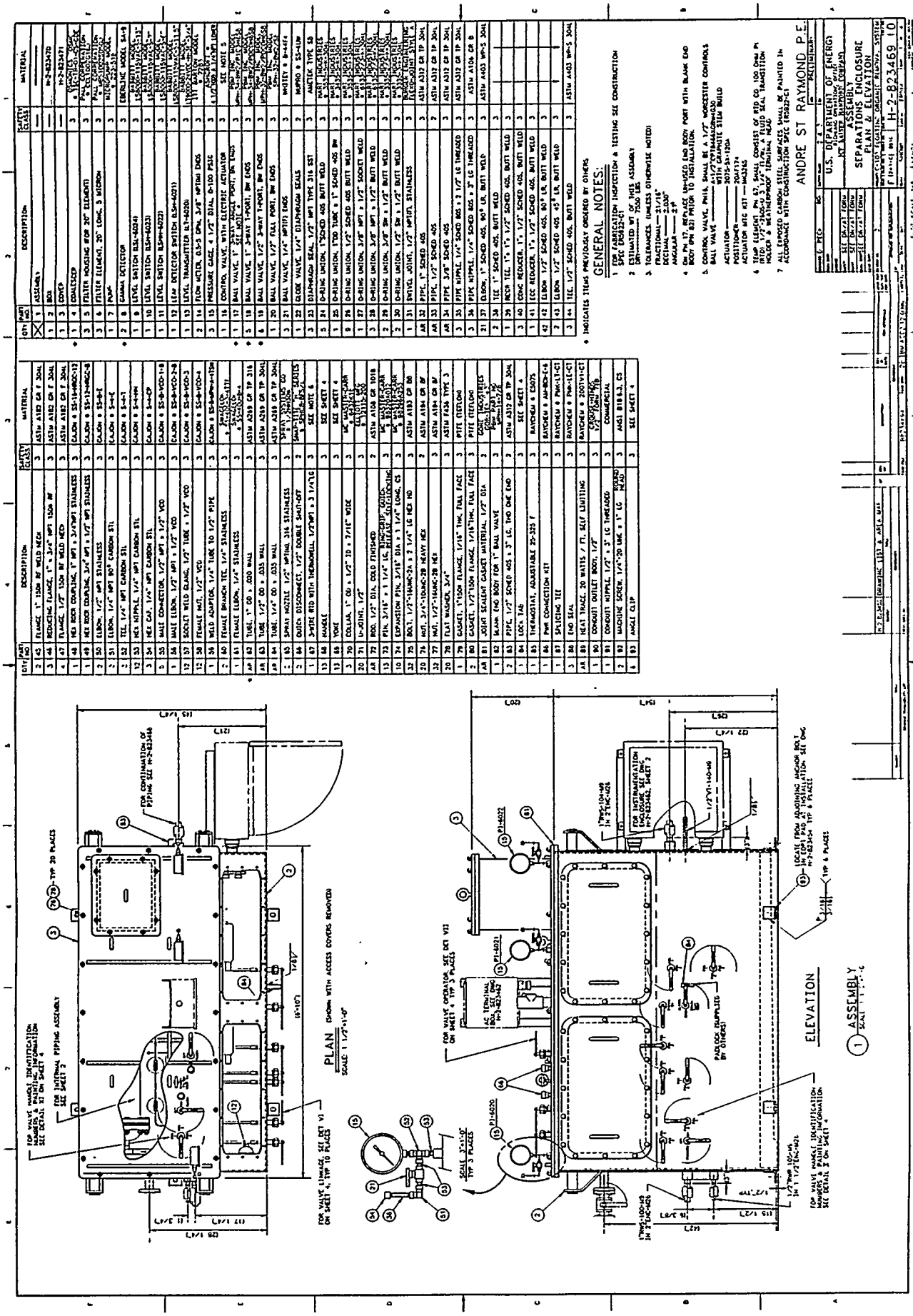
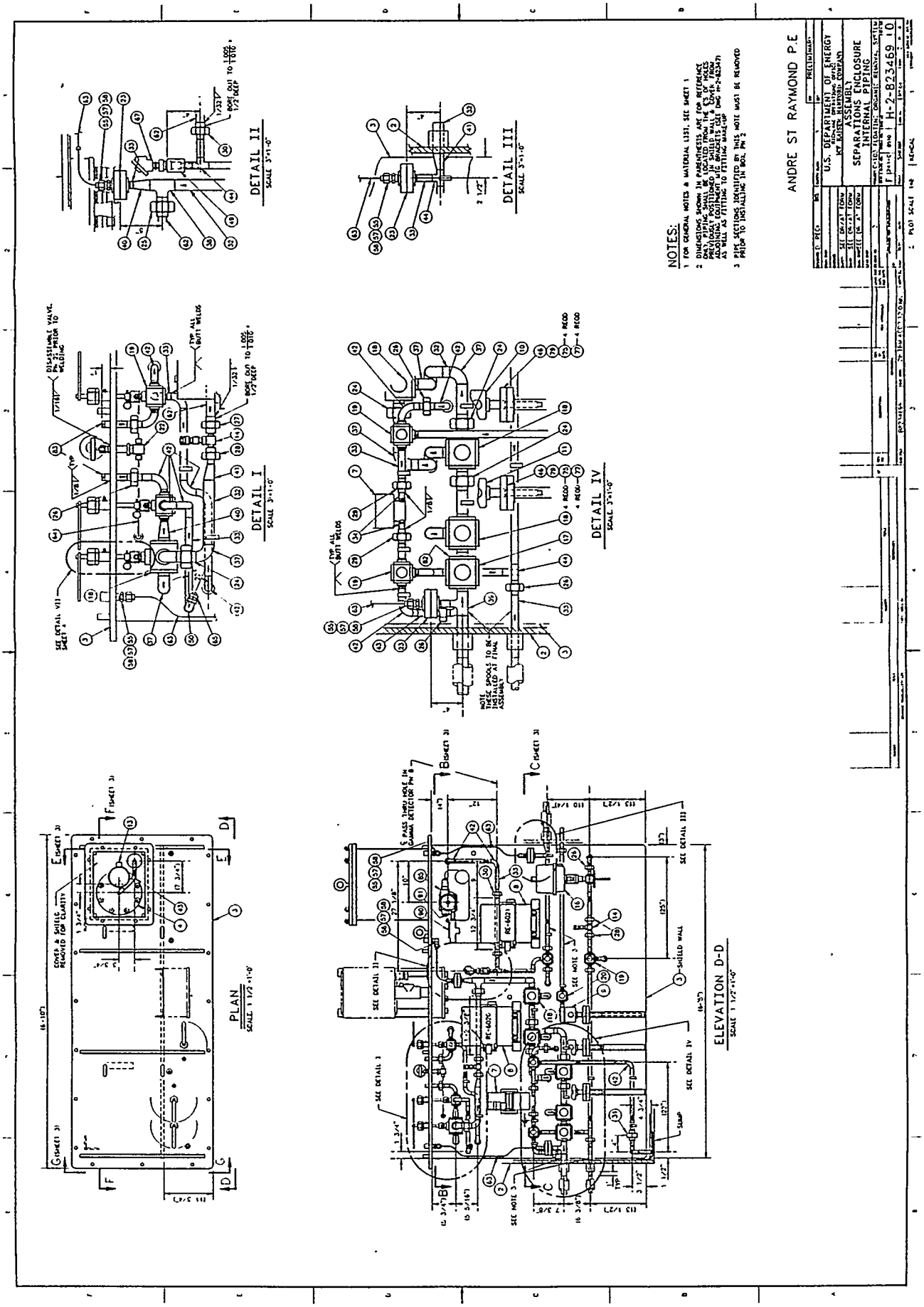
GENERAL NOTES:
S-1
S-2
S-3
S-4
S-5
S-6
HOLD #1
HOLD #2
HEEL PIT 03B
SLUCE PIT 03C
PLAN
SECTION
NORTH


ANDRE ST RAYMOND P.E
U.S DEPARTMENT OF ENERGY
PIPING
TANK 103
SECTIONS & DETAILS
H-2-823468
NOTES:
1 FOR GENERAL NOTES SEE SHEET 1
2 HEPA FILTER SHALL BE FLANGERS TYPE NONE SUPER-FLOW II METAL FRAME SIZE BB-D, SUPPLIED WITH 1 1/2" 150# CARBON STEEL FLANGE, EACH END.
3 S-6 INDICATES PIPE SUPPORT, SEE SH 1 FOR DETAILS
HOLD #2
HOLD FOR FINAL SHIELDING REQUIREMENTS
1/8" THK LEAD SHEET COMMERCIAL GRADE
STAGGER ALL HORIZONTAL & VERTICAL SEAMS
ENCASEMENT PIPE
1/2" WIDE STAINLESS HOSE CLAMPS, MIN 18" ON CENTER
INTERNAL PIPE SUPPORT SEE SHEET 1
JOINT AS REQD FOR ASSEMBLY
SEPERATIONS ENCLOSURE SEE DWG H-2-823469
SEPERATIONS ENCLOSURE SEE DWG H-2-823466
LEAD SHIELDING
END OF LEAD
FOR TYP BEND SEE DETAIL
FOR TRANSFER PUMP PIPING SEE DWG H-2-823466
SPLIT END THIS SECTION
HEPA FILTER, SEE NOTE 2
START ENCASED LINE FABRICATION AT THIS ENC TYP BOTH LINES
TOP OF CONC EL 645-8"
NORTH
NORTH
1 DETAIL
2 DETAIL
3 DETAIL
4 DETAIL
C SECTION
B SECTION




DETAIL II
SCALE 3"=1'-0"
DETAIL III
SCALE 3"=1'-0"
DETAIL I
SCALE 3"=1'-0"
DETAIL IV
SCALE 3"=1'-0"
PLAN
SCALE 1 1/2"=1'-0"
ELEVATION D-D
SCALE 1 1/2"=1'-0"
NOTES:
1 FOR GENERAL NOTES & MATERIAL LIST, SEE SHEET 1
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U.S. DEPARTMENT OF ENERGY
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INTERNAL PIPING
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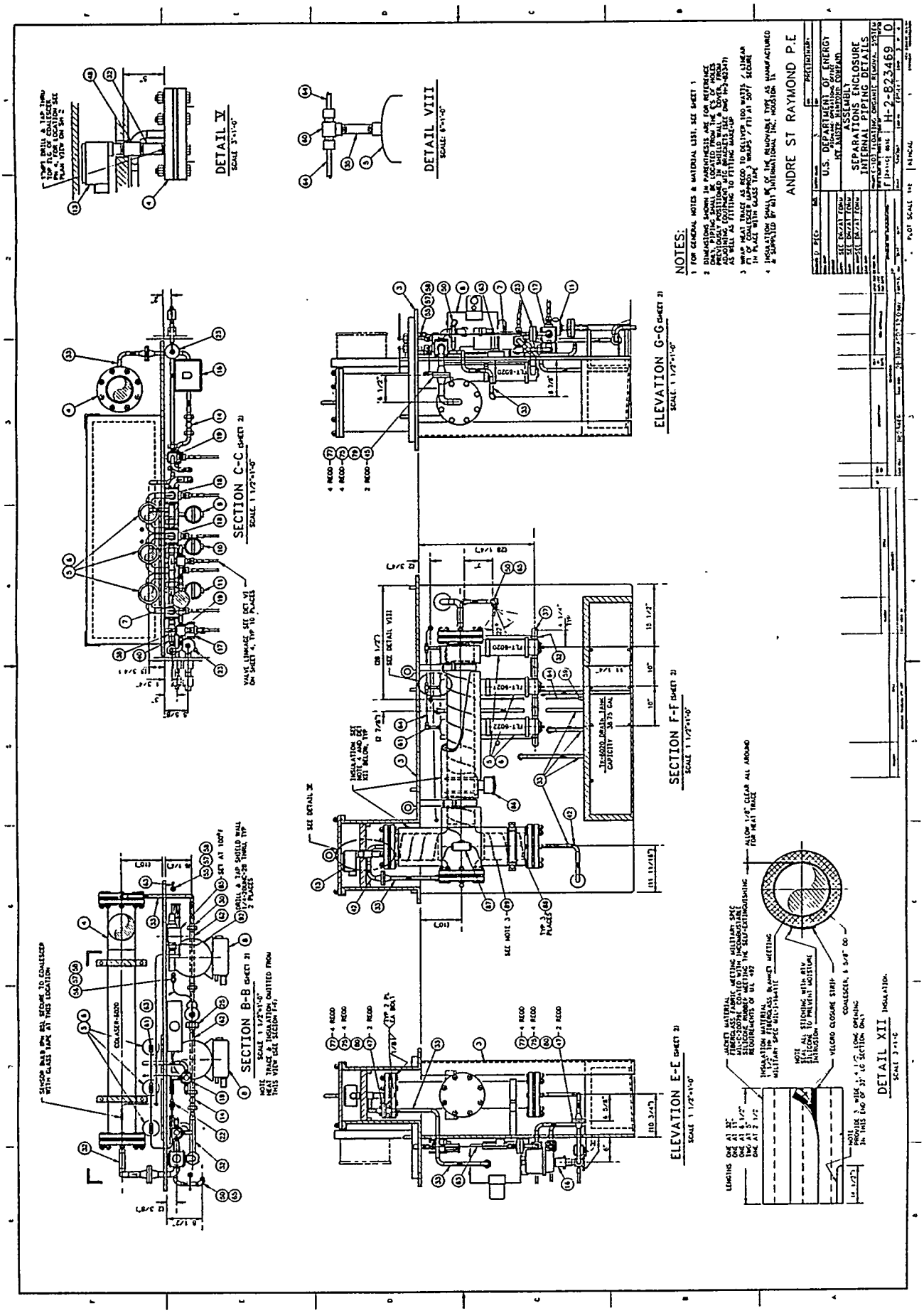
DETAIL V
DETAIL VIII
SECTION C-C
SECTION B-B
ELEVATION G-G
SECTION F-F
ELEVATION E-E
DETAIL XII
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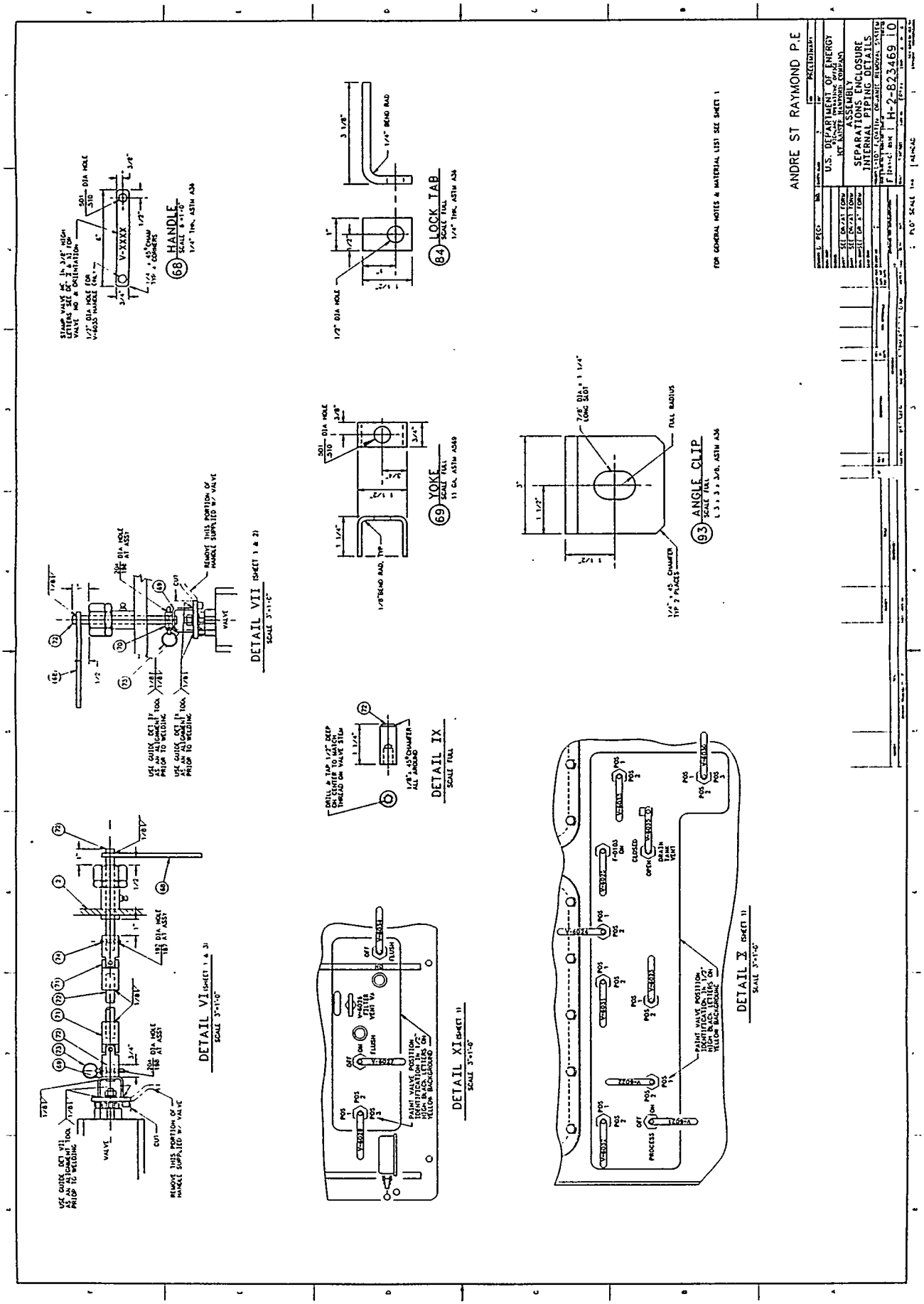
U.S. DEPARTMENT OF ENERGY
SEPARATIONS ENCLOSURE
INTERNAL PIPING DETAILS
H-2-823469


DETAIL VI
DETAIL VII
DETAIL IX
DETAIL XI
DETAIL X
68 HANDLE
84 LOCK TAB
69 YOKE
93 ANGLE CLIP
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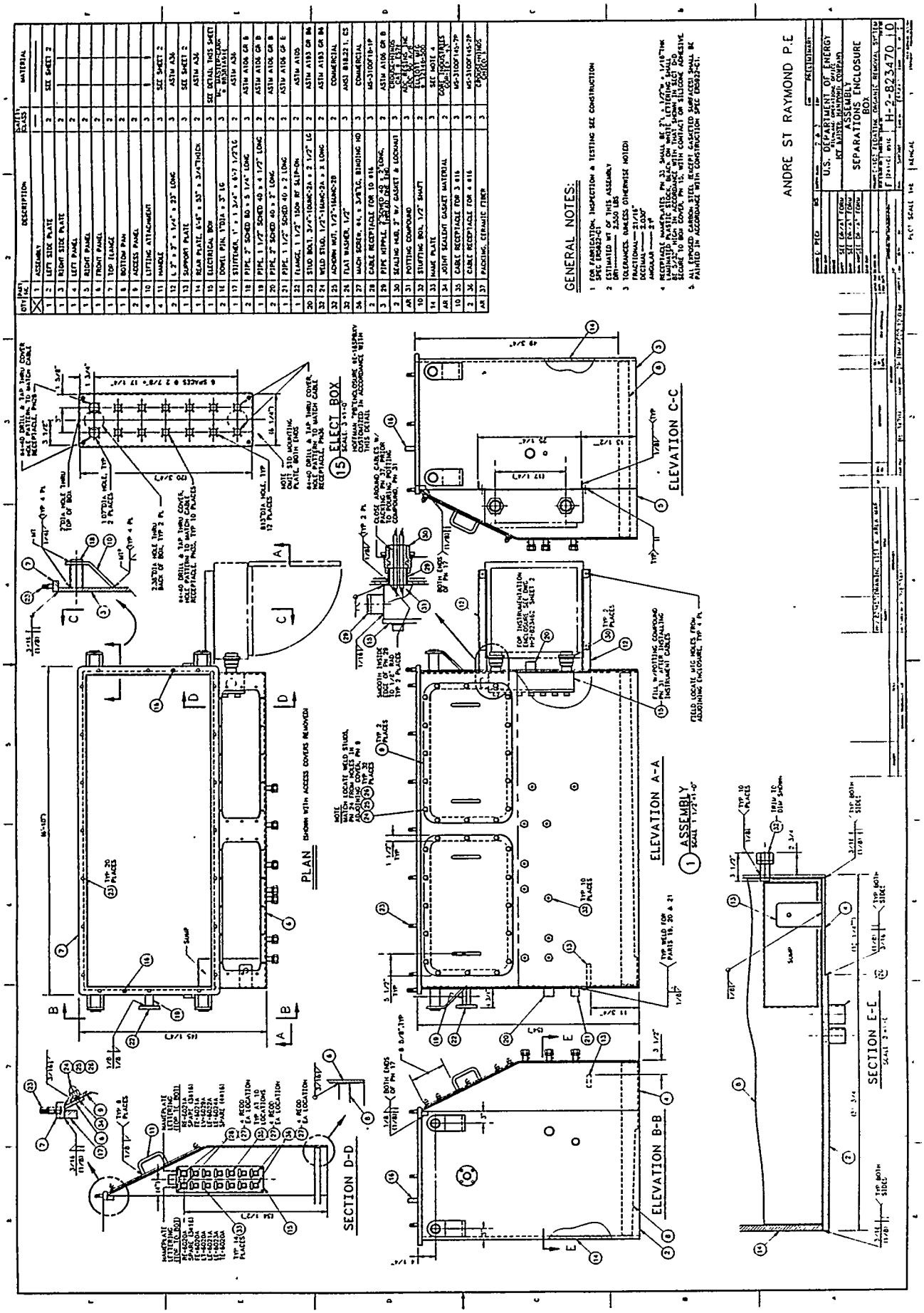
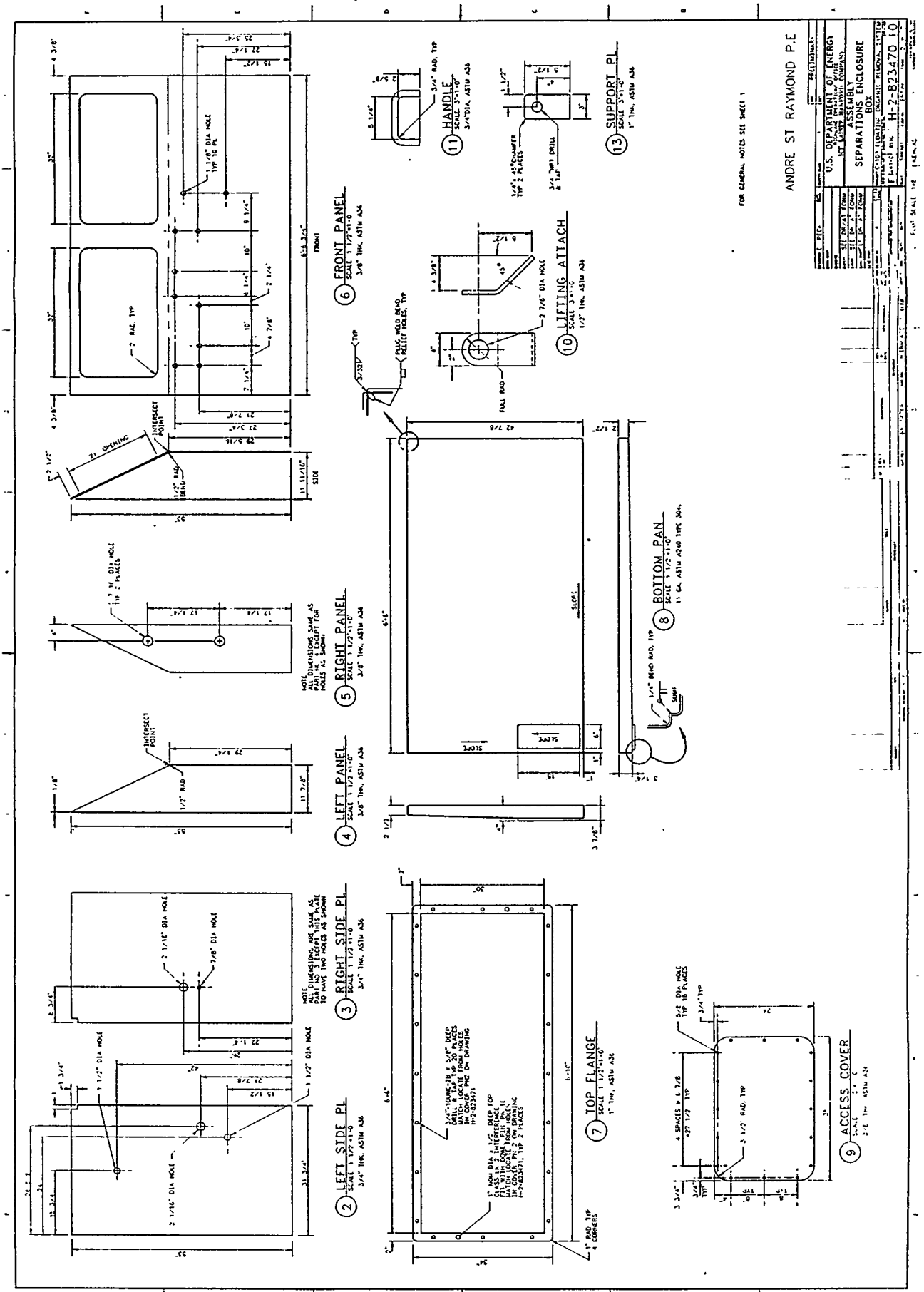
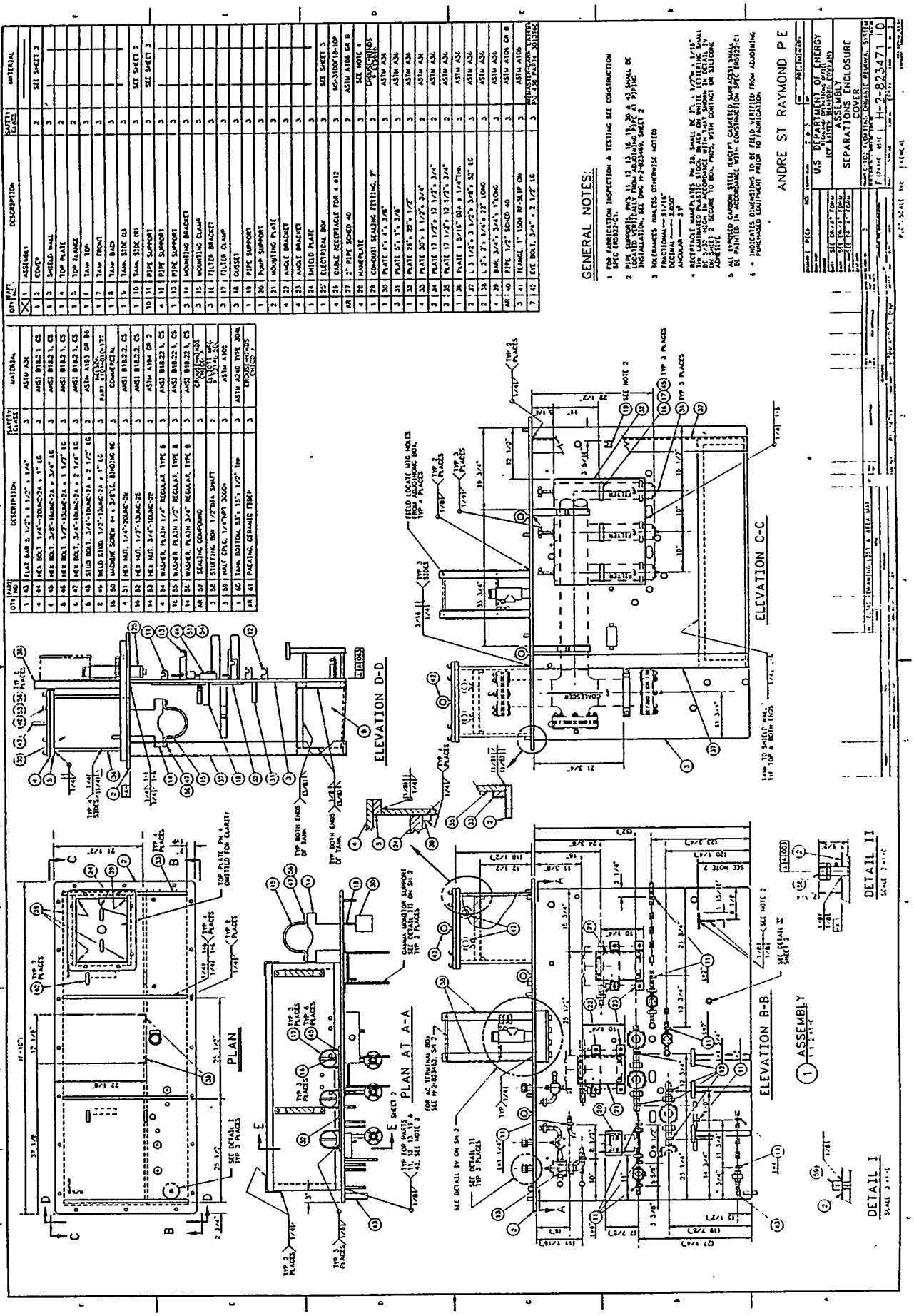
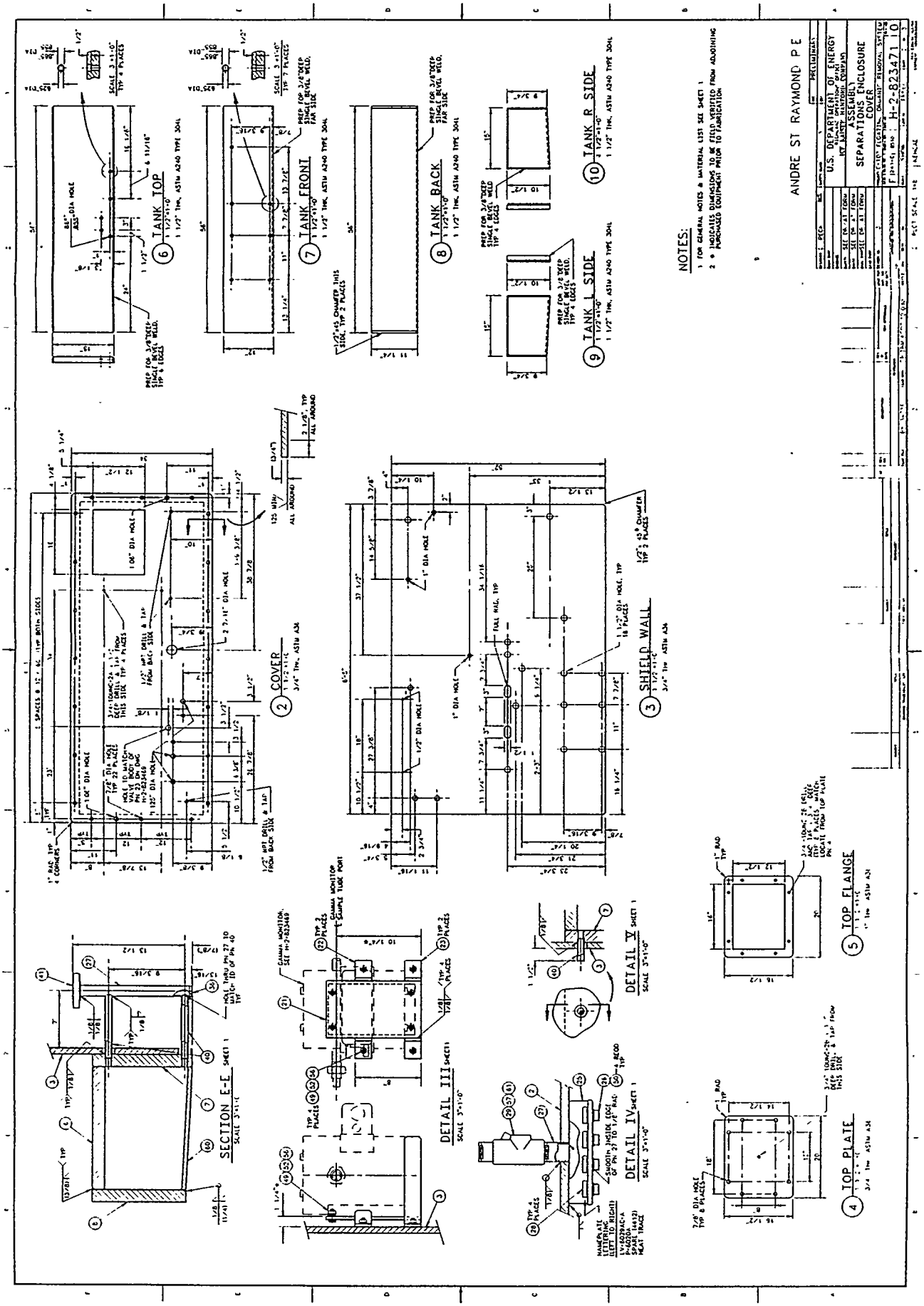
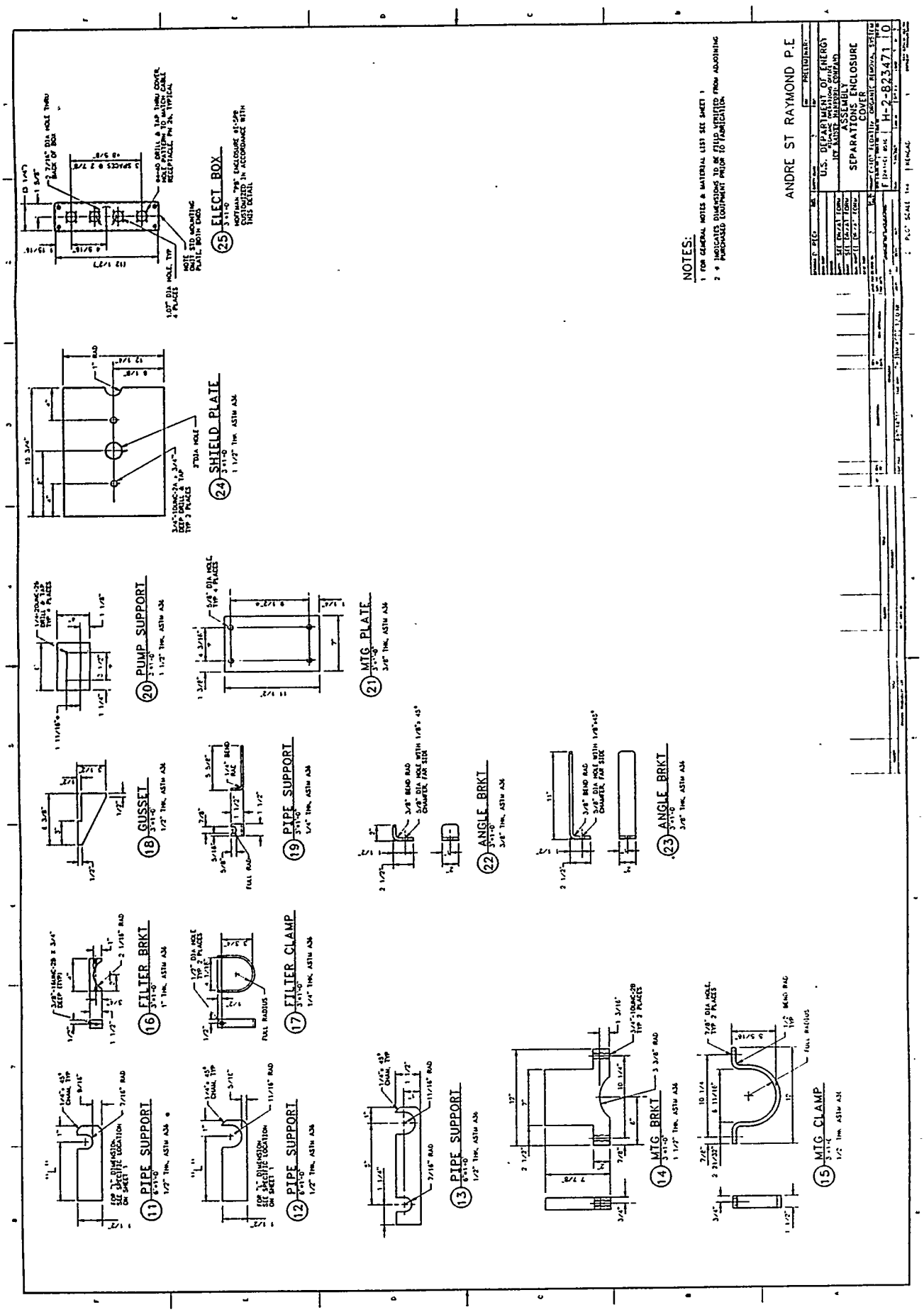
U.S. DEPARTMENT OF ENERGY
SEPARATIONS ENCLOSURE
INTERNAL PIPING DETAILS
H-2-823469 10




ANDRE ST RAYMOND P.E
U.S. DEPARTMENT OF ENERGY
ASSEMBLY
SEPARATIONS ENCLOSURE BOX
H-2-823470 0
FRONT PANEL
RIGHT PANEL
LEFT PANEL
LIFTING ATTACH
HANDLE
SUPPORT PL
BOTTOM PAN
LEFT SIDE PL
RIGHT SIDE PL
TOP FLANGE
ACCESS COVER


GENERAL NOTES:
ELEVATION C-C
ELEVATION D-D
ELEVATION B-B
PLAN
PLAN AT A-A
DETAIL I
DETAIL II
ASSEMBLY
U.S. DEPARTMENT OF ENERGY
ASSEMBLY
SEPARATIONS ENCLOSURE COVER
ANDRE ST RAYMOND P E


6 TANK TOP
7 TANK FRONT
8 TANK BACK
9 TANK L SIDE
10 TANK R SIDE
2 COVER
3 SHIELD WALL
5 TOP FLANGE
4 TOP PLATE
SECTION E-E
DETAIL III
DETAIL IV
DETAIL V
NOTES:
ANDRE ST RAYMOND P E
U.S. DEPARTMENT OF ENERGY
SEPARATIONS ENCLOSURE COVER ASSEMBLY
H-2-823471 10


NOTES:
1 FOR GENERAL NOTES & MATERIAL LIST SEE SHEET 1
2 * INDICATES DIMENSIONS TO BE FIELD VERIFIED FROM ADJOINING PURCHASED EQUIPMENT PRIOR TO FABRICATION
ANDRE ST RAYMOND P.E
U.S. DEPARTMENT OF ENERGY
SEPARATIONS ENCLOSURE COVER
H-2-823471
(25) ELECT BOX
(24) SHIELD PLATE
(20) PUMP SUPPORT
(21) MTG PLATE
(18) GUSSET
(19) PIPE SUPPORT
(22) ANGLE BRKT
(23) ANGLE BRKT
(16) FILTER BRKT
(17) FILTER CLAMP
(11) PIPE SUPPORT
(12) PIPE SUPPORT
(13) PIPE SUPPORT
(14) MTG BRKT
(15) MTG CLAMP

ATTACHMENT
E-1

ENGINEERING TASK PLAN FOR REMOVAL OF THE FLOATING ORGANIC LAYER IN WASTE TANK 241-C-103

June 15, 1994

Authors

R. J. Parazin
P. D. Baughman
C. E. Hanson

WHC-SD-WM-ETP-077
REV. 0

TABLE OF CONTENTS

1.0 INTRODUCTION 2
1.1 OBJECTIVE 2
1.2 SUMMARY DESCRIPTION 2

2.0 SCOPE 5
2.1 ENGINEERING 5
2.2 FACILITIES VERIFICATION 6
2.3 PROCUREMENT 6
2.4 FABRICATION AND CONSTRUCTION 6
2.5 TESTING 7
2.6 EQUIPMENT INSTALLATION 7
2.7 ORGANIC REMOVAL OPERATION 7
2.8 POST ORGANIC REMOVAL TASKS 7
2.9 ORGANIC STORAGE 7
2.10 SHIPMENT AND DISPOSAL 8
2.11 ENVIRONMENTAL AND REGULATORY SUPPORT 8
2.12 WASTE TANK SAFETY SUPPORT 8
2.13 QUALITY ASSURANCE SUPPORT 8

3.0 ORGANIZATIONAL RESPONSIBILITIES AND DELIVERABLES . . . 8
3.1 SPECIAL PROJECTS 8
3.2 CHEMICAL ENGINEERING PROCESS DEVELOPMENT 10
3.3 ICF KAISER DESIGN SERVICES 10
3.4 TEST ENGINEERING 11
3.5 TANK FARM HEALTH PHYSICS SUPPORT 11
3.6 TANK FARMS QUALITY ASSURANCE 12
3.7 WASTE TANK SAFETY ASSURANCE 12
3.8 ENGINEERED PROCESS APPLICATIONS 12
3.9 EAST TANK FARM OPERATIONS 12
3.10 ORGANIC DISPOSAL OPTIONS 13
3.11 MISCELLANEOUS SUPPORT SERVICES 13
3.12 TWRS ENGINEERING SUPPORT 14
3.13 SINGLE-SHELL TANK SAFETY ANALYSIS 14
3.14 TANK FARM MAINTENANCE 14
3.15 FABRICATION SERVICES 15
3.16 QUALITY CONTROL 15

ATTACHMENT 1. SCHEDULE 16

ATTACHMENT 2. COST ESTIMATE 24

WHC-SD-WM-ETP-077
REV. 0

C-103 ORGANIC LAYER REMOVAL, TREATMENT AND DISPOSAL ENGINEERING TASK PLAN

1.0 INTRODUCTION

1.1 OBJECTIVE

This document presents the plan for the removal, treatment and disposal of an approximately 5,000 gallon floating layer of organic found in Tank 241-C-103. It defines the tasks associated with the selection of technical alternatives, regulatory and environmental strategies, and the design, construction, fabrication, acceptance testing, installation, operation and disposal of the equipment necessary for the plan's implementation.

The plan presents detailed descriptions of all essential tasks. All implementing and supporting organizations are identified with specific responsibilities and deliverables. Technical requirements are provided including those which describe design configuration control and verification methods, quality assurance, safety, and regulatory requirements in addition to baseline estimated costs, schedule and assumptions.

In this initial draft of the plan, some selection has been made with respect to technologies and regulatory strategies. The breadth of alternatives would preclude the crafting of a manageable plan without doing so. In most instances this is done with a bias to be inclusive and conservative with respect to needed support. As work progresses and the plan matures, key decisions will be made and the plan will be revised to reflect the narrowing, more selective focus of the mission.

1.2 SUMMARY DESCRIPTION

1.2.1 Background

Since November of 1987, the U.S. Environmental Protection Agency authorized the Washington State Department of Ecology (WDOE) to regulate mixed waste within the state. Under this authorization, the WDOE establishes the operational requirements for the hazardous waste Treatment, Storage and Disposal(TSD) units of which the SSTs are a part. In addition, the WDOE delineates the requirements for obtaining permits for these TSD units. The permitting process requires that the operator specify the requirements for operations, closure and post-closure care for the TSD units. The SSTs have been collected into six TSD operable units.

A TSD units may be granted interim status under the permit process to allow continued operations until a final permit decision is reached. Interim status for these units has been granted to DOE through a Part A permit. All interim status activities for continued operations under the Part A permit are

regulated under WDOE Dangerous Waste Regulations, WAC 173-303 for hazardous chemical constituents in addition to applicable DOE and NRC regulations for radioactive constituents. Authorized under this permit are activities which range from characterization to stabilization and include other activities to mitigate safety concerns (such as limited retrieval) and/or to address unreviewed safety questions (USQ).

An USQ was declared for single-shell tank 241-C-103 on September 21, 1992, due to the presence of a floating organic layer on the waste surface. The safety issue relates to the potential for ignition of the organic material, resulting in an increase in temperature and pressure within the tank, and consequential release of radioactivity to the environment.

The WAC 173-303-395 describes the precautions for dealing with ignitable, reactive or incompatible hazardous waste. The TSD operable unit, 200-PO-3 includes tank 241-C-103. This tank contains an immiscible layer of hazardous organic waste which is both ignitable and incompatible with other tank wastes. This regulation requires the separation of the waste. It also provides a listing of prohibitions to be followed when dealing with such materials. The organic layer is believed to be composed of 30 volume percent NPH and 70 volume percent TBP. The organic layer is estimated to be approximately 2 inches in depth, representing about 5,000 gallons of material in the 75 foot diameter tank.

Removal of the organic from the tank will eliminate the environmental, regulatory and safety concerns and allow the safety issue to be closed. A commitment has been made to the DOE to complete the removal of the organic by March 31, 1995. No commitment has been made for the disposal of the organic.

1.2.2 Mission Description

The ultimate goal of the plan is the disposal of the floating organic layer found in tank C-103. This goal can be broken down into five steps or functions; removal, separation, treatment, storage, and disposal. Removal constitutes the retrieval of the organic layer from the tank and its transfer to downstream functions. Separation addresses the task which may be required to concentrate the organic and whatever aqueous liquid is carried or mixed with organic into separate process streams. Treatment captures the processing which may be necessary to reduce the concentration of radionuclides in the organic stream to acceptable limits to accommodate downstream functions. Storage addresses the need to safely contain or store process streams in the course of the engaging the other functions. Disposal refers to the final disposition of the organic material.

The following is a brief description of the mission built upon a baseline strategy which appears supported by preliminary sample data and present development of the study. Note that the technical alternatives recommended in the final draft of the study could lead to a significantly different strategy. For this draft, the portion of the mission leading to the

satisfactory completion of the March 31, 1995 milestone are more detailed. Subsequent drafts will be more inclusive in all areas.

Retrieval - The organic layer will be pumped from the tank, undergo separation, and with minimal entrained aqueous be transferred to a tank on a lo-boy trailer. The trailer will be located in close proximity to C-103.

The pump will be of positive displacement design capable of transferring organic through double walled, small bore pipe or hose system. The pump will operate at low flows, less than 2 gpm. It will be deployable through an existing riser with minimum facility modifications required. Equipment removal from existing risers and pits will be kept to a minimum. The pumping control system will include master pump controls integrated with pressure and flow indication, and multiple and redundant radiation level indication. Diversion capabilities will also be integrated with the control system such that out-of-specification product is returned to the tank or other acceptable storage.

The pump system will selectively remove the organic phase with minimal aqueous entrainment or mixing. However, the pumped product will undergo separation locally, e.g. within a pit, on a pad, etc., prior to transfer to the storage container because of the likelihood of carryover particularly during operations with a thin organic layer remaining.

Retrieval will be a one step process whereby the pumping activity will be sufficient to achieve an acceptable residual thickness of the organic layer. System flushing and decontamination effluents will be routed to acceptable storage and will not be returned to the tank.

Separation - Separation of the mixed product stream will be performed by a passive coalescer system. Separation will be performed prior to transfer to the storage container. The activity within the separated organic stream will be within limits suitable for on-site transport using existing tanker trailers and handling practices. The separated aqueous stream will be returned directly to the tank's aqueous layer without treatment.

Storage - Temporary storage of the storage container will be integrated with the treatment strategy. Provisions will be made to acceptably store the storage tank and its organic inventory as required. This will entail the development of temporary, modified or new storage sites to satisfy regulatory requirements. Following treatment, sufficient bulk storage capability for the organic will be available for integration with the off-site disposal strategy. Existing storage facilities with minor modification are expected to be satisfactory.

Disposal - The organic will be disposed off-site using a licensed commercial operator. The waste type designation, i.e. hazardous, LLMW, LLW, etc. as shipped from Hanford, will ultimately be determined by the effectiveness of the treatment process selected and the regulatory constraints of the licensed

commercial operator and involved federal and state agencies which govern both waste transport and disposal.

2.0 SCOPE

This section identifies the tasks necessary to perform the organic disposal mission. This plan and all related design and fabrication of related equipment will be per WHC-CM-6-1, EP-2.4 for prototype equipment development. The following sections summarize each task and its relationship to the mission. Deliverables which are derived from or are a product of the task are more specifically described in Section 3.0 in addition to the identification of the responsible organizations, performers and funding source.

The strategy of the plan is such that the technologies employed will be commercially and industrially proven, and adapted as directly as possible to field use. Existing facilities and the balance of plant infrastructure will be used as much as possible. Testing will be performed primarily to select and validate concepts and verify performance in our application. These efforts are not to be construed as a development program. It is a plan focused to achieve the timely removal of the floating organic layer in a manner which is fully integrated with a treatment and disposal strategy.

2.1 ENGINEERING

There are a number of tasks closely related to the selection, validation and implementation of technologies and related equipment and facility design. These are considered here in this section as the core engineering tasks.

2.1.1 Selection of Technical Alternatives There are a variety of technologies and strategies which can be used to accomplish the mission. The basis for selection of the technologies is an Engineering Study, *Removal, Treatment, and Disposal of Floating Organic Layer in Tank 241-C-103* (WHC-SD-WM-ES-293). The study presents a suite of technical alternatives and strategies for performing the mission. The study develops the data necessary to support the alternative analysis and selection of the preferred technologies integrated into a viable mission strategy. The study employs a decision analysis technique which clearly documents the basis for alternative selection and mission strategy.

2.1.2 Product Testing - Technologies and/or equipment identified in the study may require testing to assure suitability for our mission. This testing will be performed on a minimum scale sufficient to evaluate and validate concepts and/or application. It may be performed by a manufacturer or vendor under our direction or by a site contractor in site facilities. Testing of equipment specifically fabricated for mission use is covered in Section 2.7.

2.1.3 Design - The direction derived from the study must be translated into the equipment and facility infrastructure necessary to perform the mission.

This task will provide the specifications, functions and requirements, drawings and other related design media necessary for the purchase, fabrication and assembly of equipment and facility construction/modification.

2.1.4 Design Verification - As an adjunct to the design process and certainly prior to operation, adequate reviews must be performed of the design media, purchase specifications, and other relevant engineering data to assure that design objectives and the overall mission goal is met. The level of review, etc. will be determined through compliance with appropriate Engineering procedures.

2.1.5 Engineering Liaison - Integration of the tasks described in this section will be required to assure that all interfacing activities are executed properly and in a timely manner.

2.2 FACILITIES VERIFICATION

As a support to the selection of technology alternatives identified in Section 2.1.1, it will be necessary to verify the current or "as built" condition of facilities and balance of plant systems considered in the study. It will not be necessary to accomplish this for all alternative strategies considered. However, at some point in the decision-making process, there will be a need for certain critical information. This task will likely include, "facility walk-downs", equipment identification, facility system assessments, and other "hands-on" data needed for design direction or engineering evaluation. Direction for the task will originate during or soon after conclusion of the study.

2.3 PROCUREMENT

Procurement will support the mission in two different areas; Product Testing identified in Section 2.1.2 and Fabrication and Construction identified in Section 2.4. Support to product testing will involve the purchase of sole source items for site testing or the placement of contracts with specified manufacturers to perform the testing. Procurement in support of equipment fabrication and construction will be typical of Capital Work Orders or General Plant Projects or other expense funded activities.

2.4 FABRICATION AND CONSTRUCTION

This task will deliver the assembled equipment and facility additions and modifications needed to perform the mission. It will be based on the design media developed in Section 2.1.3 with implementation typical of Capital Work Orders, General Plant Projects or other expense funded activities. A Plant Forces Work Review will be performed as part of this task to properly assign the work. It is likely that multi-contractor craft forces will be involved in addition to Operations personnel and integration with other ongoing tank farm project activities.

2.5 TESTING

2.5.1 Pre-Operational Testing by Acceptance Test Procedure (ATP) - Performance testing of assembled equipment will be needed to verify that design objectives are met prior to installation. Pre-operational testing of equipment will be performed on-site in suitable test facilities.

2.5.2 Operational Testing by Operational Test Procedure (OTP) Operational testing of installed equipment and systems will be done prior to any operations to verify system performance. No actual waste will be used in this testing activity. This testing will be used in part, as the basis of Acceptance for Beneficial Use (ABU).

2.6 EQUIPMENT INSTALLATION

This task includes all field work necessary in the installation of mission specific equipment. It also may also include the removal of existing equipment. All Job Control System activities will be part of this task. All activities other than OTPs, leading to Acceptance for Beneficial Use will be performed under this activity.

2.7 ORGANIC REMOVAL OPERATION

This task will include all operational activities associated with the actual organic removal, in-process separation, and transfer activities. The task will involve a variety of organizations and multiple facilities. Further definition of this task will be possible following completion of the study.

2.8 POST ORGANIC REMOVAL TASKS

Following completion of removal activities. The equipment, systems and facilities involved in the mission will be dispositioned. This may involve equipment removal and disposal, facility stabilization and/or isolation activities. Integration with future tank farm activities, i.e. stabilization, retrieval, closure, will strongly influence what is done.

2.9 ORGANIC STORAGE

2.9.1 Pre-Treatment Storage - Due to treatment and/or transfer limitations, organic removal may be limited to batch operations. This task encompasses all activities associated with this storage. It may involve the storage or citing of a filled tank and lo-boy trailer, the placement and use of temporary tankage place in existing facilities or the use of tankage in existing facilities. The completed study will define the specific alternative.

2.9.1 Post-Treatment Storage - This task addresses the storage of treated organic prior to disposal. The options available are similar to pretreatment storage however because the organic at this point will carry very low activity

and may not be considered a 'listed' waste, the constraints on storage will not be as limiting.

2.10 SHIPMENT AND DISPOSAL

Following treatment, the organic will be transported off-site to a licensed commercial disposal operation. The method of transport may be by highway trailer or rail. The task includes the preparation and execution of a plan to recognize and satisfy all appropriate transport regulations. The completed study will define a specific alternative.

2.11 ENVIRONMENTAL AND REGULATORY SUPPORT

This task is comprised of the preparation and execution of a plan to recognize and satisfy all appropriate regulatory and compliance requirements. The plan will apply to the entire mission, from initial site activities through organic removal to disposal by an off-site licensed commercial operator.

2.12 WASTE TANK SAFETY SUPPORT

This task provides the necessary safety documentation and overview to support the mission. Typically this constitutes the development and implementation of a plan to provide a safety equipment list, preliminary safety evaluation and safety assessment. The plan will apply to initial site activities through removal to post-treatment storage. Direction for the plan will be better defined following completion of the study.

2.13 QUALITY ASSURANCE SUPPORT

This task provides the necessary quality documentation and overview to support the mission. Typically this constitutes the development and implementation of a plan which provides surveillance, inspection, review, verification and approval of appropriate activities and documents.

3.0 ORGANIZATIONAL RESPONSIBILITIES AND DELIVERABLES

This section delineates the anticipated organizations that are necessary for the successful completion of the 241-C-103 organic layer removal project. Further, organizational responsibilities and deliverables are discussed and outlined.

3.1 SPECIAL PROJECTS

Special Projects is responsible for the following:

- Bob Parazin, on loan from TWRS Process Engineering, is responsible for overseeing the removal, treatment, and disposal of floating organic layer in tank 241-C-103 program to ensure its successful completion.

- Oversee development of a video in C-103 in two phases: One for viewing initial level measurement and one for viewing the organic removal process.

- Development of the ripple generator concept.

- In-tank equipment (skimmer,pump,motor) specification and procurement for testing and final use.

- Elastomer and plastic investigation for compatibility in the C-103 environment. This also includes determining availability of materials.

- Organic level measurement system and follow-up on deployment for initial level measurement and on-line level during pumping of the organic layer for FY 95.

- Provide direction to Chemical Engineering Laboratory to test skimmer, pump, and UT system

- Provide input for preliminary testing of various organic removal technologies.

- A system of over ground transfer lines to transfer the organic waste from C-103 to the storage tank. Special projects is to ensure that all WHC and DOE guidelines and standards are followed.

- A separations enclosure is required to shield the environment and personnel from the following; the coalescer, the filter, the aqueous return to the tank, the sump, and various valves. Special Projects is to ensure the design, procurement and fabrication of this enclosure and to ensure that said enclosure meets or exceeds the standards of WHC and DOE.

- Special projects is responsible for the interim storage facility including the procurement of the tank and the trailer

- A control trailer is needed to monitor the workings of the skimmer operation as well as a place to watch the activity monitors. Special projects is responsible for the procurement of the trailer and to make sure it meets safety standards.

- A general activity monitor is needed to watch the system as a whole as well as a separate monitoring system for Cesium. Special Projects is responsible for designing and procuring these systems.
- A flush system will be needed for the interim storage tank when the organic waste is permanently disposed of. Special projects is responsible for designing and procuring such a system.
- Write all appropriate ATPs and OTPs

_____ Date_____
C.E. Hanson, Manager
Special Projects

3.2 CHEMICAL ENGINEERING PROCESS DEVELOPMENT

The Chemical Engineering laboratory is responsible for the following:

- Testing and evaluation of the coalescer, skimmer, pump, and motor.
- Testing material compatibilities with TBP and NPH simulants
- Serve as the interface with the special activity services (SAS) lab
- Providing reports on the skimmer, pump, material compatibility, and coalescer test results

_____ Date_____
M. J. Schliebe, Manager
Ch.E. Process Development

3.3 ICF KAISER DESIGN SERVICES

The ICF Kaiser Design Services are required to complete the following:

- Provide a preliminary design for the project
- Provide definitive layer design drawings and related information necessary for purchase, fabrication, assembly and installation of all mission equipment necessary for the removal and storage of the organic

- Perform any additional support, as required for the project, under the direction of Robert Parazin, lead engineer.

_____ Date_____
M. W. Manderbach, Project Manager
KEH

3.4 TEST ENGINEERING

Test Engineering will participate in the design, testing, and fabrication efforts of all of the hardware developed for this program. In addition to this support, they will prepare, and obtain approvals on the work plans for all work to be done on C Farm, in support of this program.

_____ Date_____
R. W. Reed, Manager
Test Engineering

3.5 TANK FARM HEALTH PHYSICS SUPPORT

Tank Farm Health Physics is responsible for the following:

- Provide radiological support as a point of contact.
- Prepare or assist in preparation of ALARA Management Worksheets (AMWs) if required.
- Support the installation of the equipment necessary for the removal of the floating organic layer in tank 241-C-103.
- Assist in preparation of the ALARA design review and coordinate reviews with the ALARA chairman if required.
- Review training, operating, and maintenance procedures as required.

_____ Date_____
D. L. Kelly, Manager
East Tank Farms Health Physics

3.6 TANK FARMS QUALITY ASSURANCE

Tank Farms Quality Assurance shall provide oversight support to ensure that the plans and procedures are adequate for the completion of a quality product that meets or exceeds the requirements set forth by the DOE and WHC.

_____ Date_____

D. C. Board, Manager
Quality Assurance

3.7 WASTE TANK SAFETY ASSURANCE

Waste Tank Safety Assurance shall ensure that the facility and equipment are adequate to meet with the safety guidelines of the DOE and WHC.

_____ Date_____

M.N. Islam, Manager
Waste Tank Safety Assurance

3.8 ENGINEERED PROCESS APPLICATIONS

Engineering Process Applications shall integrate all regulatory functions associated with the removal of the organic waste and provide any additional environmental assessment studies that are required.

_____ Date_____

J. A. Hunter
Manager, Engineered Process Applications

3.9 EAST TANK FARM OPERATIONS

East tank farms operations will be responsible for the following:

- Perform an ATP in the field
- Operation of the equipment to perform the removal of the organic layer

- Perform an integrated system test
- Check to see that all equipment is functional after fabrication
- Prepare and/or review training, operating, and maintenance procedures as required.

_____ Date_____

R. Ni, Manager
East Tank Farms Operations

3.10 ORGANIC DISPOSAL OPTIONS

Waste Tank Process Control is responsible for disposal alternatives following the organic waste removal.

_____ Date_____

N. W. Kirch, Manager
Waste Tank Process Control

3.11 MISCELLANEOUS SUPPORT SERVICES

Pacific Northwest Laboratories (PNL) will conduct a series of low temperature precipitation tests.

Scientific Application International Corporation (SAIC) is responsible for the following:

- Developing a risk benefit study (task order 36)
- Procedure development support (task order 36)
- Safety analysis support (task order 36)
- Ion exchange technical report for organic treatment (task order 24)

_____ _____ Date_____

K. H. Pool, Manager
PNL

M. M. Beary, Manager
SAIC

3.12 TWRS ENGINEERING SUPPORT

TWRS Engineering Support is accountable for coming up with a plan for disposal of the organic waste and any equipment and resources used during the removal, including (if necessary) packaging and shipping of those items.

_____ Date_____

R. K. Brown, Manager
TWRS Engineering Support

3.13 SINGLE-SHELL TANK SAFETY ANALYSIS

The single-shell tank safety analysis will meet the following criteria:

- An initial safety evaluation
- Performing an unresolved safety question (USQ) screening
- Writing the hazard class document
- Safety equipment list

_____ Date_____

Gary Smith, Manager
TWRS Safety Analysis Report applications

3.14 TANK FARM MAINTENANCE

Tank farm maintenance is responsible for preparing, and obtaining approval for the work package(s) needed to ensure the successful installation of the organic layer removal system.

_____ Date_____

K.W. Leliefeld, Manager
Tank Farm Maintenance

3.15 FABRICATION SERVICES

Fabrication services is responsible for overseeing the fabrication of all the necessary items for this program.

_____ Date_____

D. G. Hay, Manager
Fabrication Services

3.16 QUALITY CONTROL

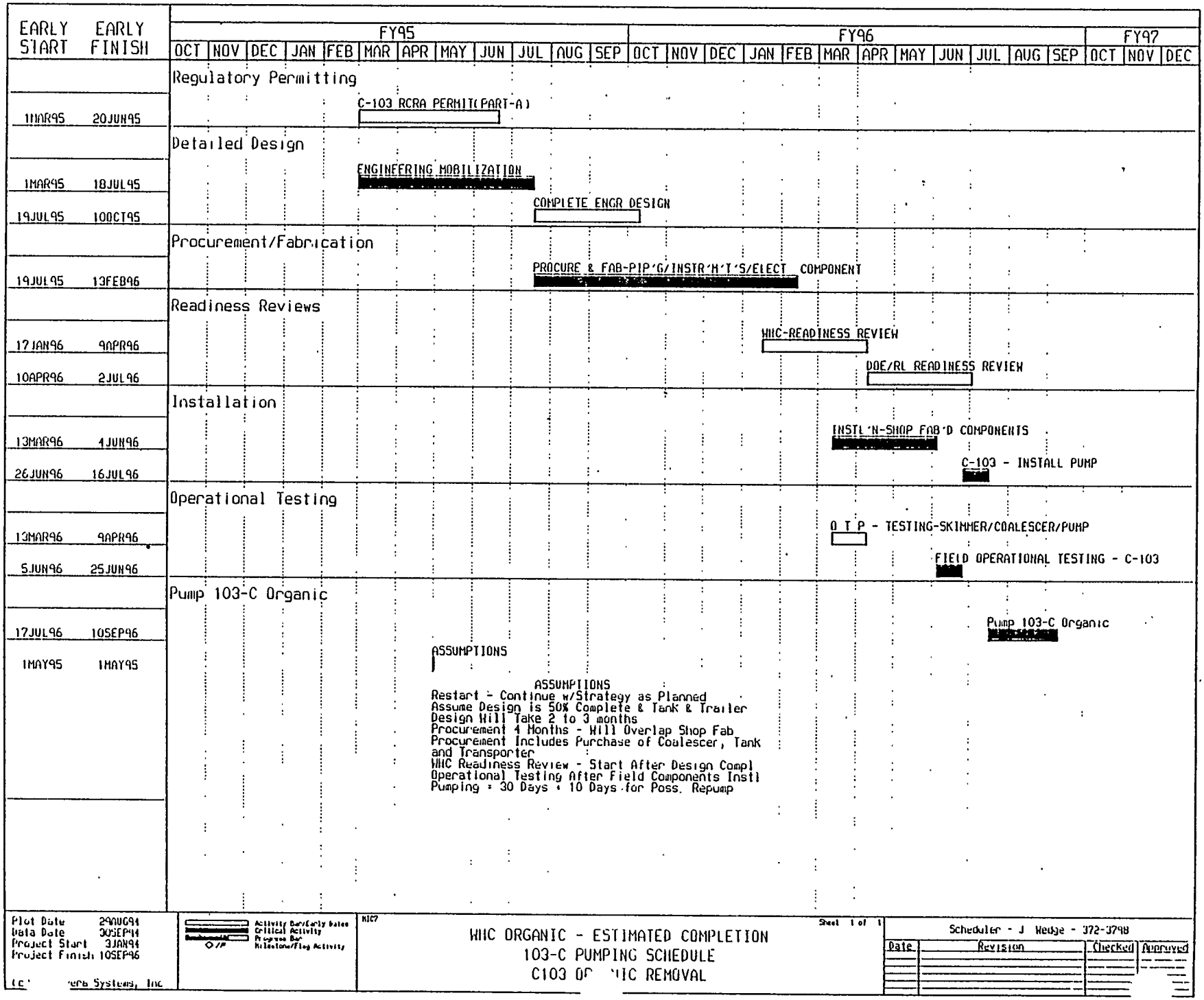
Fabrication quality control is responsible for performing all necessary quality control overview on the fabricated items produced for this program.

_____ Date_____

S. W. Scott, Manager
Quality Control

WHC-SD-WM-ETP-077
REV. 0

ATTACHMENT 1. SCHEDULE



E-1-10

WHC-SD-WM-PLN-092
REV 0

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902	14MAR95	20MAR95	5	0	WHC **
950	24JAN95	8MAY95	75	0	**
951	24JAN95	1MAY95	70	0	WHC **
952	2MAY95	8MAY95	5	0	WHC **
201	25APR91A	6MAY91A	0	100	KEH
202		31MAY91A	0	100	KEH/PHL
203	27MAY91A	12AUG91	0	99	WHC/KEH/PH
500	13JUN91A	18NOV91	70	39	KEH**PART
501	13JUN91A	17AUG91	3	95	KEH
502	10JUL91A	25AUG91	9	75	KEH
504	13JUN91A	25AUG91	9	75	KEH
506	1AUG91A	21SEP91	28	20	KEH **
507	18JUN91A	29SEP91	34	50	KEH**PART
521	10JAN95	20FEB95	30	0	KEH **
524	15AUG91	25SEP91	15	0	LARRY D **
530	15JUN91A	9SEP91	20	35	** PART.
100	23MAR91A		0	100	
101	23MAR91A	29APR91A	0	100	PHL
105	23MAR91A	29APR91A	0	100	PHL
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126	22AUG91	9SEP91	15	0	KIM **
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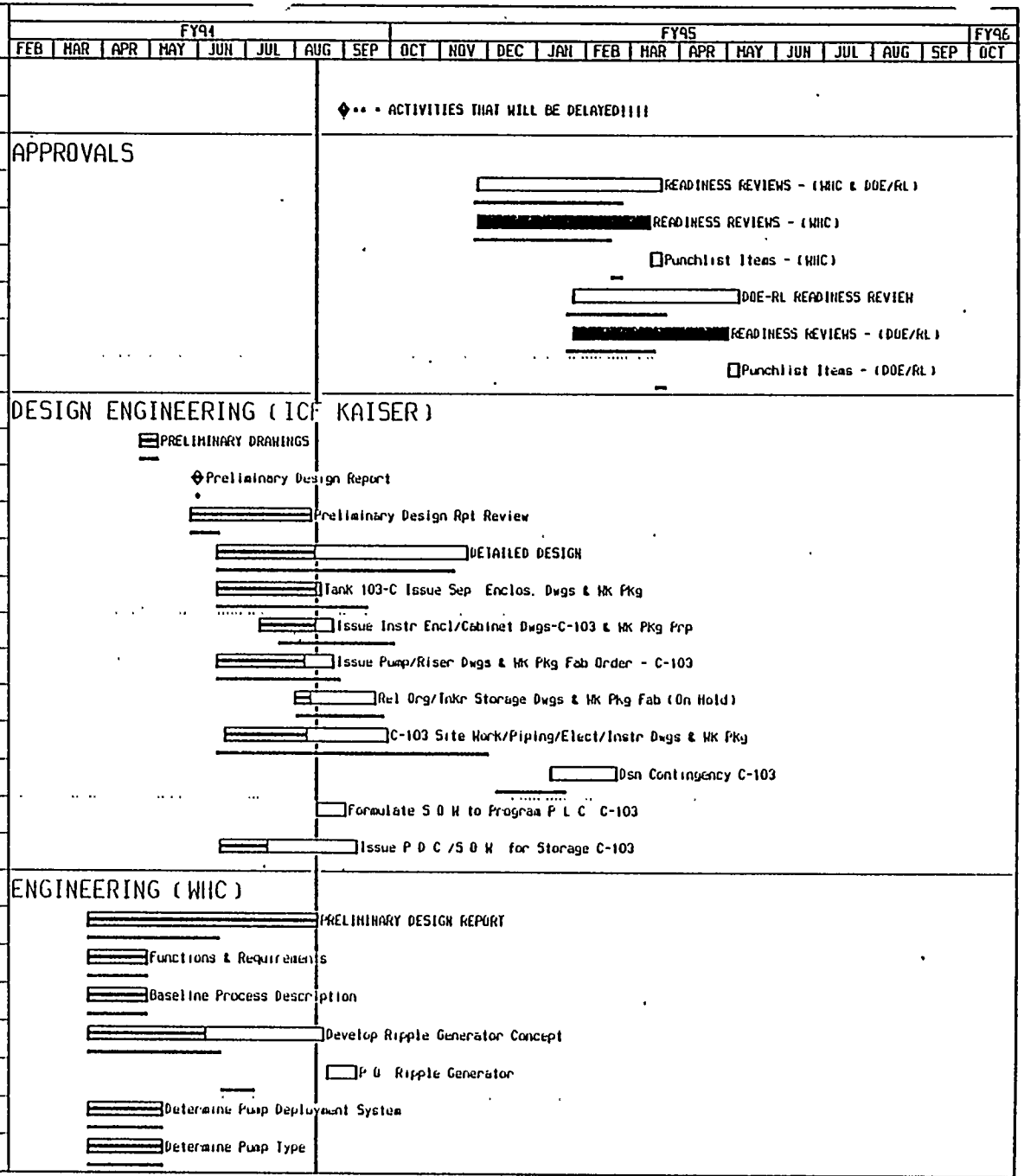
131	23MAR91A	9MAY91A	0	100	KIM



C-103 ORGANIC REMOVAL SCHEDULE
C-103 PUMPING SCHEDULE
C-103 ORGANIC REMOVAL - TOTAL SORT

E-1-19

WHC-SD-WM-PLN-092
REV 0

ACTIVITY ID	EARLY START	EARLY FINISH	REM DUR	PCT	RESPONSIBLE
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141	28MAR94A	10JUN94A	0	100	TOM
142		15JUL94A	0	100	WHC TEAM
145	25MAR94A	9MAY94A	0	100	TOM
150	28MAR94A	9MAY94A	0	100	TOM
151	1APR94A	9MAY94A	0	100	TOM/KEH
155	25MAR94A	2MAY94A	0	100	LARRY
156	25MAR94A	3MAY94A	0	100	LARRY
157	25MAR94A	3MAY94A	0	100	LARRY
160	28MAR94A	8APR94A	0	100	BOB/KIM
161	3JUN94A	17AUG94	3	85	KYLE H/KIM
162	25AUG94	7SEP94	10	0	KIM/KYLE H
164	15DEC94	27JAN95	30	0	KIM **
167	3JUN94A	24AUG94	8	60	KYLE H
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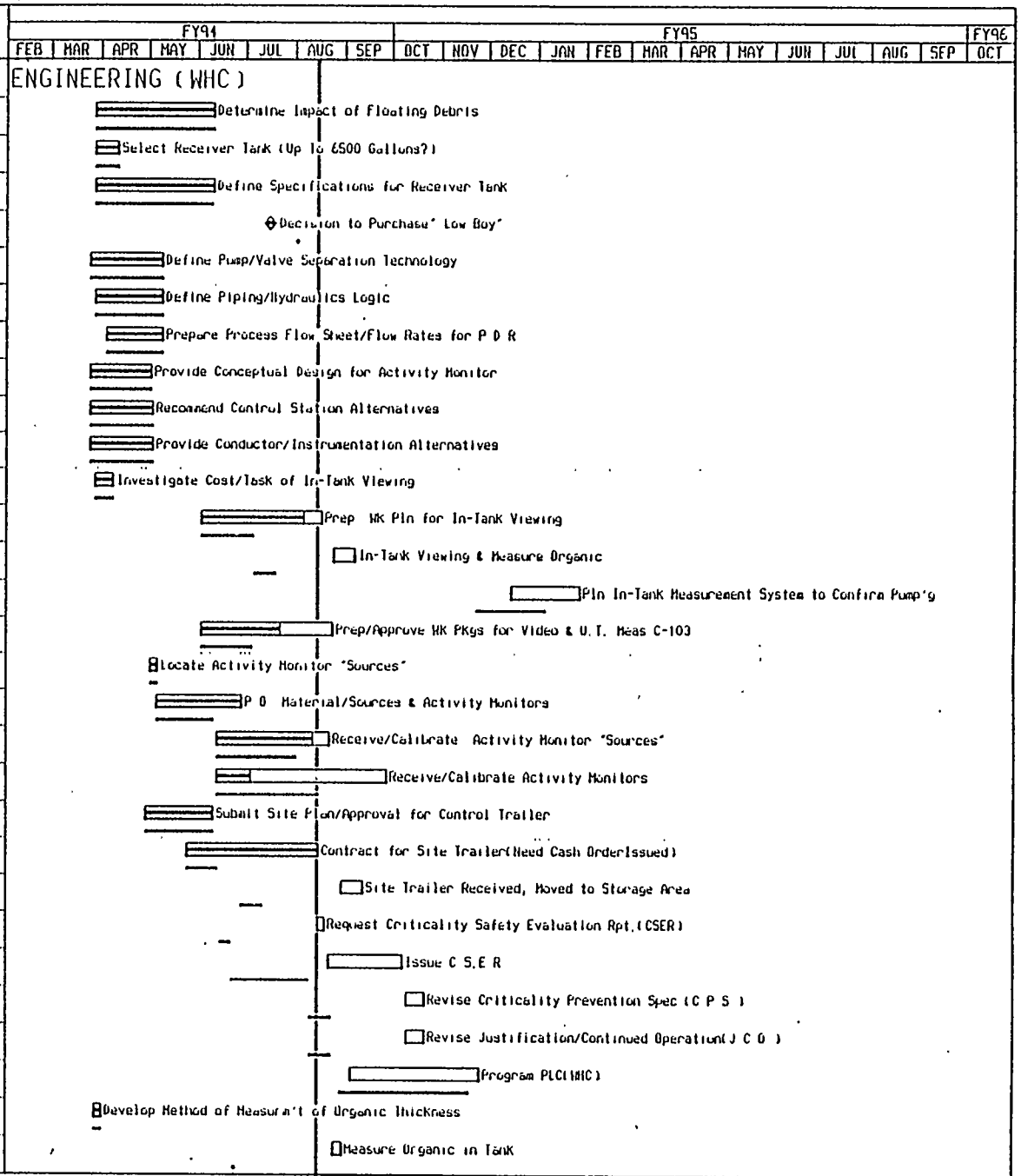
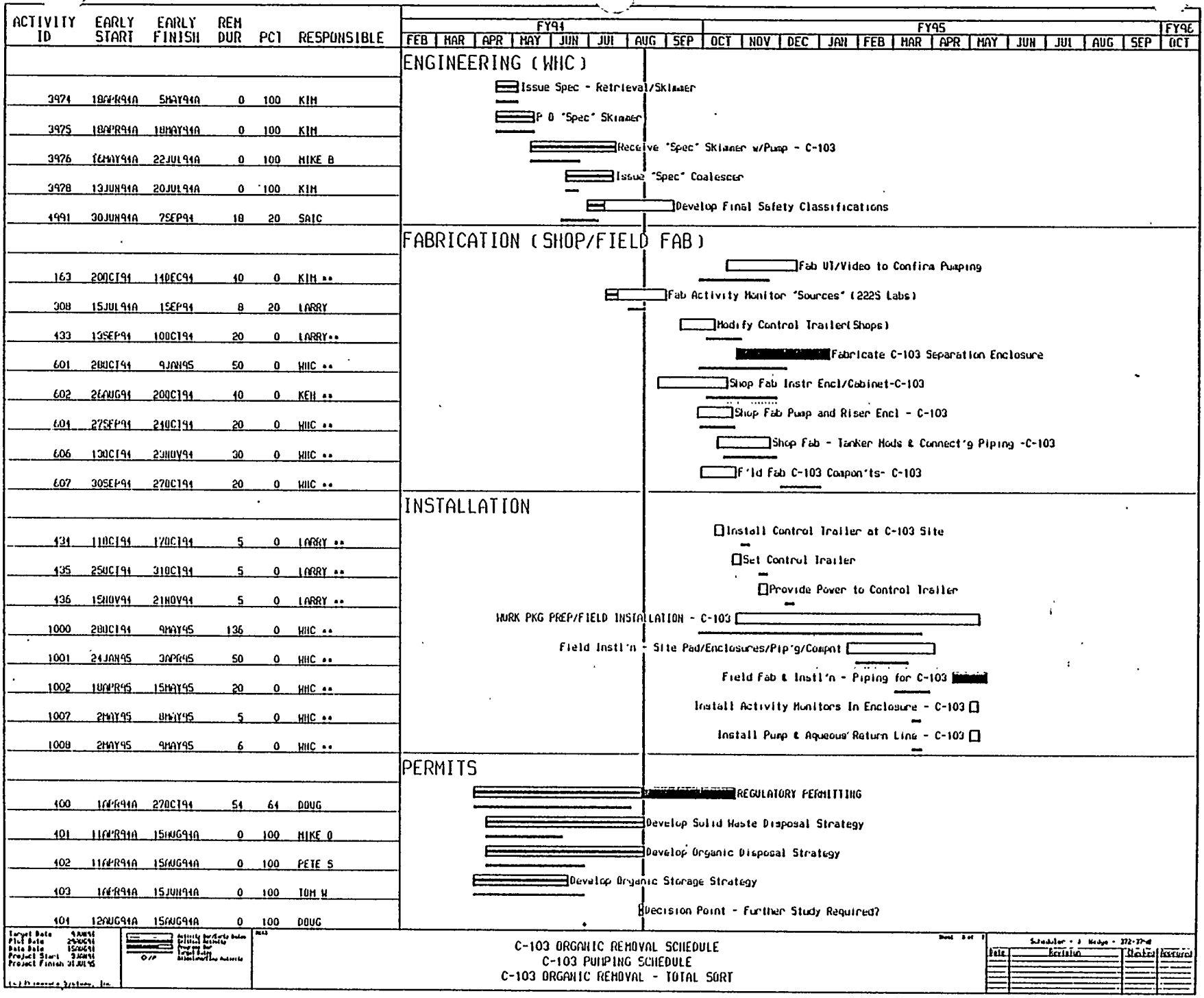
431	25MAY94A	15AUG94A	0	100	LARRY
432	30AUG94	12SEP94	10	0	LARRY*PART
110	15AUG94	19AUG94	5	0	T VAIL **
111	22AUG94	70CT94	35	0	T VAIL **
442	10OCT94	21OCT94	10	0	KELLY/PT**
443	10OCT94	21OCT94	10	0	**
525	5SEP94	25NOV94	60	0	LARRY/PT**
3191	28MAR94A	1APR94A	0	100	BOB/GARY
3193	25AUG94	30AUG94	4	0	KIM



C-103 ORGANIC REMOVAL SCHEDULE
C-103 PUMPING SCHEDULE
C-103 ORGANIC [illegible]VAL - TOTAL SORT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EARLY FINISH
REM DUR
PCT
RESPONSIBLE
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4991 30JUN94A 7SEP94 18 20 SAIC
163 20OCT94 14DEC94 40 0 KIM **
308 15JUL94A 15SEP94 8 20 LARRY
433 13SEP94 10OCT94 20 0 LARRY**
601 28OCT94 9JAN95 50 0 WHC **
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101 11APR94A 15AUG94A 0 100 MIKE O
102 11APR94A 15AUG94A 0 100 PETE S
103 10APR94A 15JUN94A 0 100 TOM W
104 12AUG94A 15AUG94A 0 100 DOUG
FY94
FEB MAR APR MAY JUN JUL AUG SEP
FY95
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
FY96
OCT
ENGINEERING (WHC)
Issue Spec - Retrieval/Skimmer
P O "Spec" Skimmer
Receive "Spec" Skimmer w/Pump - C-103
Issue "Spec" Coalescer
Develop Final Safety Classifications
FABRICATION (SHOP/FIELD FAB)
Fab UT/Video to Confirm Pumping
Fab Activity Monitor "Sources" (222S Labs)
Modify Control Trailer(Shops)
Fabricate C-103 Separation Enclosure
Shop Fab Instr Encl/Cabinet-C-103
Shop Fab Pump and Riser Encl - C-103
Shop Fab - Tanker Mods & Connect'g Piping -C-103
Fld Fab C-103 Compon'ts- C-103
INSTALLATION
Install Control Trailer at C-103 Site
Set Control Trailer
Provide Power to Control Trailer
WORK PKG PREP/FIELD INSTALLATION - C-103
Field Instl'n - Site Pad/Enclosures/Pip'g/Compnt
Field Fab & Instl'n - Piping for C-103
Install Activity Monitors In Enclosure - C-103
Install Pump & Aqueous Return Line - C-103
PERMITS
REGULATORY PERMITTING
Develop Solid Waste Disposal Strategy
Develop Organic Disposal Strategy
Develop Organic Storage Strategy
Decision Point - Further Study Required?
C-103 ORGANIC REMOVAL SCHEDULE
C-103 PUMPING SCHEDULE
C-103 ORGANIC REMOVAL - TOTAL SORT

ACTIVITY ID	EARLY START	EARLY FINISH	REM DUR	PCT	RESPONSIBLE
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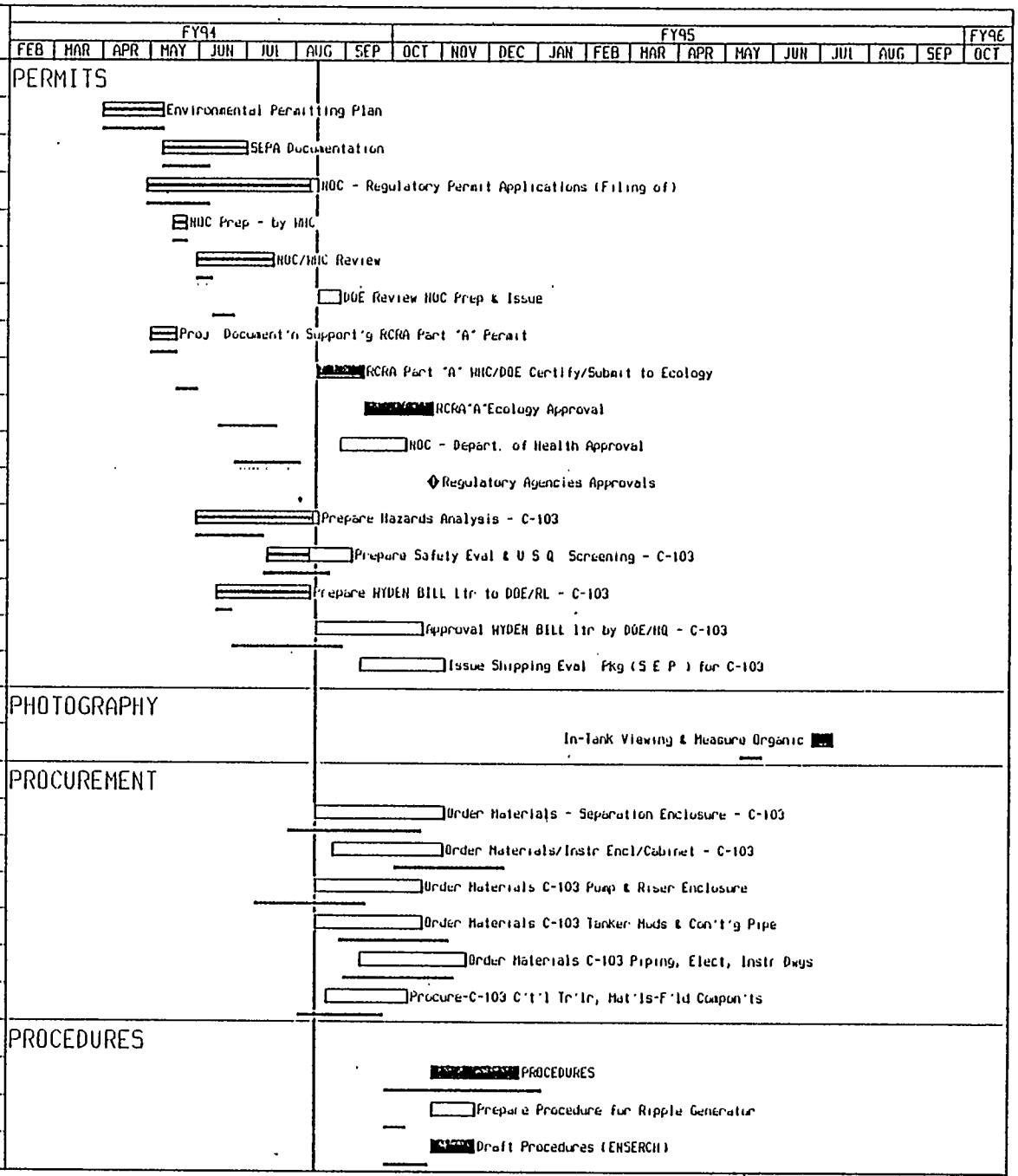
410	9MAY94A	1JUL94A	0	100	DOUG
415	29APR94A	15AUG94	1	95	DOUG
416	16MAY94A	24MAY94A	0	100	DOUG
417	31MAY94A	18JUL94A	0	100	DOUG
418	16AUG94	29AUG94	10	0	DOUG
420	2MAY94A	10MAY94A	0	100	DOUG
421	15AUG94	13SEP94	22	0	DOUG
422	14SEP94	27OCT94	32	0	DOUG
424	30AUG94	10OCT94	30	0	DOUG
426		27OCT94	0	0	DOUG
150	31MAY94A	16AUG94	2	95	TOM
451	15JUL94A	6SEP94	15	50	GREG H
460	13JUN94A	12AUG94	0	98	PETE S
461	15AUG94	21OCT94	50	0	PETE **
535	12SEP94	4NOV94	40	0	**
165	27JUN95	10JUL95	10	0	KIM **
511	15AUG94	4NOV94	60	0	KEH **
512	26AUG94	3NOV94	50	0	KEH **
514	15AUG94	21OCT94	50	0	KEH **
516	15AUG94	21OCT94	50	0	KEH **
517	12SEP94	10NOV94	50	0	KEH **
610	22AUG94	12OCT94	38	0	WHC
800	20OCT94	22DEC94	40	0	WHC **
801	20OCT94	24NOV94	20	0	KIM **
805	20OCT94	24NOV94	20	0	WHC **



C-103 ORGANIC REMOVAL SCHEDULE
C-103 PUMPING SCHEDULE
C-103 ORGANIC 'AL - TOTAL SURT

E-1-22

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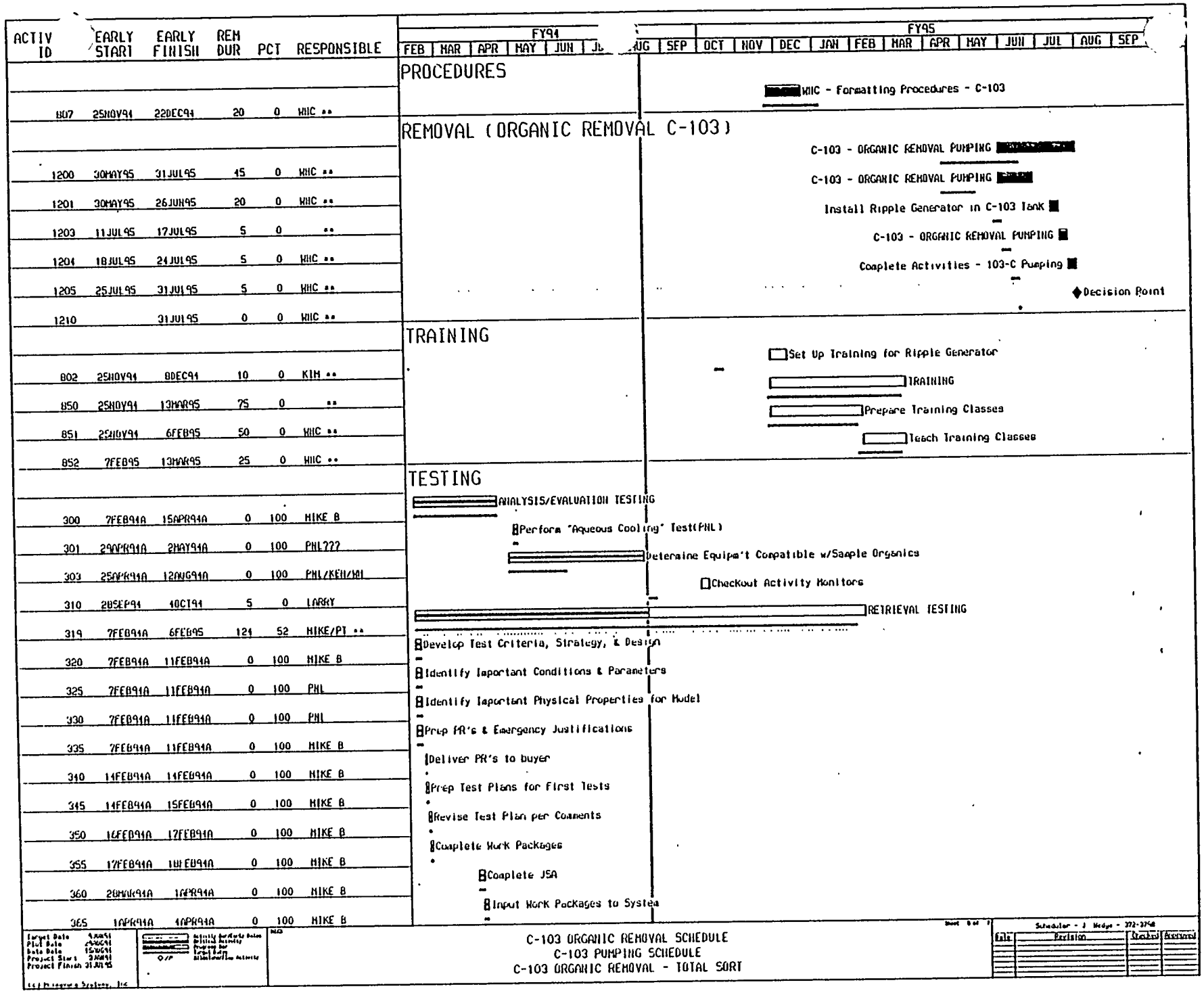
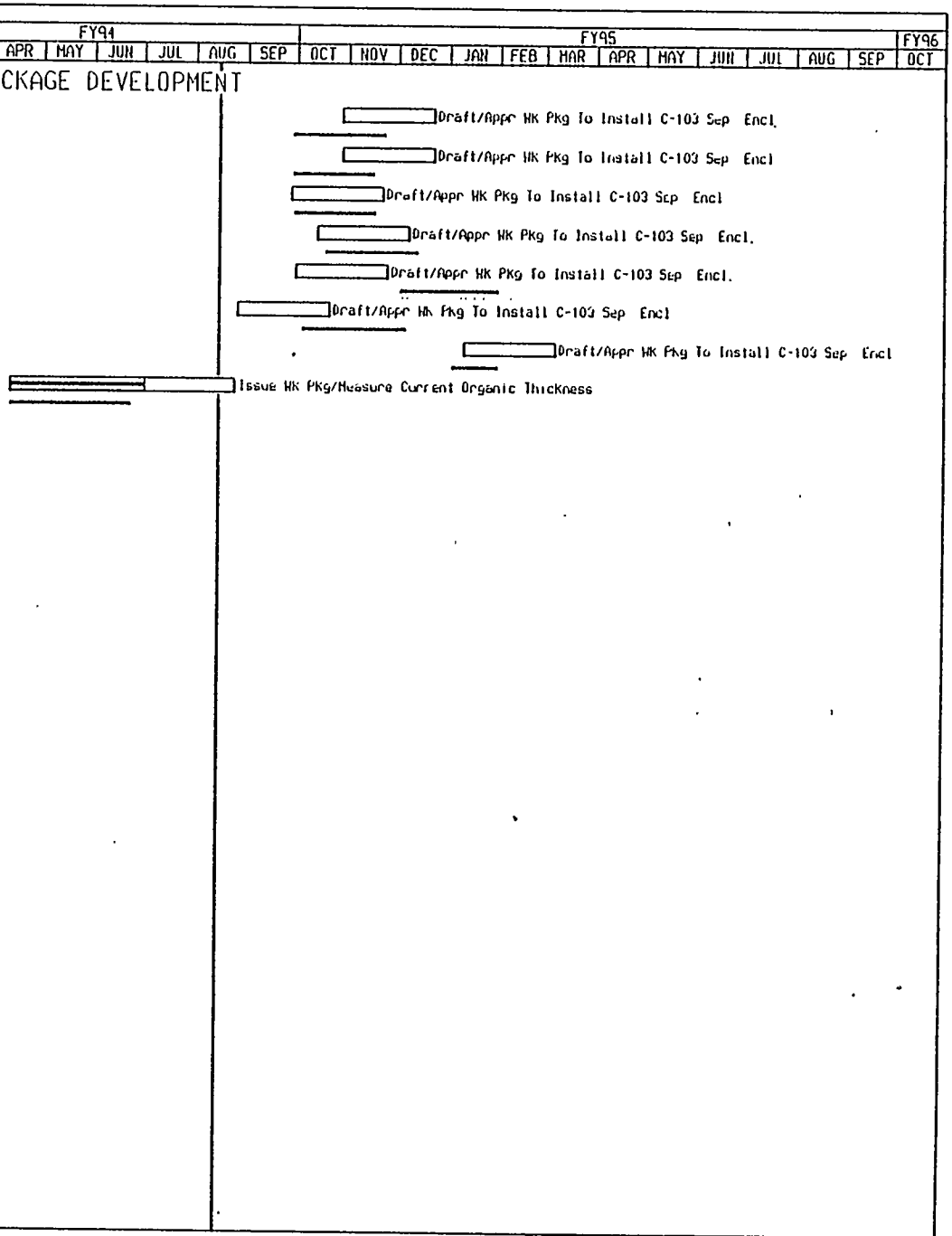

ACTIV ID
EARLY START
EARLY FINISH
REM DUR
PCT
RESPONSIBLE
FY94
FEB MAR APR MAY JUN JL
AUG SEP
FY95
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
PROCEDURES
807 25NOV94 22DEC94 20 0 WHC **
WHC - Formatting Procedures - C-103
REMOVAL (ORGANIC REMOVAL C-103)
1200 30MAY95 31JUL95 45 0 WHC **
1201 30MAY95 26JUN95 20 0 WHC **
1203 11JUL95 17JUL95 5 0 **
1204 18JUL95 24JUL95 5 0 WHC **
1205 25JUL95 31JUL95 5 0 WHC **
1210 31JUL95 0 0 WHC **
C-103 - ORGANIC REMOVAL PUMPING
C-103 - ORGANIC REMOVAL PUMPING
Install Ripple Generator in C-103 Tank
C-103 - ORGANIC REMOVAL PUMPING
Complete Activities - 103-C Pumping
Decision Point
TRAINING
802 25NOV94 8DEC94 10 0 KIM **
850 25NOV94 13MAR95 75 0 **
851 25NOV94 6FEB95 50 0 WHC **
852 7FEB95 13MAR95 25 0 WHC **
Set Up Training for Ripple Generator
TRAINING
Prepare Training Classes
Teach Training Classes
TESTING
300 7FEB94A 15APR94A 0 100 MIKE B
301 29APR94A 2MAY94A 0 100 PNL???
303 25APR94A 12AUG94A 0 100 PNL/KEH/MI
310 28SEP94 40CT94 5 0 LARRY
319 7FEB94A 6FEB95 124 52 MIKE/PT **
320 7FEB94A 11FEB94A 0 100 MIKE B
325 7FEB94A 11FEB94A 0 100 PNL
330 7FEB94A 11FEB94A 0 100 PNL
335 7FEB94A 11FEB94A 0 100 MIKE B
340 14FEB94A 14FEB94A 0 100 MIKE B
345 14FEB94A 15FEB94A 0 100 MIKE B
350 16FEB94A 17FEB94A 0 100 MIKE B
355 17FEB94A 18FEB94A 0 100 MIKE B
360 28MAR94A 1APR94A 0 100 MIKE B
365 1APR94A 1APR94A 0 100 MIKE B
ANALYSIS/EVALUATION TESTING
Perform "Aqueous Cooling" Test(PNL)
Determine Equipm't Compatible w/Sample Organics
Checkout Activity Monitors
RETRIEVAL TESTING
Develop Test Criteria, Strategy, & Design
Identify Important Conditions & Parameters
Identify Important Physical Properties for Model
Prep PR's & Emergency Justifications
Deliver PR's to buyer
Prep Test Plans for First Tests
Revise Test Plan per Comments
Complete Work Packages
Complete JSA
Input Work Packages to System
C-103 ORGANIC REMOVAL SCHEDULE
C-103 PUMPING SCHEDULE
C-103 ORGANIC REMOVAL - TOTAL SORT
Date
Revision
Checked
Approved

E-1-23

ACTIVITY ID	EARLY START	EARLY FINISH	REM DUR	PCT	RESPONSIBLE
1011	28OCT94	22DEC94	40	0	..
1012	28OCT94	22DEC94	40	0	..
1014	27SEP94	21NOV94	40	0	..
1016	13OCT94	7DEC94	40	0	..
1017	30SEP94	24NOV94	40	0	..
1018	26AUG94	20OCT94	40	0	..
1021	10JAN95	6MAR95	40	0	..
3192	11APR94A	24AUG94	8	60	KYLE H



C-103 ORGANIC REMOVAL SCHEDULE
C-103 PUM SCHEDULE
C-103 ORGANIC - TOTAL SORT

E-1-24

ATTACHMENT
E-2

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PRELIMINARY DESIGN REPORT REMOVAL AND SEPARATION OF THE FLOATING ORGANIC LAYER IN TANK C-103

May 9, 1994

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E-2-1

LIST OF ACRONYMS

ALARA	As Low As Reasonably Achievable
ANS	American Nuclear Society
ANSI	American National Standards Institute
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
CEL	Chemical Engineering Laboratory
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DSSI	Diversified Scientific Services, Inc.
Ecology	Washington State Department of Ecology
EMT	electrical metallic tubing
EPA	U.S. Environmental Protection Agency
HDPE	high density polyethylene
HEPA	high efficiency particulate air
HPS	Hanford Plant Standards
INEL	Idaho National Engineering Laboratory
LEL	lower explosive limit
LSA	low-specific activity
MRP	Management Requirements and Procedures
NEC	National Electric Code
NESHAP	National Emission Standard for Hazardous Air Pollutants
NOC	Notice of Construction
NPH	normal paraffin hydrocarbon
PDR	preliminary design report
PLC	programmable logic controller
PNL	Pacific Northwest Laboratory
PUREX	Plutonium/Uranium extraction
PVDF	polyvinylidene difluoride
SDC	Standard Design Criteria
SEG	Scientific Ecology Group
SEPA	State Environmental Policy Act
TAP	toxic air pollutant
TBP	tributyl phosphate
TLV	threshold limit value
Tri-Party Agreement	Hanford Federal Facility Agreement and Consent Order
TSD	treatment, storage, and disposal
USQ	unresolved safety question
WAC	Washington Administrative Code
WHC	Westinghouse Hanford Company

TABLE OF CONTENTS

1.0 INTRODUCTION 1-1
1.1 PROJECT BACKGROUND 1-1
1.2 PRELIMINARY DESIGN SCOPE 1-4

2.0 BASELINE DESIGN 2-1

3.0 FUNCTIONAL REQUIREMENTS 3-1
3.1 PROCESS/PERFORMANCE REQUIREMENTS 3-1
3.1.1 Organic Removal System 3-1
3.1.2 Organic-Aqueous Separation 3-5
3.1.3 Organic Storage 3-6
3.2 ENVIRONMENTAL 3-8
3.2.1 Dangerous Waste Requirements 3-9
3.2.2 Airborne Release Requirements 3-9
3.3 OPERABILITY AND MAINTAINABILITY 3-10
3.4 DECONTAMINATION, DECOMMISSIONING, AND DISPOSAL 3-12
3.5 NATURAL FORCES CRITERIA 3-14
3.5.1 Design Basis Earthquake 3-14
3.5.2 Design Basis Flood 3-14
3.5.3 Volcanic Eruptions 3-15
3.6 ADDITIONS TO TANK 103-C 3-15

4.0 PROCESS SYSTEMS 4-1
4.1 REMOVAL OF ORGANIC 4-1
4.1.1 Organic Removal System Design 4-1
4.1.2 Organic Removal System Operation 4-6
4.2 AQUEOUS-ORGANIC SEPARATION 4-8
4.2.1 Aqueous-Organic Separation System Description 4-9
4.2.2 Aqueous-Organic System Arrangement 4-9
4.2.3 Instrumentation and Control 4-12
4.2.4 Aqueous-Organic Separation Interfaces 4-14
4.2.5 Operation of the Organic Removal and Separation Facility 4-14
4.3 ORGANIC RECEIVING 4-19
4.3.1 Systems Description 4-19
4.3.2 System Arrangement 4-21
4.3.3 Instrumentation and Control 4-21
4.3.4 System Interfaces 4-21
4.3.5 Operation of the Truck-Mounted Tank 4-22
4.4 LONG-TERM STORAGE 4-23
4.5 PRE-STARTUP TESTING 4-24
4.6 RADIONUCLIDE SEPARATION 4-24
4.7 DISPOSAL 4-26

5.0 SUPPORT SYSTEMS 5-1
5.1 CIVIL/STRUCTURAL 5-1
5.1.1 Site 5-1
5.2 MECHANICAL 5-1

5.2.1 Tank C-103 5-1
5.2.2 Separation Enclosure 5-2
5.2.3 Organic Receiver Truck-Mounted Tank 5-3
5.2.4 Containment Pads 5-3

TABLE OF CONTENTS (cont'd)

5.3 PROCESS CONTROL 5-4
5.3.1 Tank C-103 5-4
5.3.2 Separation Enclosure 5-4
5.3.3 Organic Receiver Truck-Mounted Tank 5-5
5.3.4 Control Trailer 5-5
5.4 ELECTRICAL 5-6
5.4.1 Site 5-6
5.4.2 Tank C-103 5-7
5.4.3 Separation Enclosure 5-7
5.4.4 Organic Receiver Truck-Mounted Tank 5-7
5.4.5 Control Trailer 5-8

6.0 ENGINEERING ASSESSMENTS 6-1
6.1 ORGANIC RECOVERY FLOWSHEET 6-1
6.2 DOSE RATE ANALYSIS OF TANK C-103 WASTE AND SHIELDING ANALYSIS 6-1
6.2.1 Technical Approach and Assumptions 6-4
6.2.2 Results of Dose Rate and Shielding Analyses 6-4
6.3 CRITICALITY 6-6
6.4 SAFETY 6-7
6.5 FIRE HAZARD ANALYSIS 6-7
6.6 REGULATORY 6-8
6.6.1 Environmental Regulation Detail 6-8
6.6.2 Administrative Requirements 6-12

7.0 DESIGN RISKS AND UNCERTAINTIES 7-1
7.1 PUMP NOW OR PUMP LATER 7-1
7.2 FILTERS 7-1
7.3 TEMPERATURE 7-1
7.4 RADIONUCLIDE REMOVAL 7-2
7.5 CONSTRUCTION COORDINATION 7-2
7.6 MATERIAL IDENTIFICATION 7-2
7.7 SAFETY CLASSIFICATION 7-3
7.8 RADIATION EXPOSURE 7-3
7.9 EQUIPMENT SUITABILITY 7-3
7.10 HYDRAULICS 7-4
7.11 DISPOSAL 7-4
7.12 AMMONIA/ORGANIC VAPOR 7-4
7.13 LIQUID DETECTION FOR RETENTION PAD 7-5
7.14 LINER COMPATIBILITY 7-5
7.15 TOXIC AIR POLLUTANTS 7-5
7.16 REGULATORY APPROVAL 7-5

8.0 REFERENCES 8-1

LIST OF APPENDIXES

Appendix A Drawings . . . . . A-i
Appendix B Engineering Assessments . . . . . B-i
Appendix C Engineering Studies . . . . . C-i

LIST OF FIGURES

Figure 6-1 Flowsheet Schematic 6-2

LIST OF TABLES

Table 6-1 Tank C-103 Organic Recovery Flowsheet 6-2
Table 6-2 Shielded vs. Unshielded Dose Rate Analysis Results 6-5
Table 6-3 Shielded (2.5 cm Lead) Dose Rate Analysis Results 6-6
Table 6-4 Source Terms Potentially Released from Hypothetical Accidents 6-7
Table 6-5 Summary of Applicable Administrative Requirements 6-13

1.0 INTRODUCTION

1.1 PROJECT BACKGROUND

Tank C-103 is one of twelve 530,000-gal mild steel-lined concrete tanks constructed in 1943 to 1944 to store high-level aqueous waste solutions. The tank was initially placed in service in August 1946 to receive metal waste solutions from the bismuth phosphate process for plutonium separation at B Plant. The metal waste was subsequently removed from Tank C-103 in the early 1950s and later, coating waste and other miscellaneous waste solutions of intermediate radioactivity were discharged from the Plutonium/Uranium Extraction (PUREX) Plant directly into the tank or overflowed into the tank from the primary receiver, Tank C-102.

Subsequent to its use as a receiver for coating and other waste solutions from the PUREX Plant, various waste solutions from numerous sources were transferred into/through Tank C-103, as described below (Carothers 1988).

Tank C-103 remained active until July 1979, after which no wastes were transferred into or out of the tank. During the time when the tank was receiving waste, it served as a primary receiver for insoluble strontium-leached solids from both B Plant and AR Vault during the PUREX acidified sludge secondary recovery operations. Other wastes transferred into Tank C-103 originated from supernatant pumping tanks in the 200 East Area that were historically either primary receivers of waste or secondary receivers of waste from other tanks. Tanks involved in these transfers included Tanks 107-C, 108-C, 109-C, 110-C, 111-C, 112-C. Besides the PUREX strontium-leached solids, other waste types contributing to the tank transactions include Hot Semi-Works waste, cesium recovery waste, and strontium recovery waste from fission product recovery, B Plant high-level waste, B Plant low-level waste, PUREX high-level waste, thoria waste, strontium semiworks waste, N Reactor waste, Battelle Northwest waste, and decontamination waste.

The transfer of PUREX organic wash waste containing large quantities of emulsified organic into Tank C-102 and, subsequently, from Tank C-102 into Tank C-103 is the apparent sequence of events that introduced PUREX solvent, a mixture of 30% tributyl phosphate (TBP) and normal paraffin hydrocarbon (NPH), into Tank C-103. Ineffective separation of the PUREX solvent from the aqueous wash at PUREX resulted in the solvent being transferred to Tank C-102. Prior to the last transfer from Tank C-102 in November of 1975, the tank was observed to contain a 10 to 13 in. layer of organic (Anderson 1969). The last transfer from Tank C-102 was to Tank C-103 and a subsequent photograph of Tank C-102 showed a dry, lumpy surface of sludge with very shallow puddles of liquid visible (RHO 1984). The transfer of the supernatant liquid also resulted in the transfer of misplaced PUREX organic to Tank C-103.

The original depth of the organic layer transferred from Tanks C-102 and C-104 was 10 to 13 in. (Postma et al. 1994). Due to evaporation over time, particularly during periods of forced ventilation, the depth has been reduced from 1.5 to 2.0 in. (Huckaby 1993) equivalent to 4,100 to 5,500 gal.

The NPH evaporated in greater quantities than the TBP due to the higher volatility of NPH. As a result, the relative concentrations of NPH and TBP have changed from their original relative concentrations. The NPH is now approximately 30% of the organic layer and TBP is approximately 70%.

In July 1987, noxious vapors emitting from Tank C-103 caused illness and hospitalization (for observation) to two Westinghouse Hanford Company (WHC) workers. Analysis of the samples of the headspace gases in Tanks C-102 and C-103 revealed several organic and inorganic compounds. The major compounds were 1-butanol, NPH, TBP, acetone, and ammonia. Concentrations of all five compounds exceeded the threshold limit values (TLVs) for these substances.

The detection of combustible organic vapors in the headspace of Tank C-103 and the subsequent verification of a second liquid organic phase in the tank resulted in placing Tank C-103 on the "Watch List" of waste tanks containing high organic content (Hanlon 1993). Tank C-103 is one of eight

single-shell tanks on the Watch List and the only one with a floating organic layer.

In addition to the toxicity of the vapors, the primary concerns regarding the floating organic layer are the flammability of the liquid and the explosiveness of the vapor. These latter two concerns have been the subjects of recent studies. Current theoretical and experimental data indicate that the sum of all combustible specie (aerosol + gas) concentrations amounts to less than 10% of the lower explosive limit (LEL) (Postma et al. 1993). Recent experiments at Pacific Northwest Laboratory (PNL) yielded an average value for the flash point of the Tank C-103 organic of 119 °C (Pool and Bean 1994).

The flammability of the organic and the potential for an in-tank fire and/or explosion, with the resultant dispersion of radioactivity to the environment, was the reason for the declaration of an resolved safety question (USQ). Actions resulting from this USQ included restrictions on operations performed and limitations on vehicles allowed in the area of Tank C-103.

Removal of the organic layer will reduce the available combustible material in this single-shell tank. This preliminary design report (PDR) establishes the preliminary design requirements for this option. This approach has been concurred with, by both the Washington State Department of Ecology (Ecology) and the U.S. Environmental Protection Agency (EPA), and it has been established as a milestone in the *Hanford Federal Facility Agreement and Consent Order* (Tri Party Agreement).

The original concept for pumping the organic layer included relatively quick offsite shipment of the organic to an offsite vendor for disposal. Current plans indicate an onsite storage period of approximately two years with up to five years onsite possible. As a result of this change, a risk/benefit study is being performed to compare the pumping alternative identified in this PDR (near-term pumping with onsite storage) with the option

of leaving the organic layer in Tank C-103 until the layer can be pumped, possibly treated, then shipped directly offsite.

The organic is floating on a 78-in. deep mixture of aqueous supernate and sludge of intermediate radioactivity. The sludge has settled in an approximately 2.5 ft deep layer at the bottom of the tank.

Recent samples show the organic and aqueous phases to be essentially free of suspended solids and the organic, at least in the upper portion of the layer, to be free of aqueous entrainment (Huckaby 1993). The organic samples were reported to be bright red and the aqueous supernate sample was a lighter brownish-red in color. The organic phase is relatively low in radioactive contamination; the 100-mL sample bottles read 2 to 5 mRad on contact, compared to a contact reading of about 200 mRad for the 100 mL sample of supernate (Huckaby 1993). Analyses of the organic samples, reported by Pool and Bean (1994), revealed the radionuclide content of the organic phase to be typically within the limits for low-specific activity (LSA) material but greater than the U.S. Department of Transportation (DOT) limits for bulk shipment of liquids. The radionuclide concentration of the pumped organic may be higher than the in-tank concentration due to aqueous contamination during removal. Onsite shipment is acceptable at the current radionuclide concentrations. Offsite shipment will require resampling and likely will include material treatment.

1.2 PRELIMINARY DESIGN SCOPE

This preliminary design is for the selection of operation methods and equipment involved in the retrieval of the organic layer from Tank C-103, separation of the organic from any entrained aqueous waste solution, and transfer of the separated organic phase into a holding truck-mounted container.

The primary goal of the organic removal facility will be to reduce the volume of combustible material in Tank C-103. The organic removal facility will be designed so that the impact of the removal operation on the safety of the environment, public, and onsite workers will be negligible.

Specifically excluded from the scope of this PDR is the conceptual design of process and equipment required for removal of residual radionuclide contamination from the organic.

The organic will be pumped from Tank C-103 with a low-capacity, positive displacement pump, and routed through a coalescer device in a shielded enclosure. The coalescer will separate entrained aqueous phase from the organic and route the aqueous phase back into the tank. The separated organic will be routed through an encased line into a truck-mounted container for temporary storage and transport. The holding container and trailer will be in a specifically designed berm in the C Tank Farm approved for temporary storage. Once pumping is completed, the storage container and trailer will be moved to an approved and permitted bermed area in B Tank Farm for up to five years.

The following are salient features of the organic removal and separations facility.

- The organic removal system will consist of a retrieval device designed to fit into the tank through a nominal 12-in. diameter access riser.

- A shielded and lined enclosure of the same diameter and containing flush provisions and a ventilation filter will be mounted on the top of the access riser.

- Shielding and secondary containment will be provided for the pumpout and aqueous return lines extending from the shielded riser enclosure to the separations enclosure.

- The separations enclosure will consist of a two-compartment shielded box approximately 3 by 6 by 6 ft high. An encased line will extend from the separations enclosure to a trailer mounted container located on a bermed, temporary loading pad.

- The facility will be equipped with radiation detection devices to ensure that highly radioactive solution is not pumped to the above ground container.

- Instrumentation and controls will provide for automatic shutdown of the process for high radiation, leaks, and other important process central parameters.

- The system is designed to contain leaks in either the piping containment, the coalescer enclosure, or the bermed storage area.

2.0 BASELINE DESIGN

The 1-1/2 to 2 in. layer (maximum of 5,500 gal) of organic in Tank C-103 will be removed by a skimmer pump assembly lowered through a nominal 12 in. riser into the tank. The skimmer will preferentially remove the organic layer.

There are three separate units that comprise the organic removal and separation system (See Appendix A for drawings):

- A skimmer-pump assembly installed in Riser 02 on Tank C-103
- A coalescer in a separate shielded enclosure
- A trailer mounted container in a bermed containment pad adjacent to Tank C-103.

The skimmer assembly by virtue of its buoyancy and weir design initially removes only organic, but as the depth of the organic layer decreases, the skimmer-pump begins removing some aqueous with the organic. Separation of the aqueous is a continuous operation completed outside the tank in a separate enclosure. The processing rate is variable with a nominal capacity of 2 to 3 gal/min and a maximum design rate of 5 gal/min. Initially the pumping rates are the highest and decrease to a fraction of a gallon per minute as the depth of the organic layer decreases to the required residual level of 2 mm based on studies performed by Burelbach (Burelbach 1994), Fauske and Associates, Incorporated (FAI 1994), and onsite testing of equipment and simulants. The total operating time for actual, on-line organic removal is expected to be in the range of 5 to 30 days. This time planning was based on round the clock operations. Current plans include the potential for continuous operation. This would significantly reduce system operating time.

A coalescer was selected for the aqueous-organic separation because of its demonstrated capability to separate two phases with a small difference in the surface tension into two homogenous streams. A comparable gravity settler

decanter was considered unacceptable due to the larger size which would require a larger enclosure with more shielding. Aqueous removed by the skimmer pump will be separated from the organic to the extent that the entrained aqueous in the organic is reduced to a fraction of 1% by volume. The aqueous is returned to Tank C-103 and the organic is collected in a tank truck.

Temperature affects coalescer performance. The lowest temperature the coalescer has been operated at, using simulants, is 20 °C. Efficient operations have been achieved at temperatures less than 25 °C. Better results have been achieved at slightly elevated temperatures (40 °C). Temperature characteristics, including effects of solar heat, are under evaluation.

Possible alternatives to a separation enclosure for the coalescer are for it to be located within Tank C-103 or the Tank C-103 pump pit. A combined system of skimmer pump and coalescer located within Tank C-103, while considered to be economically desirable, is unachievable because the size of the aqueous-organic separator exceeds the size of the riser. Installation in a pump pit on Tank C-103 was not considered feasible for the following reasons:

- The Tank C-103 pump pits have been weatherized (sealed with a sprayed on, impermeable covering) to prevent rainwater from leaking into and vapors from leaking out of the pit

- Condition of the pump pits is unknown and the effort required to prepare a pit for beneficial use is also unknown, but expected to be extensive

- Work in the C Tank Farm within 15 ft of any riser requires restrictive respiratory protection requirements due to potential fumes complicating any pit work.

- Other nearby construction work (Project W-320 to prepare Tank C-106 for sluicing) could interfere with work at Tank C-103 and cause delays.

As a result of these problems, work in the C Tank Farm would be difficult to accomplish and could cause delays that could jeopardize the schedule.

Shop fabrication of both the separations enclosure to house the aqueous-organic separation device and the skimmer pump assembly avoids the potential delays due to Project W-320 construction activities. The separation enclosure with the aqueous-organic separation equipment and the skimmer pump assembly will be moved to the C Tank Farm as separate units. The skimmer pump assembly will be lowered through Riser 02 and connected to the nearby separation enclosure piping. Piping out of the separation enclosure will be connected to the truck-mounted container. Tank farm installation work will be limited to lowering the skimmer pump assembly into the riser, installing the shielding enclosure on the riser, placing the separation enclosure close to the riser, and making the piping connections.

The coalescer and all related equipment is designed for the life of the project. Flushing the coalescer and selected piping to maintain required performance and acceptable exposure levels is included in the system. Flushes are returned to Tank C-103 through the saltwell pit (See Drawing ES-ER5602-C2, Appendix A).

3.0 FUNCTIONAL REQUIREMENTS

This section provides a summary description of the removal and separation system for Tank C-103 which documents minimum concepts and requirements to form a basis and provide limitations governing design for a complete, safe, and operable system adequate for its intended purpose.

Sections 4 and 5 of this document provide a conceptual design that implements the requirements set forth in this section. This conceptual design was developed to ensure that the selected design is feasible and that risks are identified. Changes to the conceptional design may occur as long as the functional requirements are met.

There remains several issues, including regulatory and engineering, that require further resolution and incorporation as necessary. These issues are identified primarily in this section and in Section 7, Design Risks and Uncertainties. Resolution will be through existing regulatory channels and through established WHC procedures. Definitive design reports will include the engineering results of issue resolution.

Several studies and assessments have been performed and are referenced throughout this document. Brief descriptions of some of these are contained in Appendixes B and C.

3.1 PROCESS/PERFORMANCE REQUIREMENTS

3.1.1 Organic Removal System

The performance requirements for organic removal from Tank C-103 are presented below.

Pump and Skimmer Assembly

Assembly Size	Must fit through Riser 02 in Tank C-103, a nominal 12-in. diameter riser
Organic Removal	Must remove organic phase in this 75 ft diameter tank to within 2 mm of the aqueous interface with an allowable intake of aqueous phase to be determined during testing
Pump Type	Positive displacement, self priming to 3 ft
Pump Flow Characteristics	Minimize fluid shear by specifying pump with lower shear characteristics. For a positive displacement lobe pump, a dual lobe shall be specified, to reduce fluid shear. Pump system (pump and piping) shall be tested to determine if stable microemulsions are present that are inseparable in the coalescer.
Pump Motor	Variable speed, reversible hydraulic motor with hydraulic drive unit located at grade level
Flow Rate	0.6 to 2.0 gal/min. Laminar flow at 0.6 gal/min (Reynold's number $\leq$ 2,000).
Pressure Limit	100 lb/in^2 (gauge)
Solids Size	Capable of passing 0.25 in. solid particles and remaining functional
Radiation Resistance	Capable of remaining functional after radiation exposure of 250,000 Rad

Materials of Construction	Compatible with organic and aqueous phase tank waste, examples include 304 stainless steel, 316 stainless steel, Kalrez a perfluoroelastomer, (Kalrez is a trademark of E.I. duPont de Nemours and Company), and Kynar (polyvinylidene difluoride [PVDF]) (Kynar is a trademark of ELF Atochem North America, Inc.)
Seals	Static/mechanical
Skimmer	Self-righting on lowering into tank or restrained from overturning

Decontamination Collar and Shielding Enclosure

Shielding	Adequate to reduce surface contact dose to 10 mrem/hr above background during pump operation
Decontamination Ring	Provide 360° coverage for decontamination spray
Decontamination Water	Supplied by portable decontamination system using inhibited water.
Piping Connections	Self sealing, no drip, quick disconnect
Venting	Passive, connected upstream of Tank C-103 filters

Organic Feed Line

Pipe Containment	Shielded, double-containment, steel

Shielding	Adequate to reduce surface contact dose to 10 mrem/hr above background during pump operation
Materials of Construction	304 or 316 stainless steel

Aqueous Return Line

Pipe Containment	Shielded, double-containment, steel
Shielding	Adequate to reduce surface contact dose to 10 mrem/hr above background during pump operation
Discharge Location	Tank C-103 salt well, approximately 1 ft below the tank liquid surface
Materials of Construction	304 or 316 stainless steel

Instrumentation and Control

The organic removal skimmer pump shall be controlled by a microprocessor control unit and a variable frequency variable speed drive. Provisions shall exist for monitoring and controlling the flow rate and discharge pipe pressure. Integral indicators will include a fault indication. These components will be in a cabinet mounted with a control trailer.

Backup manual controls shall be provided as required to achieve and maintain a safe shutdown condition in the event that normal power or control is lost.

3.1.2 Organic-Aqueous Separation

The performance requirements for the organic-aqueous separation system are listed below.

- The system shall be designed so that the line from the separations enclosure to the trailer tank drains back to the separations enclosure and the two lines connecting the separations enclosure to Tank C-103 drain back to Tank C-103. Alternatively, if this is not possible, vacuum breakers shall be installed at the high point in the lines. The vacuum breakers shall be vented back to the enclosure or directly/indirectly to Tank C-103 head space.

- The system enclosure shall be vented through a high efficiency particular air (HEPA) filter located at the enclosure. The enclosure vent line shall connect to the Tank C-103 vent upstream of the filters

- The system shall be capable of removing all particles $\geq$ 5 μm from the feed stream to the coalescer.

- The system shall be capable of automatic shutdown for any of the following contingencies:

  - High radiation in the separated organic
  - High-high level indication in the drain tank
  - Liquid indication in the enclosure sump/line encasement collection point
  - High liquid level in receiver/storage container.

- The coalescer shall separate any emulsions created by the retrieval process into two streams, organic and aqueous.

- Minimum purity of organic discharged to container: less than 2% aqueous carryover.

- Material of coalescer element: corrosion and radiation resistant (e.g., glass fibers).

- Material of coalescer vessel: preferably 316 or 316 L austenitic stainless steel.

- Coalescer Flow capacity: 5 gal/min maximum.

- Coalescer operating pressure: 2 to 5 lb/in^2 (gauge) differential.

- Coalescer operating temperature: 25 to 60 °C.

- Level control is needed to maintain aqueous/organic interface at about the midplane of the longitudinal axis of the coalescer element.

- System shall be flushable.

- The separations enclosure shall be shielded to limit personnel exposure to no greater than 30 mR/hr or less.

3.1.3 Organic Storage

The performance requirements for the organic storage system are listed below.

- Fire protection shall be provided as identified in the Fire Hazard Analysis (Section 6.5).

- System shall be flushable.

- Materials of construction must be compatible with the waste, preferably austenitic stainless steel.

- Secondary containment shall be utilized as required for control of hazardous materials including:

  - Double wall piping
  - Enclosure
  - Chemically resistant, lined berms.

- Organic storage vessel shall be ventilated through HEPA filters:

  – During filling operations the filtered discharge is connected to the Tank C-103 vent system upstream of the filter

  – HEPA filter shall remain in place when the organic is placed in storage. The height of the discharge stack will be approximately 14 ft.

- Storage system shall not exceed 72 °C to ensure that the organic remains below its flashpoint.

- A minimum working capacity of 6,000 gal shall be provided.

- Berm liner shall have the capacity to contain the full contents of the tanker and be chemically compatible with the Tank C-103 contents.

- Pursuant to WHC-CM-4-9, *Radiological Design*, the area and equipment reserved for the storage of Tank C-103 organic waste shall be shielded to avoid creating a high radiation area, by limiting personnel exposure to 100 mR/hr or less.

- A high liquid level detector shall be used in the storage container.

- Leak and overflow detection shall be used as necessary and in accordance with U.S. Department of Energy (DOE) and State requirements during pumping and storage.

3.2 ENVIRONMENTAL

Environmental requirements encompassing the scope of the organic material removal from Tank C-103 include the functional equipment and procedural performance requirements as well as administrative requirements. Functional environmental requirements are generally described here and are detailed by regulatory citation in Section 6.6.1. Administrative requirements are those involved with the preparation and approval of documentation required by the various legislative and regulatory standards originating externally from the DOE and originating as DOE Orders. Administrative requirements are described and detailed in Section 6.6.2.

Equipment and procedural requirements for the proposed action are clearly definable in relation to equipment components with respect to waste material handled in the action. The equipment components may be described in terms of the potential environmental media impact (i.e. air, water, soil[1]) and thereby be identified with appropriate regulatory review and requirement identification.

Tank C-103 is a single-shell tank containing radioactively contaminated hazardous waste. As such, fluid transfer systems (piping) through the tank shell may impact soils and must comply with ancillary equipment standards for tank systems under hazardous waste regulations. Ventilation and gaseous displacement as a result of fluid transfers may impact the air and must then comply with appropriate regulations for the airborne release of radionuclides and toxic materials. Liquid return and waste removal may result in material dispersion within the tank and may impact the air and must then comply with appropriate regulations for the airborne release of radionuclides and toxic materials.

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[1] Soil impacts are those associated with hazardous wastes (i.e., the Resource Conservation and Recovery Act and the Hazardous and Solid Waste Amendments).

Waste transfer systems (piping) and other ancillary systems (all operations within the separations enclosure) associated with the tank may impact the soil and the air. As such, such systems must comply with appropriate hazardous waste and airborne release requirements.

The waste removed from Tank C-103 is intended to be received in a 6,000 gal truck-mounted tank. The truck-mounted tank will be moved to an approved, permitted, bermed, storage site in B Tank Farm while awaiting any further treatment and ultimate transportation to a disposal facility. Such storage may impact both air and soil media and must then comply with hazardous waste and airborne release requirements.

3.2.1 Dangerous Waste Requirements

As described above, piping, operations within the separations enclosure, and waste retention must comply with hazardous waste requirements. Within the state of Washington, such requirements are embodied with the *Dangerous Waste Regulations* [Washington Administrative Code (WAC) 173-303]. Additionally, such requirements are described within the *Environmental Compliance Manual* (WHC-CM-7-5, Section 3.9).

Functionally, these requirements delineate the need to ensure the compatibility of the waste with waste handling and retention systems, ensure that adequate secondary containment of dangerous waste exists, and that such systems be tested and inspected to ensure their continued compliance with standards developed to prohibit unnecessary release of hazardous materials to the environment. Secondary containment includes double-wall piping or enclosures and berms as necessary to prevent the spread of leaking fluids.

3.2.2 Airborne Release Requirements

Ventilation systems and passive filtration of displaced gases from Tank C-103, the separations enclosure, and the truck-mounted tank must comply with regulations governing airborne release of radioactive and toxic materials. As all air flows from the proposed operations will have been in contact with the waste, each potential emission point must comply with such standards. This PDR requires two levels of HEPA filtration during pumping operations. The separations enclosure and the truck-mounted tank will each have its own HEPA filter. These HEPA filters will be discharged to a common line connected to the upstream side of the Tank C-103 passive HEPA filtration system. During storage, the truck-mounted tank will retain its own passive HEPA filtration. As such, each potential displacement is returned to the normal emission point for the tank.

Airborne release requirements for toxic material releases are embodied within WAC 173-460, *Controls for New Sources of Toxic Air Pollutants.* Functionally, this body of regulation places requirements upon the extent of air pollution abatement. In context, the primary air contaminant anticipated to be controlled under this body of regulation is TBP. As such, maintenance of modest fluid temperatures and the HEPA filtration common to nuclear-grade applications is anticipated to achieve and ensure compliance with this regulation.

Applicable airborne release requirements for radioactive materials are embodied within Federal requirements of the National Emission Standards for Hazardous Air Pollutants (NESHAP), Subpart H, and Washington State requirements under WAC 173-480 and WAC 246-247. Again, the functionality of these regulations is the ensurance of sufficient pollution abatement. In this context, aerosol particles containing radioactive contaminants are the pollutants of concern. HEPA filtration common to nuclear-grade applications is anticipated to achieve and ensure compliance with these standards. The HEPA filtration units must be manufactured from appropriate chemically resistant materials.

3.3 OPERABILITY AND MAINTAINABILITY

As currently planned, the organic removal and separation facility will be used for a very limited period of time. The initial pumping rate is planned to be 5 L/min (1.32 gal/min) and will be slowed as the depth of the organic layer decreases. The depth will be indicated by a probe lowered into the tank through a riser.

If pumping were to be conducted on a weekday, 2 shift/day basis then operation would take 40 days to complete. This duration could be shortened substantially if pumping operated for 24-hour/day, 7 day/week. Operations staff have indicated that around-the-clock pumping would be acceptable.

The expected operating period for Tank C-103 service is of short duration and the standard "off-the-shelf" equipment selected is expected to perform satisfactorily without maintenance. Thus the organic removal and separations facility is designed for limited maintainability. Components with a very low probability of failure or with built-in redundancy will be permanently mounted with all welded piping and will not be maintained. Components with a higher probability of failure will be contact maintained. The components to which a no-maintenance philosophy was applied in the design are located in the heavier-shielded section of a two-compartment containment enclosure and are as follows:

- Filters (three piped in parallel)
- Coalescer
- Accumulation tank.

Three separate filter units will be provided, piped in parallel and with isolation valves so that spares are available in the event of plugging. The coalescer-decanter is designed for a flow rate of 5 gal/min, which is of sufficient over-capacity that even moderate plugging should not adversely affect the operation. The filters, coalescer, and accumulation tank are the primary sources of radiation in the facility and for this reason, are more

heavily shielded. The issue for filter plugging is considered significant and is the subject of alternatives study currently being performed. The results of this alternatives study will likely affect the definitive design of this process.

Components with a higher probability of failure will be located in an accessible compartment of the enclosure. This compartment will contain less shielding (3/8-in.-thick steel walls) and will be equipped with removable covers for ready access for contact maintenance. Components to be located in this compartment include the following:

- Pump
- Valves
- Radiation detectors
- Instrument sensing heads (temperature, pressure, liquid level, flow).

In the unlikely event of a premature failure of some component, the lines can be drained, the coalescer and accumulation tank can be flushed internally, and the entire system can be flushed externally within the enclosure. The covers to the contact maintained compartment can then be removed. The covers are of a size that they can be removed by hand. Any maintenance involving opening of the enclosure will require the erection of a temporary "greenhouse" for confinement.

Failure of any component in Tank C-103 will require removal and replacement/repair in much the same manner as is used for removal of any other equipment from an underground high-level waste storage tank.

3.4 DECONTAMINATION, DECOMMISSIONING, AND DISPOSAL

The design of the systems for removal, treatment, and disposal of the organic from Tank C-103 shall facilitate decontamination so that the equipment

can be decommissioned and disposed. Guidance for equipment design to facilitate eventual decommissioning and disposal shall be obtained from DOE Order 6430.1A, Section 1300-11. Most equipment that has come in contact with Tank C-103 liquid will be treated as mixed-waste contaminated until it has been adequately decontaminated. The following principles shall be employed to the extent practicable.

- Designs that ease cut-up, dismantlement, removal, and packaging of contaminated equipment shall be employed.

- Modular, separable enclosures for radioactive and other hazardous materials shall be used to preclude contamination of fixed structures.

- Ventilation filters shall be located at or near individual enclosures to minimize long runs of internally contaminated ductwork.

- Penetrations shall be designed to minimize technical and mechanical problems associated with closing and sealing at the time of decommissioning.

- Surfaces should be free of crevices, ledges, and/or protrusions that could collect radioactive material.

- Drains and similar piping shall have physical provisions for cleaning.

- Systems shall be flushable.

- Piping systems shall be sloped and free of traps except as required for process isolation.

- Adequate clearance shall be provided for equipment transfer.

- Lifting lugs shall be used on large tanks and equipment.

- Modular radiation shielding shall be used instead of, or in addition to, monolithic shielding walls.

The project shall be designed to minimize hazardous and nonhazardous waste generation and use of hazardous materials during construction, operation, and decontamination/decommissioning. Materials used that are hazardous, or likely to be designated as hazardous waste at disposal, shall be documented by the project on drawings or other design media as appropriate.

Where lead or similar hazardous materials are used for shielding or other purposes, the item shall be encapsulated to prevent radioactive contamination and to allow retrieval in an uncontaminated condition. The item shall be permanently marked as to its contents.

Disposal of the individual organic retrieval, treatment, and disposal system components will be handled separately. These components will be designed to ease removal from the system and decontamination to the extent practical. Portions of these components not adequately decontaminated will be stored as mixed waste. Decontamination decisions will be made to ensure cost-effective operation. Decontamination and disposal will be further defined during definitive design. Reuse of some components is also under consideration.

3.5 NATURAL FORCES CRITERIA

The components for the removal, separation, and disposal of the floating organic layer in Tank C-103 that are important to safety shall be designed taking into consideration the loads generated by seismic events and other natural phenomena. The methods given in Hanford Plant Standard (HPS), Standard Design Criteria (SDC) 4.1 shall be applied in analyzing structural integrity of those structures, systems, and components. This section

discusses the naturally occurring design basis accident scenarios that shall be considered during preparation of the safety analysis and project design phase.

Due to the relative short duration and type of operation of this project, waivers for some of these design criteria will also be submitted.

3.5.1 Design Basis Earthquake

All systems components and structures shall be designed for the design seismic load as specified in HPS, SDC 4.1 and DOE Order 6430.1A for safety class 3 unless approved waivers are obtained.

3.5.2 Design Basis Flood

The elevation of the 200 Areas has been judged to be outside the maximum extent of the Hanford Site design basis flood.

3.5.3 Volcanic Eruptions

The location of the Hanford Site suggests that volcanic action could provide ashfall that may affect operation. The safety class items design shall include as required by HPS, SDC 4.1, protection from ash resulting from volcanic eruption unless approved waivers are obtained.

3.6 ADDITIONS TO TANK 103-C

This preliminary design report includes the flushing liquids back to Tank C-103. Pursuant to compliance with Public Laws 101-510, Section 3137 (Wyden Amendment), it is unclear at this time whether approval of the Secretary of DOE will be required to route these liquids back to Tank C-103.

A decision will be made during definitive design and any impact to the mission will be addressed accordingly.

4.0 PROCESS SYSTEMS

The process systems are divided into three main categories: (1) removal of organic, (2) aqueous-organic separation, and (3) organic receiving. This section reviews each of these systems, including systems descriptions and arrangements; instrumentation and controls; system interfaces; and operations. Also provided in this section are discussions of pre-startup testing, long term storage, radionuclide separation, and disposal.

4.1 REMOVAL OF ORGANIC

The following description of the organic removal process consists of two sections: system design and system operation.

4.1.1 Organic Removal System Design

This system design description consists of four sections: a general description of the system, the system arrangement, instruments and controls, and system interfaces.

4.1.1.1 System Description. The organic removal system will be temporarily installed in Riser 02 of Tank C-103 to remove the 2-in. thick organic layer. The organic layer is floating on a layer of aqueous supernate estimated to be 1 ft to 4 ft thick. The organic removal system is designed to skim off the organic layer while minimizing mixing within the underlying supernate layer and between the organic and supernate layers. Liquid skimmed from the tank will be pumped to a separation enclosure containing filters and a coalescer to facilitate the separation of the organic from residual supernate. After treatment in the separation enclosure, any recovered supernate will gravity flow or be pumped back into Tank C-103 through the salt well located in Heel Pit 03B.

4.1.1.2 System Arrangement. The following system arrangement is one proposed design which would meet the functional and process requirements specified in Section 3.

The organic removal system is designed to be installed through and structurally supported by Riser 02, which has a nominal 12 in. diameter flange. The organic removal system is composed of three main components: (1) the decontamination collar, (2) the shielding enclosure, and (3) the skimmer pump assembly. The decontamination collar will contain spray nozzles for decontamination, the shielding enclosure will shield the top of the riser and will provide a solid base to mount the support mast for the pump assembly. The pump assembly consists of a pump and skimmer suspended below the riser on a solid support mast (see Appendix A, drawing ES-ER-5602-M1). A discussion of the removal system components is provided below.

At the top, a shielded, flanged decontamination collar will contain high-pressure decontamination nozzles and will be compatible with the nominal 12-in. riser flange. The decontamination collar assembly will also be integrated with the existing Tank C-103 HEPA filter. This system will continue to provide passive ventilation of the tank head space. The decontamination collar will be operated whenever the pump assembly is being removed from the tank.

The shielding enclosure will be fabricated from a section of nominal 12 in. diameter pipe and will be designed to be bolted to the top flange of the decontamination collar. All penetrations in the riser assembly will be air and liquid tight to prevent the accidental release of contamination. A pump support mast will be attached to the underside of the shielding enclosure and extend into the tank. The attachment of the mast to the enclosure will be designed to be a non-moment bearing connection. The bracket on the lower end of the support mast will rigidly support the pump, coupling, motor, and (if required) gear box in a vertical shaft orientation without rotation. The pump will self-prime to 3 ft and will have mechanical seals. The floating skimmer

will be supported below the pump support bracket to prevent the pump suction connection or pump pulsations from tipping the skimmer.

Installing the removal system will require special evaluations including the potential for critical lifts and dome loading. A safety analysis of this installation is scheduled.

The pump assembly includes the skimmer, the pump, a hydraulic motor coupled to the pump shaft and a flexible connection between the skimmer and the pump. The pump is required to be variable speed and reversible with the ability to pump solids up to 0.25 in. in diameter.

The engineering requirements for the skimmer and pump include the following:

- Variable speed
- Low flow = 0.6 gal/min
- High flow = 2.0 gal/min
- Pressure limit = 100 lb/in^2
- Operating pressure = 60 lb/in^2
- Pump inlet and outlet size = 1.5 in.
- Piping size = Depending on Reynold's number calculations (1/2 to 1 in.)
- Dry prime to 3 ft.

The skimmer and pump system must fit down a nominal 12 in. riser. The skimmer chosen for this application is over 12 in. long horizontally. The skimmer will have to be lowered with this side in the vertical direction, then righted when it reaches the liquid level.

The skimmer is a stainless steel rectangular float with a central sump. Entry to the sump is from a floating weir hinged to the body of the skimmer. In front of the weir is an elastomer flap. This flap provides the liquid-tight seal to the aqueous solution below the organic. A port at the center of

the back side of the skimmer connects to a flexible hose connected to the pump inlet.

The pump is a dual-lobe, positive displacement type. The dual lobe style is recommended by the vendor for minimum mixing/agitation of fluids with discrete particles. For this application, the single lobe provides the lowest fluid shear in this model pump. The pump requires testing to confirm its low fluid shear capabilities for this application.

The pump will be positioned approximately 3 ft above the liquid surface. A flexible connection will connect the pump inlet to the skimmer float. The connection of the float skimmer will be designed to allow for a minimum of 1 ft of variance of the liquid elevation in the tank and will not interfere with the operation of the skimmer. A safety bridle will be attached between the pump and float to allow recovery should the flexible connection break. For draining the pump suction and discharge lines, the pump and motor will be reversible. The pump shall also be capable of self-drainage.

The hydraulic motor is directly coupled to the pump shaft and mounted to a foot bracket on the same base as the pump. The inlet and outlet to the motor are ported at the rear. The drive unit is located approximately 50 ft from the motor at grade level. The hydraulic motor is driven by a 3 hp, 230 V, 3-phase electric motor. The hydraulic system is reversible via a directional flow control switch and variable speed via a flow control. The hydraulic system has an over pressure switch that can be set manually. Testing to determine the hydraulic system's over pressure which correlates with the organic layer process system's 100 lb/in^2 pressure limit is required.

To avoid emulsification that can prevent separation of the aqueous and organic phases in the coalescer, the pump, piping, fittings, and valves will be designed to have laminar flow with a Reynold's number of 2,000 or less at a flow rate of 0.6 gal/min. The pump will be capable of passing 0.25-in. particles and sludge or floating solids that may be on the surface of the organic layer or at the aqueous interface.

The pumped liquid will be delivered a vertical distance of 33 ft to the top of the riser, through a separation enclosure, and 15 ft vertical (maximum) to the fill port on the top of the trailer mounted container that will be placed 10 ft beyond the Tank C-103 perimeter, a horizontal distance of 50 ft. The separation enclosure will have piping, valves, filters, and a coalescer as the major pressure drop producing elements. Aboveground, pumped liquid will flow in a pipe or hose inside a shielded secondary, containment pipe. Self-sealing, no drip, quick disconnect couplings will be used at all field break connections. The overall pressure drop for these components at 5 gal/min is assumed to be 60 lb/in^2 with dirty filters.

For As Low As Reasonably Achievable (ALARA) consideration, shielding will be placed around the tank riser, decontamination collar, and shielding enclosure to minimize radiation exposure levels. The tank riser will be shielded by placing a collar of pipe around the riser. Shielding for the decontamination collar and shielding enclosure will consist of a shell that can be attached and easily removed if needed. The thickness and type of shielding material required will be determined during detailed design.

The pump and all components in the tank will be designed to be operable at the end of 15 weeks (2,500 hours) in the tank after a radiation dose of 250,000 Rad. Appendix B includes the engineering assessment for this radiation level. All in-tank components exposed to liquid or vapor will be compatible with organic and aqueous liquid with nominal viscosities of 3 and 1.7 cP and specific gravities of 0.868 and 1.1, respectively. The components must be compatible with solutions of pH from 7 to 10. The organic nominal composition will be 70% TBP and 30% NPH. The nominal composition of the aqueous is dilute sodium nitrite with minor amounts of nitrate and sulfate ions. All components in the tank will be 304 or 316 stainless steel, Kalrez, or other materials known by test to be compatible with the chemical and radiation concentrations in the Tank C-103.

4.1.1.3 Instrumentation and Controls. Instrumentation and controls for the organic removal system will consist of a hydraulic motor on/off switch and a

directional flow control switch that allows manual flow rate adjustment of the variable speed drive. The removal system will be operated from the control trailer.

4.1.1.4 System Interfaces. The liquid removal system will be designed to interface with the separation enclosure, the truck loading station, and the high-pressure decontamination pump. Three general categories of interfaces will exist: (1) process control, (2) process piping, and (3) electrical. A description of the system interfaces by categories is provided below.

Process Control

The variable frequency variable speed drive will interface with the microprocessor process control system. Organic flow rate, tank liquid level from the separation enclosure, and tank trailer level signals will provide primary input for control of the organic recovery skimmer pump system. Automatic system shut-off will occur if process piping, separation enclosure, or truck-mounted tank system leakage is detected or radiation limits are exceeded by either of the in-line monitors.

Process Piping

Process piping will consist of one section of double containment piping that connects the pump discharge line from the shielding enclosure to the separation enclosure. The primary and secondary pipelines will be fabricated from steel and will have welded connections. The double containment pipeline will be sloped to drain from the separations enclosure to Tank C-103 through the shielding enclosure mounted on Tank C-103. A weep hole will allow the secondary containment line to drain into the riser mounted shielding enclosure. Shielding requirements for the secondary pipeline will be specified in the final design.

Electrical

The hydraulic motor is driven by a 3 hp, 230 V, 3-phase electric motor. The electric drive will be outside of Tank C-103.

4.1.2 Organic Removal System Operation

All operations of this system will be strictly controlled through the use of engineering and administrative controls. Engineering controls are the focus of this PDR. Administrative controls will include the use of approved procedures and personnel that have fully completed approved training.

The planned process at Tank C-103 is to lower the pump assembly by crane through the nominal 12 in. diameter Riser 02. Critical lift procedures will be used if necessary. The 2-in.-deep floating organic will be removed to within 2 mm of the aqueous interface with a minimum intake of aqueous. The aqueous interface will be determined by a probe lowered into Tank C-103 through a different tank riser. Following removal and decontamination the nominal 35-ft-long pump and skimmer support will be cut into appropriate lengths for disposal.

4.1.2.1 Normal Operations. Startup of the organic removal system will follow a standard procedure. The appropriate valves in the shielding enclosure and the separation enclosure will first be positioned and confirmed. The desired pump flow rate will be set and instrumentation operability will be verified.

During normal pumping the organic layer and some supernate will be skimmed from the tank and pumped to the separation enclosure. In the separation enclosure the organic layer will be separated from the supernate and transferred to the storage container; the supernate will then be returned to Tank C-103. The initial pumping rate from the tank is expected to be 2 gal/min. This rate will be decreased as the organic layer falls below approximately 10 mm. The final level will be 2 mm. The criteria for 2 mm is based on work performed by Burelbach (Burelbach 1994), Fauske and Associates, Incorporated (FAI 1994), and onsite testing of equipment and simulants.

A series of organic removal tests using chemical simulants were performed by WHC at the Chemical Engineering Laboratory (CEL). These tests indicate that efficient removal of the organic can continue until the organic layer reaches its minimum height. When the organic layer height reaches its minimum limit, the organic layer breaks apart forming pools of organic separated by uncovered aqueous. At this point, the flow of organic towards the organic removal equipment becomes very inefficient. Other tests performed at the CEL, again with simulants, determined that the minimum organic height is less than 1 mm.

The total organic phase in the tank is believed to be approximately 5,000 gal, with a successful removal process leaving only 200 gal of organic in Tank C-103. Based on pilot plant testing skimmer operation should recover at least 4,000 gal of 100% organic phase. In-line radiation monitoring will be used to detect an increase in aqueous phase pumping. This will allow better control of operations and lower system radiation levels. The system will be designed for both daily and extended (> 2 day) shutdowns and for continuous operations. Current plans favor continuous operations.

Shutdown of the liquid removal system will follow a standardized procedure. For short (overnight) shutdowns, the piping will be drained to prevent freezing during cold weather. The coalescer, however, will not be drained. For longer-term (weekend or longer) shutdowns and shutdowns for equipment maintenance, the separation enclosure equipment and piping may be drained and flushed with small volumes of inhibited water. The resulting decontamination water will be discharged to Tank C-103. The appropriate valves in the separation enclosure will be positioned to prevent backflow to the pump assembly. Backflushing of the skimmer pump discharge will be routed back through the pump with the pump operating in reverse. There will be sufficient clearance between the lobe impeller and the casing to provide for drain back through the pump without pump operation at all.

During final shutdown and removal, the flushing will be repeated; piping, hydraulics, and auxiliary systems connected to the shielding enclosure

will be disconnected; and the enclosure and pump support mast will be lifted from the tank while the decontamination collar is used to spray the equipment with decontamination water. Following the successful removal of the pump and skimmer system, the decontamination collar will be removed, and a blind flange will be placed on the tank riser.

4.1.2.2 Abnormal Operations. The organic removal system will be designed to mitigate the effects of or provide a recovery method from the following abnormal operating conditions.

- Cavitation or suction starvation of the recovery pump will be prevented by correct placement of the pump in the tank.
- Over-pressurization will be limited by pump design and hydraulic control and will be monitored by the process control system. The system will include automatic shut-off due to high pressure.
- Detection of high radiation levels by the in-line monitors

4.2 AQUEOUS-ORGANIC SEPARATION

In the skimming operation there is a transition from the removal of pure organic to a mixture of organic and aqueous with the aqueous fraction increasing as the organic layer is reduced. The separation of the aqueous from the retrieved organic and the return of the aqueous to the Tank C-103 is performed by a coalescer located in a separate shielded enclosure.

4.2.1 Aqueous-Organic Separation System Description

The shielded enclosure houses the aqueous-organic separation system that consists of the following:

- Pre-filters
- Coalescer

- Aqueous drain tank
- Aqueous return drain tank pump.

The pre-filters remove particulates from the separation system inlet. The coalescer separates the organic and aqueous phases. The aqueous drain tank serves many functions including temporary storage of separated aqueous, aboveground system drain, separation enclosure sump, and flush tank. The aqueous return drain tank pump is one method to transfer the contents of the drain tank to Tank C-013.

4.2.2 Aqueous-Organic System Arrangement

The following system arrangement is one proposed design that would meet the functional and process requirements specified in Section 3.

The separations system is designed to be installed separate from Tank C-103. It is connected to the organic removal system through double-wall piping. Double-wall piping is also used as the return line to Tank C-103 from the aqueous drain tank.

The first component of this system is the pre-filters. The pre-filters prevent the particulates from plugging the coalescer. Three coalescer pre-filters are provided, but only one pre-filter is on-stream at a time. The sintered metal cartridges are rated for 5 μm particles and the filter housing is drainable. The filter system design is still preliminary due to concerns regarding particle volume, size, filter size, flushing, and system plugging. A separate study is reviewing these issues. The results of this separate study will be evaluated and incorporated into the definitive design.

The filtered organic and aqueous waste is pumped by the skimmer pump into the coalescer which is constructed of 6 in. schedule 40 pipe fabricated in the shape of a tee. The coalescer is installed with the long leg in the horizontal position and the two short legs in a vertical orientation. The

feed is introduced into the horizontal leg of the coalescer which contains a hollow, cylindrical spun glass coalescer element. The emulsion of Tank C-103 aqueous and organic waste flows radially from the hollow core of the coalescer element to the exterior. The density of the spun glass in the coalescing element is varied radially from the interior to the exterior of the element. Initially, the fluid passes through a low density spun glass zone that strips away any colloidal dirt film that surrounds the droplets. The second zone is high density spun glass where the droplets are brought into close contact and begin to coalesce. A second zone of low density spun glass increases droplet size and a screen covering the coalescing element is the site for droplet release. The coalescing element is manufactured without adhesives or binders that could be degraded by chemicals or radiation. The spun glass is resistant to both.

The enlarged droplets formed in the coalescing element, separate by gravity into two distinct phases. The fluid velocity through the coalescer is sufficiently low to allow fine droplets of aqueous or organic to migrate to the respective phases before exiting the unit. The aqueous accumulates in the down-leg of the "tee" and the organic rises and exits the coalescer through the upper section of the "tee". Performance testing of the coalescer was performed at WHC's CEL with chemically equivalent simulants which included additives to further simulate the disengaging times determined by observing actual tank waste organic/aqueous samples. This testing has shown the organic outlet stream will contain no more than 0.2% aqueous phase.

The skimmer pump transfers the Tank C-103 organic through the coalescer to the truck-mounted tank. As the mixture of aqueous to organic increases with the decrease in the organic level in Tank C-103, the interface between the two phases will tend to vary. An interface control valve in the aqueous return maintains the interface at a constant level.

The aqueous drains into the drain tank and is pumped by a positive displacement pump to the salt well pit on Tank C-103, far removed from the organic recovery operation at the Riser 02. The coalescer aqueous stream may

also be valved to gravity drain to the salt well pit. The separation between recovery and return is to prevent the C-103 sludge layer from being dislodged and pumped to the separation enclosure where the sludge impact coalescer performance. The drain tank also serves as aboveground system and drain sump for the separation enclosure. As a system drain, the drain tank will capture purified organic from the overground transfer lines at shutdown. The drain tank should be sized to accommodate twice the volumetric capacity of the aboveground system, excluding the trailer mounted container.

The drain tank also serves as flush tank. This tank is vented to the separation enclosure. The open vent prevents the tank from becoming pressurized and forcing process solution out of the separation enclosure through the flush connection. Flush solution added to this tank can be circulated through the filters and coalescer returning to the drain tank. After the operation is completed, all separation enclosure piping can be flushed via the drain tank.

A sump leg and valve allow the drain tank pump to return any accumulated aqueouls or flush liquids in the enclosure to C-103. An additional option is a valve, located on the tank vent line, at the top of the drain tank. If the sump pump fails, pressurization of the drain tank via the flush connection will allow drainage of the tank.

In consideration of the maintainability functional requirements in Section 3.3, an equipment arrangement was prepared that allows for contact maintenance of valves, pump, instruments and monitors. The drain tank, the coalescer, and the pre-filters are not maintainable by contact methods because of the high radiation field associated with them. In addition, they are isolated and shielded from personnel.

Appropriate compensating measures have been taken to ensure that non-maintained items are functional for the life of the project. The coalescer element cannot be replaced, but the unit is oversized, thus increasing the operational life in an operation that is of short duration. The filter

element cannot be replaced, but currently three filters are required. The drain tank is stainless steel, all-welded construction and is not likely to fail or plug.

The separation enclosure is divided into two compartments by a partition. The arrangement is similar to a common design used in plutonium operations. The so-called cabinet design has an operating side and a maintenance side. Contamination control, a priority in maintenance of plutonium equipment is effected by locating the maintenance side in a room separate from the operating side. The maintenance side is normally accessible only when significant repairs or changes in process are required. The partition between the maintenance side and operating side of the cabinet serves as a radiation shield of expected high exposure items.

The partition wall in the separation enclosure serves a similar purpose, shielding the operator from the radiation emissions from the drain tank, coalescer, and filter. Located on the operating side is the pump, valves, and instrumentation which are accessible for maintenance through removable panels. The extension rods for the valve handles pass through the operating side panel. The backside of the separation enclosure is sealed; the only access is through the lid. The radiation monitors are located on the operating side, one on the inlet and the other on the outlet of the coalescer. Other instrumentation in the operating compartment includes the interface detector, liquid-level detectors, flowmeters, and the temperature element.

4.2.3 Instrumentation and Control

A trailer located outside the C Tank Farm fence is the control room for the separation enclosure, the skimmer pump and the tank truck. The display in the control trailer allows the operator to monitor and control the operation. A self-contained standalone microprocessor handles the analog inputs, analog outputs, discrete inputs, and discrete output. The microprocessor controller

is contained in a cabinet with the analog and discrete termination panels and signal conversion modules.

The separation enclosure instrumentation is primarily for monitoring and controlling the coalescer. The only control loop is associated with the coalescer. A level monitor instrument will be used to position of the aqueous drain valve.

The performance of the coalescer is indicated by radiation monitors fixed to the coalescer inlet pipe and the outlet pipe. The ionization chambers, which are shielded from background radiation, detect the level of radioactivity of the feed and the separated organic. The continuous online monitoring of the radioactivity in these streams provides the operator with immediate indication of the inability of the coalescer to effect a clean phase separation. A high level of detected radiation in the organic will actuate an interlock shutting down the skimmer pump.

There are two options for aqueous removal from the coalescer. The primary option is by gravity drain directly from the coalescer to Tank C-103 controlled only by the aqueous discharge control valve. As a back up pumping is possible from the drain tank as follows.The aqueous draining from the coalescer accumulates in the drain tank until the liquid level reaches the high-level detector, which causes the switch to close, starting the drain tank pump. Transfer of aqueous waste to Tank C-103 continues until the pumping has lowered the liquid level to the low level detector, which switches the pump off. The drain tank is also equipped with a high-high liquid level detector that is a backup to the high liquid level detector. If liquid in the drain tank should exceed the level that would normally cause the pump to start because the high level detector-switch system failed then the high-high liquid level actuates an interlock that shuts down the skimmer pump.

A liquid detection probe is used to detect leakage into the separation enclosure sump. When contacted with any liquid solution, this probe actuates an interlock that shuts down the skimmer pump.

The coalescer performance is best at temperatures greater than 25 °C. A temperature device is mounted in the organic product line. The temperature of the Tank C-103 waste and the heat from the drain tank pump is expected to maintain the operating temperature of the coalescer above 25 °C. However, a winter operation is planned that could cause unacceptably low system temperature. Manually adjusted electrical resistance heating of the coalescer is provided to increase the coalescer temperature to the optimum level.

Flowmeters on the coalescer feed and aqueous drain lines are of primary importance to the skimmer operation. The skimmer pump flow rate is reduced as the quantity of organic in Tank C-103 is reduced. Reducing the pumping rate reduces the quantity of entrained aqueous removed in the skimming operation. The pumping rate is highest initially when the skimmer is removing pure organic. The coalescer feed flowmeter indicates to the operator that the desired skimmer flow rate is being maintained and the microprocessor controller calculates, totals, and displays the organic processed. The total is verified by the liquid level measurement on the truck-mounted tank. The pumping rate is reduced when the skimmer pump begins removing aqueous. The fractional flow of aqueous at the lower pumping rates varies from 10% to 90% of the total flow, hence the aqueous flowmeter has a lower flow rate range than the feed flowmeter. Performance testing of the combined system will determine the optimum operating parameters. The flow rate from both flowmeters and the total organic and aqueous recovered is displayed in the control trailer.

Pressure readings are by gauges located on the upstream and downstream side of the prefilters and the coalescer. The pressure gauges are the only locally mounted instruments in the enclosure. A high differential pressure between upstream and downstream gages indicates a plug. The flowmeter on the feed to the coalescer will actuate an interlock on low flow shutting down the skimmer pump.

4.2.4 Aqueous-Organic Separation Interfaces

The aqueous-organic separation enclosure is connected by encased lines to the Tank C-103 and to the trailer mounted container tank. There are two encased lines from Tank C-103, the discharge line from the skimmer pump to the enclosure and the aqueous return to the salt well riser, and one encased line connecting the coalescer to the trailer mounted container. A filtered vent line at the separation enclosure is connected to the existing charcoal filter system on the tank.

4.2.5 Operation of the Organic Removal and Separation Facility

All operations of this system will be strictly controlled through the use of engineering controls and administrative controls. Engineering controls are the focus of this PDR. Administrative controls will include the use of approved procedures and personnel that have fully completed approved training.

As currently planned, the Tank C-103 organic removal and separation facility will be designed to operate both continuously and as a two-shift per day (12 hr/day) operation. Thus, daily startups and shutdowns may be the normal operating mode. A daily shutdown would not necessarily require complete draining of all equipment in the facility. However, for shutdowns of a weekend or longer in duration, draining and, possibly, even cursory flushing of the equipment may be desirable. Startups will also be different, depending on whether the entire system was drained during the previous shutdown.

The operational activities involved in the various operating phases and during off-normal operations are described briefly in the following subsections.

4.2.5.1 Startup. Initial pre-startup or pre-startup anytime after the equipment in the enclosure has been drained will require that an aqueous level be established in the coalescer. This is accomplished by adding approximately 25 L (6.5 gal) of water to the drain tank and pumping it through the filter and into the coalescer. The other pre-startup activity involves the usual

check of the instruments for operability and status of the enclosure equipment.

Startup of the aqueous-organic separation system occurs simultaneously with startup of the organic removal system. The startup operation involves the following activities:

- Open the inlet and outlet valves to the appropriate (initially, the No. 1) filter
- Position the valve in the organic discharge line to route the organic to the trailer mounted container
- Switch the control valve in the aqueous discharge line from the coalescer to automatic operating mode
- Turn on the power to the aqueous discharge pump and position the valve in the pump discharge line to route the aqueous to Tank C-103
- When the skimmer pump is turned on, the filter inlet and outlet pressures and other instrumentation in the control trailer should be monitored closely to verify proper operation of the system.

4.2.5.2 Normal Operation. Normal, steady-state operation of the organic removal and separation facility will be, essentially, a hands-off operation, with operational duties consisting of monitoring the instruments to verify continuing, steady operation of the equipment. It is expected that the pressure drop across the filter will increase slowly until the flow to the coalescer commences to decrease, at which time the flow would be diverted through the second filter. This pressure increase and flow decrease should, however, occur over a relatively long period of time.

As the depth of the organic layer decreases, the pumping rate must also be reduced to avoid pumping excessive aqueous through the system. Entrainment of aqueous during pumping of the first ~10,000 L (~50%) of the organic is undesirable, as it increases the possibility of interfacial and other suspended solids being entrained, with the accompanying premature plugging of the filter.

4.2.5.3 Shutdown. The procedure for a daily shutdown will include turning off the power to the pumps and closing the inlet valve to the filter and the valves in the organic and the aqueous discharge lines from the coalescer. The control valve in the aqueous discharge line should be closed by switching the controller to manual operating mode and the valve control position to closed.

Shutdown for an extended period (weekend or longer) involves draining the lines and the coalescer and water flushing the coalescer and the lines in the enclosure. The sequence of activities for extended shutdown are as follows.

- Shut off the organic skimmer pump in Tank C-103.

- Switch the coalescer interface controller to manual operating mode and set the valve at full open. (This will allow both aqueous and organic phases, including the organic in the discharge line to the trailer tank, to drain into the drain tank). After ~5 minutes, close the valve in the organic line to the trailer tank.

- Leave the inlet and outlet valves to the filter open for ~5 minutes after turning off the skimmer pump. (This will allow the feed line from the skimmer pump, the filter, and the line from the filter to the coalescer to drain back into Tank C-103).

- Switch the aqueous discharge pump to manual operating mode so that the heel in the drain tank can be pumped to Tank C-103. Continue

to operate the pump for ~5 minutes after the low-level shutoff is activated.

- Add flush water to the drain tank and pump to Tank C-103.
- Position the three-way valve in the pump discharge line and the three-way valve upstream of the filters to recycle solution back through the system.
- Close the aqueous letdown (interface control) valve.
- Add 11 gal of flush water to the drain tank and pump through the system into the coalescer. The liquid level should register as an interface on the interface recorder, then should go to 100% of chart.
- Drain the drain tank and pump the flush solution to Tank C-103.

The flush sequence can be repeated for as many flushes as desired. When the flushing is completed, the valves in the feed line from Tank C-103, in the organic discharge line to the trailer tank and in the aqueous discharge line to Tank C-103 (or the CR Vault) are closed.

4.2.5.4 Off-Normal Operation. Off-normal operation of the Tank C-103 organic removal and separation facility is defined as any operation or equipment failure that inhibits the normal removal of organic from Tank C-103, separation of the organic from entrained aqueous, or transfer of the organic into the trailer mounted container. Thus, filter plugging or any equipment malfunction or failure would be considered as off-normal operation. The following is a list of the more probable causes of off-normal operations and appropriate responsive/corrective actions.

- Filter plugging - Current design identifies three filters in parallel with one filter online at a time and some flushing

capabilities. A formal study is being performed to review the issue of filter design, including the potential to plug and means to flush. The results of this study will be reviewed and incorporated in definitive design.

- Malfunction in the instrumentation may or may not require a shutdown, depending on the nature of the malfunction, the time required for repair/replacement, and effects on operations. Thus, a minor malfunction on the cold side (outside of the enclosure) would probably not cause any perturbation to the process, while failure of the interface control element on the coalescer would require a shutdown, at least a cursory flush of the system, and removal of an access cover to the maintenance compartment of the enclosure for replacement.

- Failure of the drain tank pump will require an extended shutdown, flushing of the system, and removal of one or two of the access covers to maintenance compartment of the enclosure.

- Failure of the interface control motor-operated valve will require a short shutdown and draining of the system. The system might or might not require internal flushing, depending on whether the failure is with the valve, per se, or with the operator. Access to the maintenance compartment would be required in either case.

- Failure of a manual valve could be by either of two mechanisms - - packing failure or loosening of the components, causing leakage or valve stem failure. The latter mechanism, breaking or twisting off of the stem could be caused by an improper operating practice or by partial seizing of the ball. Either stem failure or a severe leak would require shutdown, internal and, possibly, external flushing, and removal of an access cover to the maintenance compartment for replacement. Small leaks may not functionally affect operations but may require specific action and

reporting in accordance with DOE and WHC requirements including off-normal event criteria and responses.

- Failure of the "filtration" cartridge in the coalescer, like plugging of all three filters, would require a complete extended shutdown, draining of the equipment, extensive flushing (both internally and externally), and probable removal of the enclosure to T Plant or some other containment facility for more extensive decontamination and replacement.

- Failure of the interface detection element will require a short shutdown, draining, and flushing of the system, and removal of one of the access covers to permit replacement of the element.

4.3 ORGANIC RECEIVING

The aqueous-free organic will be routed directly from the coalescer, via a double-contained, overground pipeline, to a 6,000-gal receiver tank. The organic will then be transported to an interim storage location to await pump out and ultimate disposal.

4.3.1 Systems Description

The storage and transport system will consist of a tank mounted on a lo-boy trailer. The following requirements outline the concept:

- **Tank:** The tank should consist of mild carbon steel, American Society for Testing and Materials (ASTM) A36 structural steel or equivalent, with a capacity of 6,000 gal. The tank must be vertical in configuration and supported to allow visual inspection of the tank bottom as well as sides. The tank must also have five 4 in., 150 lb flanges to facilitate organic sampling, tank pump

out, and related instrumentation. The tank must be designed to be certified under all applicable standards, most notably the American Petroleum Institute (API) standard, *API 650-88: Welded Steel Tanks for Oil Storage*. The tank must also be capable of accommodating the weight of worker(s) requiring access to the tank top instrumentation and fixtures. The tank must be transportable, meeting static and dynamic loading conditions as well as fully sealed (e.g. "buttoned up") during any transport. Finally, the tank must be fabricated for a maximum design life of five years, with consideration given to seismic events.

- **Lo-Boy Trailer:** The trailer should be capable of supporting a 100,000 lb (50 ton) load, located towards the rear axle. This represents the weight of the organic, tank, shielding and other equipment. The trailer must also be able to dimensionally accommodate the receiver system in length and width.

- **Shielding:** A minimum of 4 in. of concrete shielding are required to ensure personnel protection. The shielding should be pre-formed walls to form a "box" (sides and bottom) around the tank. Personnel exposure must not exceed 100 mR/hr and achieve ALARA principles.

- **Visual Inspection System:** Removable access ports will be provided at the four corners of the shielding enclosure, or placed to allow visual inspection to the tank surface for leakage.

- **Sample Points/Pump Out:** The sample points must discharge at a level greater than the free surface of the organic to prevent siphoning. The sample points, pump out and all other instrumentation must be extended to the side of the tank/shielding to ensure personnel protection.

4.3.2 System Arrangement

The trailer mounted container will be parked on a temporary, bermed containment pad, designed to retain the entire volume of the tank in the event of a leak. The pad will be located parallel to the C Tank Farm perimeter fence approximately 35 ft from the separations enclosure. After the Tank C-103 pumping is completed, the trailer mounted container will be moved to a similar bermed containment pad in the B Tank Farm area.

4.3.3 Instrumentation and Control

The trailer mounted container is equipped with a vacuum/pressure gauge, a vacuum relief device, a rupture disk, a temperature sensor, and a liquid level detector. The temperature and liquid level readings will be displayed in the control trailer. The pressure reading is displayed on the gauge at the tank. Control (of the tank liquid level) will be automatic. In addition, the fill rate, particularly, as the organic volume approaches 5,000 gal, will be very slow so that there will be more than adequate time available manually to stop the pumping before the tank overfills.

Controls will be established to maintain worker safety. Dose rate calculations will be used to establish initial safe approach distances to the tank, unless surveillance information is being obtained. The calculations will be verified by actual measurements as the tank fills.

4.3.4 System Interfaces

The trailer mounted container will interface directly with the separations enclosure via the organic fill line and indirectly with the skimmer system via the "closed" line system that utilizes the skimmer pump to move the organic through the coalescer and into the trailer mounted container.

4.3.5 Operation of the Trailer mounted container

All operations of this system will be strictly controlled through the use of engineering controls and administrative controls. Engineering controls are the focus of this PDR. Administrative controls will include the use of approved procedures and personnel that have fully completed approved training.

Operation of the trailer mounted container will consist of the activities described in the following sections.

4.3.5.1 Startup. During the initial startup, the valves in the trailer mounted container nozzles that will be in use (vent line and fill line) will be opened. Thereafter and until the organic removal operation is complete, only the valve in the fill line will require opening. The vent valve will remain open during the shutdown periods.

4.3.5.2 Normal Operation. Normal operation of the trailer mounted container will consist of periodic readings of the liquid level, temperature, and pressure and periodic sampling of the tank contents.

4.3.5.3 Shutdown. Shutdown of the trailer mounted container will consist of closing the valve in the fill line. Final shutdown at the completion of the organic removal operation will consist of closing all valves on the tank and disconnecting the lines from the separations enclosure.

4.3.5.4. Off-Normal Operation. The more probable modes of off-normal operation of the organic trailer-mounted container tank include valve failure, connecter failure and overfilling of the tank. Valve or connector failure would require shutdown of all systems until the failed item is replaced. Overfilling of the tank would result in some organic being transferred, via the vent system, back into Tank C-103, or in the event of a loose connection on the trailer tank, a small amount may leak onto the containment pad. This would also require shutdown of the skimmer pump, transfer of the excess organic back into Tank C-103 using a temporary pump, closing all valves on the

trailer tank, and disconnecting lines. The probability of the trailer tank overflowing is very low, given the total organic available (~5,300 gal maximum and, possibly, no more than 4,500 gal) and the slow pumping rate (<0.1 gal/min of the last 500 gal). To be prepared for the overflow contingency, however, a portable pump and line should be available to transfer spilled organic or contaminated aqueous from the containment pad sump back into Tank C-103. Leak detection will be provided in the temporary bermed pad in C Tank Farm.

4.4 LONG-TERM STORAGE

Current plans call for pumping the organic phase of Tank C-103 into a trailer mounted container at the C Tank Farm and then moving the tank to a bermed area at the B Tank Farm for up to five years prior to final treatment, if necessary, and offsite shipment. This section will briefly discuss the issues involving long-term storage.

The long-term storage plan at B Tank Farm will be nearly identical to the temporary pad at the C Tank Farm (see Appendix A, drawing ES-ER5602-C2). It will be designed in accordance with WAC 173-303-630(7) including the following:

- Collecting and holding spills and leaks
- Holding the additional volume that would result from precipitation of a maximum 25-year storm of 24-hours duration
- Holding the volume of the trailer mounted container
- Providing positive drainage control
- Removing spilled or leaked waste and accumulated precipitation from the containment system (berm) in as timely a manner as is necessary to prevent overflow.

Leak detection systems in these types of containment are not required.

Due to the length of time the truck-mounted trailer may be in long-term storage, regulatory agencies have been contacted and required permitting action have begun. Required permitting actions include: development of a Notice of Construction (NOC) for the purposes of air permitting (NESHAP Subpart H and WAC 246-247) and preparing RCRA Part A permit revisions. The Part A permit revisions assume that an NOI is not required. The Washington State Department of Ecology (Ecology) has responded favorably that an NOI would not be required. Formal documentation is still being transmitted between WHC, DOE, and Ecology. Under the Part A requirements, these facilities may be built "at risk" but may not be used for the intended purpose of handling dangerous waste until the Part A revisions are approved.

4.5 PRE-STARTUP TESTING

Prior to commencing separation operations, significant pre-startup testing will be required. This testing will be controlled through the use of approved procedures and trained personnel. The pre-startup tests will include the following:

- Acceptance testing of all components
- Integrated tests of all actual equipment (with the exception of the trailer mounted container)
- A formal readiness review
- Field tests to ensure continuity.

4.6 RADIONUCLIDE SEPARATION

The process for separation of radionuclides in the organic to prepare it for disposal is undetermined at this time. The requirements for radionuclide separation are established by the disposal operation or by the transportation requirement whichever is the more restrictive. Diversified Scientific Services, Inc. (DSSI), a Chemical Waste Management, Inc. Subsidiary is one contractor that may treat the organic from Tank C-103. Disposal requirements are open until a firm with applicable permits, licenses, and methods is selected.

The concentration of radionuclides in the organic will change in the process of recovery. Mixing of aqueous and organic in the pump causes some extraction of radionuclides. The quantity of radionuclides to be removed from the organic by some process will be determined by the radionuclide concentration in the recovered organic and either the disposal requirements or the transportation requirements. Any sampling events that may determine final treatment and disposal will be performed in accordance with an approved Sampling and Analysis Plan and Quality Assurance Project Plan.

Offsite transport packaging for LSA liquid materials must meet the requirements of Title 49 of the Code of Federal Regulations (CFR) Part 173.411 (General Design Requirements) as well as 49 CFR 173.425 (Transport Requirements for LSA Radioactive Materials). Of particular interest relative to bulk shipment of the organic are the restrictions of 49 CFR 173.425(c)(2) which allows bulk transport of liquids only if the total radioactivity concentration does not exceed 10% of the specified LSA levels. Recent sample analysis of the Tank C-103 organic determined that the radionuclide concentration is in excess of the 10% LSA limit, hence, radionuclide separation is required to meet the transportation limit. Samples taken after separation may result in acceptable levels; however, a greater degree of radionuclide separation may be required by the undetermined disposal method.

Regardless of the actual radionuclide concentrations, the organic product can be moved in a motor carrier tank within the boundaries of the Hanford Site subject to onsite packaging and transportation safety

requirements, including ALARA. A packaging safety evaluation would have to be performed, documented, and approved to authorize the transport of a Type A or Type B quantity of fissile-exempt material. *Hazardous Material Packaging and Shipping*, WHC-CM-2-14, controls these activities.

The tradeoff study, *Removal Treatment and Disposal of Floating Organic Layer in Tank C-103* (SAIC 1994) evaluated alkaline washing at various 200 East Area facilities. A summary of this study is presented in Appendix C. If radionuclide separation is required, then alkaline washing, as described in the tradeoff study and found effective in a preliminary PNL test (Strebin and Fadeff 1994) is one option. The recovered organic, in this case, is trucked to one of the facilities identified in the tradeoff study as being most readily adapted to the washing process. These facilities are 204-AR Building, PUREX, and B Plant.

Ion exchange is another option that is attractive because of the simplicity of the equipment. A vessel loaded with an appropriate ion-exchange medium with demonstrated capability to sorb radionuclides from degraded PUREX solvent is easily adaptable to cleanup at the C Tank Farm, or in another facility like 204-AR Building. The ion-exchange process requires, unlike the alkaline washing process, additional testing to determine the ion-exchange column size and the stability of the ion-exchange medium that is used for long term retention of the radionuclides. Proper disposal of the ion-exchange medium may require elution of the sorbed radionuclides, and is an issue that future testing and evaluation will address.

4.7 DISPOSAL

Prior to land disposal, Resource Conservation and Recovery Act (RCRA)-regulated waste must be treated in conformance with standards at 40 CFR 268. One commercial firm offering mixed waste treatment services is DSSI, a Chemical Waste Management, Inc. company and part of Chem-Nuclear Systems, Inc. located in Kingston, Tennessee. Any firm chosen will possess the necessary

RCRA permit and radioactive materials license, and other environmental permits to treat the waste from Tank C-103, provided it can be transported by highway and received in compatible quantities.

A comparison of the waste code designation assigned to Tank C-103 in Hanford's Part A permit application was made to the waste code designations acceptable to DSSI. Two potential areas of concern are noted in this comparison: characteristics of corrosivity and reactivity. These designations apply to the aqueous in Tank C-103, however, they should not be assigned to the organic layer. Other concerns included the total chloride content, total phosphate content, and the Btu content of the waste. Laboratory analyses are necessary to confirm that all license and permit conditions can be met for the Tank C-103 waste. Such analyses are also necessary to demonstrate compliance with EPA waste treatments under 40 CFR 268.

Waste treatment by DSSI also constitutes waste disposal, since DSSI would use the organic from Tank C-103 as a fuel substitute. Following successful treatment, DSSI would furnish the generator a certificate of disposal in accordance with all Federal, State, and local regulations verifying that disposal or treatment was accomplished.

Other disposal alternatives have also been evaluated. Consideration was given to transfer of the organic to Idaho National Engineering Laboratory (INEL) for use as a fuel substitute in their calciner. Continued future operation of the calciner is questionable, however making this alternative unreliable. The option of using Scientific Ecology Group (SEG), another commercial waste treatment firm, was also evaluated. However, SEG does not have a permitted and licensed facility or established technology that could treat the waste. SEG is evaluating molten metal and other thermal destruction technologies for mixed waste treatment, but this company is at least two years away from being able to treat Tank C-103 waste.

5.0 SUPPORT SYSTEMS

5.1 CIVIL/STRUCTURAL

5.1.1 Site

Access to Tank C-103 will be through an existing gate located near the Northeast corner of the C Tank Farm as shown on Drawing ES-ER5602-C1 (Appendix A). Access for the trailer mounted container will require stabilization of approximately 700 ft^2 to allow the truck to back in and exit from the retention pad.

Excavation may be required for new electrical conduit.

5.2 MECHANICAL

5.2.1 Tank C-103

Supernatant fluid will be pumped out of Tank C-103 through the existing nominal 12 in. Riser 02. A positive displacement pump will be suspended from a mast through the riser to 3 ft above the supernatant liquid. Connected to the pump suction will be a flexible connection with a skimmer at the other end. The intent is for the skimmer to float on the organic supernatant liquid while the pump skims off the organic layer of the supernatant. Any aqueous liquid drawn up will be removed from the stream in the separation enclosure.

A shielding enclosure will cover the riser outlet. All piping into and out of Riser 02 will penetrate the shielding enclosure, which also acts as a ventilation trunk with a pipeline going to an existing HEPA filter assembly.

The pump discharge pipe is double contained once exiting the shielding enclosure.

5.2.2 Separation Enclosure

The separation enclosure is a free standing, dual compartment, steel enclosure which houses the necessary equipment to filter, coalesce, and monitor the supernatant liquid as it is separated into organic and aqueous phases. The organic supernatant proceeds on to the trailer mounted container, while the aqueous phases is collected in the drain tank and pumped or drained back to Tank C-103. (See Drawing ES-ER5602-M3, Appendix A.)

The separation enclosure is made up of a heavy shielded section and a light shielded section. The components exposed to the highly radioactive aqueous solution, (i.e., coalescer, filters, and the drain tank) are mounted in the heavily shielded section. The drain tank is fabricated with 1.5-in. thick plate for additional radiation protection. The lightly shielded section, containing the valving, radiation monitors, and instrumentation, is separated from the heavily shielded area by an additional shielding plate. Front removable access panels allow for equipment replacement and maintenance in the lightly shielded section only. Final thicknesses of the shielded plates will be determined during definitive design. One preliminary shielding calculation is contained in Appendix B.

The separation enclosure will normally be sealed. All internal valves have extension rods connected through enclosure walls to external valve handles. Enclosure penetrations and nonwelded seams will be fitted either with a gasket or packing glands. There will also be a vent line with a HEPA filter in it that goes back to the existing HEPA filter system at Riser 02.

Fluid entering the separation enclosure from Riser 02 flows through 1/2 in., schedule 40, stainless steel pipe and is filtered through one of a bank of three (5 μm) filters. The filters are in a parallel arrangement with all flow directed to only one filter at a time. The filtering system,

including flushing requirements, is currently being reviewed as a separate study. These results may impact definitive design.

From the filters, fluid proceeds through the coalescer. The coalescer separates the supernatant fluid into its organic and aqueous components. The organic supernatant then proceeds to the trailer mounted container. The aqueous supernatant is collected in the drain tank. The drain tank pump, which can take suction either from the separation enclosure sump or the drain tank, transfers the aqueous supernatant to Tank C-103. Gravity draining from the coalescer to Tank C-103 is also possible. There is a vent off of the drain tank with a HEPA filter that vents to the inside of the separation enclosure.

Transfer lines from the separations enclosure to the trailer mounted container drain back to the drain tank. The coalescer and filters can also drain into the drain tank. Fluid lines between Tank C-103 and the separations enclosure
drain to Tank C-103. Flush connections are located in the fluid line, one upstream and one downstream of the coalescer.

5.2.3 Trailer Mounted Orgainc Container

The organic supernatant is transferred from the coalescer in the separation enclosure through double contained interconnecting piping to the container.

The container will be a vertical, have a capacity of 6,000 gal, with an estimated diameter of 10 ft. The interconnect piping will connect up to an existing 2 in. nozzle equipped with a vacuum breaker and HEPA filter. The fill line will have a flush connection allowing back flushing of the line to the separation enclosure.

The container will be fitted with five 1/2 in., schedule 80, sample draw pipes from which samples at the 10%, 30%, 50%, 70%, and 100% capacity can be drawn. A vent line to a HEPA filtration system that will be tied to the existing charcoal filter on Riser 02 will allow the tank to respirate while filling.

5.2.4 Containment Pads

The trailer mounted container will be located in bermed containment pads at either the C Tank Farm or the B Tank Farm. The C Tank Farm pad will be used during organic separation when fluids are pumped to the trailer mounted container. the B Tank Farm pad will be used for long-term storage. Both pads will be built in accordance with WAC 173-303-630.

5.3 PROCESS CONTROL

5.3.1 Tank C-103

Instrumentation for Tank C-103 will consist of a leak detector on the double-encased pipeline between the tank and the separation enclosure. The signal from the leak detector will be fed to the programmable logic controller (PLC) in the control trailer. The transfer skimmer pump located in the tank will be controlled by a directional flow control switch and a hydraulic flow controller providing a reversible variable speed drive.

5.3.2 Separation Enclosure

The separation enclosure houses the filters, the coalescer, the drain tank, and monitoring instruments. Local pressure indicators will be located

at the inlet and outlet of the filters and the outlet of the coalescer. These indicators will help monitor the performance of the filters and the coalescer.

At the inlet of the coalescer, there will be a radiation detector and a flow measurement device. At the outlet of the coalescer, there will be another radiation detector as well as temperature measurement device. The radiation detectors will be used to determine the adequacy of the organic separation. Radionuclides are more prevalent in the aqueous solution than they are in the organic solution. The inlet and outlet radiation readings can be compared to determine how the separation process is working. Based on the outlet radiation reading, the operator can decide to continue the transfer to the tank trailer or terminate it. High-level radiation readings will shut down the system. The temperature and flow measurement systems will be used to ensure the inlet flow and temperature are maintained for proper coalescer operation.

Level instrumentation will monitor the level in the coalescer itself. Motor operated valves will be provided at the outlet and the drain lines of the coalescer for level control inside the coalescer.

At the drain tank, a flow measurement device will measure the flow through the drain line of the coalescer into the tank. The inlet flow to the coalescer can be compared to the flow into the drain tank to indicate the percentage separation for the aqueous and organic supernatant. In the drain tank, there will be three level switches for low, high, and high-high tank level indication along with a continuous level measurement system.

Finally, there will be a leak detector in the separation enclosure sump. Leakage will shut down the system.

All the signals from the instrumentation in the separation enclosure (except the local pressure indicators) will be fed to the PLC in the control trailer for monitoring and control.

5.3.3 Trailer Mounted Organic Container

The trailer mounted container will have temperature, level, and pressure measuring instruments with local indication. The temperature and level measurement systems will feed their signals to the PLC in the control trailer. A leak detector will be provided for the C Tank Farm containment pad.

5.3.4 Control Trailer

The control trailer will contain the operator station for the system. The operator station will consist of a PLC and a monitoring screen. The monitoring screen will be connected to the PLC by an operator interface software. The PLC, associated input modules, and signal conditioning for the instruments will be housed in a instrument cabinet. The system will be capable of displaying the process variables being monitored, system alarms, and allowing the operator to control required system functions.

The PLC will be programmed to provide system interlocks for proper operation. As a minimum, these software interlocks will consist of:

- Automatic drain tank pump start on high and high-high level of the tank. Additionally, the drain tank pump will automatically shut off on low level of the tank.

- Automatic shut-off of the transfer skimmer pump based on the following signals: high radiation level at the outlet of the coalescer, high/low flow at the inlet of the coalescer, separation enclosure sump leak shutoff, a high-high level in the drain tank, high level in the trailer mounted container, and a leak in the double encased transfer line between the tank and the separation enclosure.

5.4 ELECTRICAL

This section describes the support system electrical requirements. This description is based on initial assumptions and conditions. Final installation specifications must be in compliance with the National Electric Code (NEC).

Electrical equipment with the potential of being pressurized inside of any void space, enclosure, or pressure boundary must meed the NEC requirements for Hazard Class I, Division 2.

5.4.1 Site

Power will be taken from the motor control center in the control room of building 271-CR. This will require a new drawout unit ("bucket") for the motor control center with a 100 ampere breaker in it. The power will be routed to the control trailer. The power cable will be run buried 10 in. below grade. The wire size will be 3-#2 and 1-#6 (ground).

The control trailer will include a 100 ampere service entrance-rated disconnect switch, a 480/277V 3 phase panelboard, a 30 kVA transformer, 480-120/208 V 3 phase transfer, and a 100 ampere 12/208V panelboard. The breaker in this panelboard will serve 120/208V power to a similar panelboard temporarily mounted near the tank. The power cable will run buried 10 in. deep. This panelboard will in turn serve as the power source for the coalescer heaters and other miscellaneous requirements.

Three phase power is required for the skimmer pump's hydraulic drive electric motor. The motor requires 203 V ac, 3-phase power. It will be supplied form the control trailer panelboard with four #10 wires.

5.4.2 Tank C-103

Any conduits entering Tank C-103 will be sealed so that no vapors can escape.

5.4.3 Separation Enclosure

The coalescer will be heated to maintain 100 °F by wrapping it with thermostatically controlled heat tracing tape. Power for the heat trace and all other requirements will be served from the panelboard located in the control trailer.

5.4.4 Trailer Mounted Organic Container

Cables or conduit and wire (as required) will be supplied to serve the organic container's power and instrumentation requirements.

5.4.5 Control Trailer

Power will be brought to the control trailer via a cable from the 271-CR control room and connected to the panelboard. This power will serve the heat, lighting, receptacles, and instrumentation requirements of the C-103 program.

6.0 ENGINEERING ASSESSMENTS

The below listed engineering assessments were performed in support of this PDR. The technical details are presented in Appendix B while this section presents only a brief summary of the assessments.

- Organic recovery flowsheet calculations
- Dose rate analysis
- Analysis of potential for criticality
- Safety assessment
- Fire hazard analysis
- Regulatory analysis.

6.1 ORGANIC RECOVERY FLOWSHEET

An organic recovery flowsheet (Table 6-1) was compiled to show the changes in flow rate, physical properties, radionuclide concentration, and ratio of organic to aqueous, as the organic is recovered. The parameters were calculated for an initial feed (1A) and four intermediate feeds (1B through 1E). Figure 6-1 is a simplified schematic of the organic and aqueous flows, and identifies the various feeds.

Feed 1A labels the feed in the initial phase of the skimming operation when only organic is being recovered. This composition is identical to 2A, which is the output from the coalescer during normal operation when a mixture of both organic and aqueous are fed into the coalescer. Feed 2A is also the composition of the material being collected in the container on the truck. Feeds 1B through 1E are mixtures of both organic and aqueous phases, with the ratio of organic to aqueous decreasing.

6.2 DOSE RATE ANALYSIS OF TANK C-103 WASTE AND SHIELDING ANALYSIS

Table 6-1. Tank C-103 Organic Recovery Flowsheet.

Stream Name	Feed	Feed	Feed	Feed	Feed	Organic Product (normal operations)	Organic Product (2% aqueous carryover)	Aqueous Return
Physical Characteristics Stream No.	1A	1B	1C	ID	IE	2A		3A
Flow Rate (L/min)	5.0 max, 0.3min 1.60 ave	0.3	0.3	0.3	0.3	5.0 max, 0.3 min 1.60 (ave)		
Organic/Aqueous	100	0.9	0.77	0.50	0.10	100		0.10 to 0.90
Temperature (C°)	44°	44°	44°	44°	44°	44°	44°	44°
Specific Gravity (g/mL)	0.868	0.889	0.916	0.972	1.055	0.868	0.871	1.076
Batch Size (L)	17,310	450	1,890	1,170	1,710			
Radionuclides								
$^{239-240}Pu$ (pCi/g)	194	5.06×10^3	1.11×10^4	2.25×10^4	3.71×10^4	194	982	4.04×10^4
^{241}Am (pCi/g)	179	157	131	79.9	14.7	179	175	
^{90}Sr (PCi/g)	5.5×10^5	8.41×10^6	1.81×10^7	3.65×10^7	6.03×10^7	5.5×10^5	1.82×10^6	6.55×10^7
^{60}Co (µCi/g)	7.45×10^{-4}	0.006	0.013	0.027	0.044	7.45×10^{-4}	0.002	0.0474
^{137}Cs (µCi/g)	4.13×10^{-2}	6.54	14.6	29.7	49.3	4.13×10^{-2}	1.09	53.7
^{154}Eu (µCi/g)	3.17×10^{-4}	2.79×10^{-4}	2.31×10^{-4}	1.42×10^{-4}	2.61×10^{-5}	3.17×10^{-4}	3.11×10^{-4}	
^{155}Eu (µCi/g	3.15×10^{-4}	$2.77 \times$	$2.30 \times$	$1.41 \times$	$2.59 \times$	3.15×10^{-4}	3.09×10^{-4}	

Figure 6-1. Flowsheet Schematic.

The various components comprising the waste removal system will contain high activity waste and may result in potential radiation exposure to operations and maintenance personnel that: exceeds radiological design criteria, results in personnel exposures exceeding WHC Administrative Guides, and is not ALARA.

This section provides the results of estimates of potential radiological dose rates from three process components of the separations enclosure (the coalescer, collection tank, and sintered metal filter) and analyzes the shielding required to reduce the calculated dose rates to acceptable levels. Worst-case exposure geometry and radionuclide concentrations are assumed in the interest of conservatism. The technical details of the estimates are presented in Appendix B.

It should be noted that the calculations in Appendix B are to be considered preliminary in that they were based on early design concepts and based on software modeling approximations. The calculations are not to be used for design, but instead are to be used as initial indications of the amount of shielding that might be needed. A full analysis of shielding will be necessary as part of future definitive design activities.

6.2.1 Technical Approach and Assumptions

ISOSHIELD, a radiation shielding computer modeling program, was used to compute the dose rates. As a worst-case assumption, it was assumed that the coalescer, collection tank, and filter were full of aqueous phase waste from Tank C-103. The exact size of the collection tank was not established when the modeling was performed, therefore calculations of dose rates for both a 25 and an 80 gal collection tank are included as bounding estimates of likely collection tank size. Additional assumptions are delineated in Appendix B.

6.2.2 Results of Dose Rate and Shielding Analyses

Results of the analyses are shown in Tables 6-2 and 6-3. Table 6-3 indicates that the unshielded, contact dose rate from these components would preclude hands-on maintenance while equipment is full of aqueous waste. Furthermore, the unshielded dose rate at 30 cm indicates that access would not be allowed to the equipment for inspection and maintenance according to current WHC and DOE radiological design criteria. As shown in Table 6-2, equipment access would be allowed if 2.5 cm lead shielding were used.

Table 6-2. Shielded vs. Unshielded Dose Rate Analysis Results.

COMPONENT	UNSHIELDED DOSE RATE (R/hr)		CONTACT SHIELDED DOSE RATE (R/hr)	
	CONTACT	30 cm	2.5 cm Pb	5 cm Pb
Coalescer	12.4	2.1	4.5×10^{-02}	1.0×10^{-03}
25 gal Collection Tank	20.5	3.4	7.2×10^{-02}	1.9×10^{-03}
80 gal Collection Tank	25.3	4.6	7.5×10^{-02}	1.8×10^{-03}
Filter	6.6	0.3	4.4×10^{-02}	5.7×10^{-04}

Table 6-3 indicates that 2.5 cm (approximately 1 in.) of lead placed on the outside of the components will reduce the contact (at the shielding) dose rate to acceptable levels, while 5 cm will reduce the contact exposure to about 1 mR/hr for each component. The exact amount of shielding required must be based on an analysis which will determine the extremity and whole body exposure rates that can be considered ALARA. The exposure rates at 30 cm and 100 cm from each component shielded with 2.5 cm of lead are shown in Table 6-3. These values will also be used for final shielding requirements and component placement to ensure compliance with applicable radiological design criteria.

Table 6-3. Shielded (2.5 cm Lead) Dose Rate Analysis Results.

COMPONENT	DOSE RATE (R/Hr) 2.5 cm Pb	
	30 cm	100 cm
Coalescer	$1.1x10^{-02}$	$3.7x10^{-03}$
25 gal Collection Tank*	$5.5x10^{-02}$	$1.8x10^{-02}$
80 gal Collection Tank*	$5.5x10^{-02}$	$1.8x10^{-02}$
Filter	$4.2x10^{-03}$	$5.4x10^{-04}$

* The size of the collection tank was not established at the time of the computer modeling. Twenty-five and 80 gal sizes were chosen to bound the likely collection tank size.

6.3 CRITICALITY

The mechanisms identified by which a criticality incident could occur during the pumping of organic from Tank C-103 are loss of mass control or loss of concentration control (DOE 1993). The possible loss of mass/concentration control results from the potential to extract plutonium from the aqueous during the aqueous/organic interface in the coalescer.

As shown in Appendix B, the total quantity of plutonium (^{238}Pu, $^{239+240}Pu$, ^{241}Am) pumped will be 7.48 g under the worst expected case scenario. This is less than 2% of the minimum mass required to achieve criticality.

Protection against a criticality incident is provided by maintaining the total mass of fissile material less than the single-parameter limit for aqueous mixtures of 0.45 kg ^{239}Pu, as provided in American National Standards Institute (ANSI)/American Nuclear Society (ANS) Standard 8.1, "Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors."

Reaching the limit of 0.45 kg ^{239}Pu would require the extraction of plutonium from approximately 172,000 gal of aqueous. The total volume of

supernate (organic and aqueous) as reported in WHC-EP-0182-66, *Tank Farm Surveillance and Waste Status Summary Report for September 1993* is 133,000 gal. Thus no credible mechanism exists for reaching the limiting plutonium mass.

6.4 SAFETY

The Hanford Site Tank Farm Facilities Interim Safety Basis (WHC 1993) addresses accidents and hazards associated with the transfer of solutions and daily operations with respect to single-shell tanks in *Section 3.3 Single-Shell Tank Hazards and Safety Bases Summary and Section 3.7 Watch List Tank Hazards - All Events Listing.* The pumping of organic from Tank C-103 falls within the identified scope of these operations and is bounded by the ISB analyses.

6.5 FIRE HAZARD ANALYSIS

A fire hazard analysis has been performed and is included in Appendix B. This section provides a very brief presentation of the results of that analysis.

The following two accident scenarios involving fire were hypothesized. The source terms potentially released as a result of each of the hypothetical accidents is presented in Table 6-4.

Table 6-4. Source Terms Potentially Released from Hypothetical Accidents.

Radionuclide	Fire due to Pumping Accident	Fire due to Transportation Accident
^{239}Pu	0.853 g	0.853 g
^{90}Sr	24.7×10^{-3}	15.8×10^{-3}
^{137}Cs	12.6×10^{-3}	1.03×10^{3}

- A leak or ruptures occurs while pumping the organic to the trailer mounted container. This leak or rupture is then ignited by an external source. The fire engulfs the container and the truck and the truck's fuel tank is ruptured, providing additional fuel for the fire. The fire also spreads back to the pumping enclosure and breaches the coalescer and aqueous collection tank. The pumping enclosure is at the low point of the flow path; therefore, the fire does not spread back to Tank C-103.

- During transport of the container, the truck is involved in a traffic accident. The organic is released from the container and is covered by an auto's and the truck's fuel (gasoline/diesel), which then ignites.

6.6 REGULATORY

Generally described in Section 3.2, compliance with appropriate environmental standards is fragmented into functional and administrative requirements. The functional requirements were described above in order to scope the applicable standards. This section contains specific detail on functional regulation requirements and a summary of administrative documentation required.

6.6.1 Environmental Regulation Detail

This section details and summarizes pertinent aspects of applicable functional environmental regulations to the proposed task. Such functional requirements mandate procedural or engineering development, application, and implementation.

6.6.1.1 General Requirements. General requirements are those to which any facility owner or operator must comply. In larger context, these requirements

are those imposed upon owners and operators of Treatment, Storage, and Disposal (TSD) facilities and upon hazardous waste generators.

6.6.1.1.1 Waste Generator Requirements. Waste generators must address the following general requirements:

- WAC 173-303-170, Requirements for Generators of Dangerous Waste.

  In context, this requires that the operator (WHC) of this task designate the waste material generated following the standards provided in WAC-303-070 through -100.

- WAC 173-303-200, Accumulating Dangerous Waste Onsite.

  In context, this section allows, and places procedural requirements upon, the accumulation of dangerous waste onsite without a permit for periods of up to 90 days provided that the material is stored in a container compliant with container management standards.

- WAC 173-303-210, Generator Recordkeeping

  This section requires that procedures be in place and facilities be available for retention of waste manifests, annual reports, and waste designation records.

- WAC 173-303-220, Generator Reporting

  This section requires that procedures be in place for the preparation and submittal of annual and exception reports.

6.6.1.1.2 Facility Operations Requirements. Waste treatment, storage, and disposal operations must address the following general requirements:

- WAC 173-303-390, Facility Reporting

  This section, in context, duplicates the requirements of WAC 173-303-220.

- WAC 173-303-395, Other General Requirements

  This section requires that appropriate precautions exist to prevent accidental ignition or reaction of ignitable or reactive wastes, to prevent structural integrity damage of the facility or device containing the waste, and to document compliance with the precautionary methods.

  Further, this section requires compliance with all other applicable environmental laws and regulations, that tanks and containers be appropriately labeled, and that loading and unloading be conducted in a manner, and in facilities, designed to protect the environment with regard to spill control and cleanup.

- WAC 173-303-400, Interim Status Facility Standards

  This section requires compliance with WAC 173-303-140 land disposal restrictions (affects disposal), with WAC 173-303-630 requirements upon the management of containers, and with WAC 173-303-640 requirements upon tank systems and ancillary equipment.

6.6.1.2 Requirements for Dangerous Waste Handling Equipment. Specific requirements for dangerous waste handling equipment fall under piping and tank systems of regulations. The appropriate reference is:

- WAC 173-303-640, Tank Systems

Because the process involved is that of removal and separation of material from a single-shell tank, all equipment contacting the waste material in the process from the tank is termed ancillary equipment. As such, an integrity assessment of the ancillary equipment must demonstrate that the equipment (piping and all internals of the separations module) is of sufficient structural strength and compatibility with the waste, that it is within appropriate secondary containment, that it is appropriately protected against corrosion, and that it be tested for leaks. Such tank systems must be able to contain, detect, and remove releases within a short time. Inspections of piping, tanks, and cathodic systems are required. Upon closure, all contaminated equipment, soils, and structures must be either removed or decontaminated appropriately.

6.6.1.3 Requirements for Dangerous Waste Retention. Specific requirements for the retention of dangerous waste were briefly introduced above with respect to container management. The appropriate reference is:

- WAC 173-303-630, Use and Management of Containers

  This section requires that containers holding dangerous wastes be in good condition, that they be identified through labels, that they be visually inspected weekly and the inspections logged, that containers are compatible with the waste therein, and that a containment system be in place to collect and hold leaks and spills.

  The containment system must be capable of collecting and holding spills and leaks, and the accumulated precipitation from a maximum

25-year storm of 24-hours duration. The containment area must have an impervious base. Spilled or leaked waste and accumulated precipitation must be removed from the containment system in as timely a manner as is necessary to prevent overflow.

For secondary containment during the pumping operation, the equipment located outside of the tank will be housed in an enclosure and the flow lines will be double encased. There will be a temporary pad for the truck-mounted container and the design of the pad will be in compliance with regulatory requirements for the temporary storage (i.e., less than 90 days) of dangerous wastes.

There will also be a secondary containment storage pad at the B Tank Farm for the container. This pad will be designed for compliance with the regulatory requirements for long-term storage, possibly up to five years, of dangerous wastes.

6.6.1.4 **Requirements for Air Pollutant Abatement.** Various regulations exist for the protection of the nation's air resources. The applicable regulations in the context of this task are:

- NESHAPs 40 CFR 61, Subpart H governs radionuclide emissions from DOE facilities. In this application, these standards will require that a minimum of HEPA filtration be applied.

- WAC 246-247 Radioactive Airborne Emission Program governs radioactive emissions within the state of Washington. It parallels the requirements of NESHAPs and will require a minimum of HEPA filtration.

- WAC 173-460 Controls for New Sources of Toxic Air Pollutants governs the release of toxic air pollutants. Analysis to support response to this regulation must detail the evaluation and selection of pollutant abatement. The primary toxic air

pollutants (TAPs) under consideration at this time for the task is TBP. TBP has low volatility and it is expected that simple filtration will provide adequate to excellent abatement.

6.6.2 Administrative Requirements

Administrative requirements have been reviewed with respect to the proposed operations and environmental media impact. In addition to the media impacts and the derived permitting and approval requirements of media impacts, other requirements exist which will require administrative address. Table 6-5 provides a summary of such applicable administrative requirements.

The consequential administrative and evaluative activities potentially required include preparation or conduct and submittal or implementation of the following:

- State Environmental Policy Act (SEPA) Checklist
- WAC 173460, Construction Approval Request
- 40 CFR 61 Subpart H, Modification Approval Request
- WAC 246-247 Notice of Construction
- WAC 173-401 Air Operating Permit Modification Application
- WAC 173-303 Notice of Intent (to modify)
- WAC 173-303 Part A Notice Modification
- 36 CFR 800 Cultural Resources Review
- 36 CFR 800 Excavation Permit Request
- 50 CFR 402.6 Endangered Species Approval
- DOE 5400.1 Preoperational Monitoring
- DOE 5400.5 Radiation Protection Standard Environmental Monitoring.

6.6.2.1 Status of Fulfilling Administrative and Regulatory Requirements. The following is a partial listing of the activities ongoing for fulfillment of the regulatory and administrative requirements.

Table 6-5. Summary of Applicable Administrative Requirements.

Environmental Media	Permit, Approval, or Requirement	Regulation	Regulatory Agency	Restriction
NEPA	NEPA Documentation	10 CFR 1021	DOE	Title II Design (Projects), Procurement
SEPA	SEPA	WAC 197-11	State Agency	License, Permit
Nonrad. Air Emissions	TAPs	WAC 173-460	Ecology BFCCAA	Construction
Radioactive Air Emissions	NESHAPs	40 CFR 61, Subpart H	EPA	Construction
	RAEP	WAC 246-247	DOH	Construction, Operation
All Air Emissions	Air Operating Permit	WAC 173-401	Ecology DOH	Operation
Dangerous Waste	Dangerous Waste Permit (RCRA - A/B)	WAC 173-303; 40 CFR 264, 265, 270	Ecology	Construction of New Facilities or Expansion of Existing Facilities
All Media	Cultural Resource Review Clearance	36 CFR 800	DOE	Surface Disturbing Activities & Modification of Bldgs. Eligible for Listing on Historical Register
	Excavation Permit	36 CFR 800	DOE	Excavation Project
	Endangered Species Approval	50 CFR 402.6	Fish and Wildlife Service	Construction Habitat Modification
	Preoperation Monitoring of Facilities, Sites, & Operations	DOE Order 5400.1	DOE	Operation
	Secretary of DOE Approval	Public Law 101-510, Section 3137 (Wyden Amendment)	DOE	Any material added to a Watch List Tank requires approval.
	Radiation Protection Standards	DOE Order 5400.5	DOE	Construction

- A NOC has been drafted for compliance with NESHAP Subpart H and WAC 246-247.

- Revisions are being drafted for the Dangerous Waste Part A Permit application.

- Pursuant to compliance with Public Law 101-510, Section 3137 (also known as the Wyden Amendment), it is unclear at this time whether approval of the Secretary of DOE will be required to allow equipment flushing agents to drain back into Tank C-103. A decision will be made during definitive design and any impacts to the mission will be addressed accordingly.

7.0 DESIGN RISKS AND UNCERTAINTIES

Designing a system that must remove and separate an organic combustible liquid from an aqueous phase down to a level of 2 mm in a high radiation area meeting all necessary codes, standards, and laws is very challenging. In any operation of this size, there initially will be several design risks and uncertainties. This section documents many of these and some of the current actions.

7.1 PUMP NOW OR PUMP LATER

The original design for this operation included pumping the organic from Tank C-103 to a suitable shipping truck or tank and directly transporting this removed organic to an appropriate disposal vendor. This option is not currently available. This PDR is written in accordance with the current option; pump the organic and store it onsite for up to five years. A separate study is evaluating both of these options. This study will review the comparative safety of the currently available pumping option with keeping the organic in Tank C-103 until direct offsite transfer is possible (likely five years).

7.2 FILTERS

Filter plugging or fouling can disrupt, or even halt organic removal. A study is currently being done to ensure that the proper filter and flushing systems are used.

7.3 TEMPERATURE

Temperature control is a potential engineering issue. Tests performed to date indicate that organic separation is better at 40 °C than at ambient

levels (25 °C). A functional design requirement states that the temperature shall not exceed 72 °C to ensure a large safety margin from creating atmospheric concentrations greater than the lower flammability limit. Heating elements will be provided on the separation enclosure to ensure higher than ambient temperatures. The possibility of temperatures exceeding 72 °C, either through solar loading or other mechanisms, in both the separation enclosure and the trailer mounted container, is scheduled for further evaluation.

7.4 RADIONUCLIDE REMOVAL

This PDR requires no specific radionuclide removal capabilities. The filtration system will likely result in radionuclide reductions. Ensuring that the liquid in the trailer mounted container is as free of aqueous as possible will also reduce radionuclide concentrations. Current estimates, based on in-tank samples indicate that the organic liquid, once pumped to the trailer mounted container, will require further processing. The current preferred processing method is caustic wash. Ion-exchange is also under evaluation.

7.5 CONSTRUCTION COORDINATION

Project W-320, Tank C-106 Sluicing is currently scheduled to be under construction in the same time frame as the Tank C-103 organic layer removal. As shown on drawing ES-ER5602-C1 (Appendix A), access to Tank C-103 will use the proposed access route provided by Project W-320. If access is not provide by Project W-320 or changes are made in the location and access to Tank C-106, conflicts and interferences may arise between the projects.

7.6 MATERIAL IDENTIFICATION

The material that will be used for the primary containment tie-in lines between Tank C-103, the separations enclosure and the tank trailer will be Kalrez as specified by WHC. Kynar or Kalrez was recommended for use as the primary piping based on compatibility information provided in the vendor literature. Other materials are being tested. Information from the material testing may change material selection.

7.7 SAFETY CLASSIFICATION

This PDR was developed with the assumption that the system will be safety class 3. A preliminary safety class analysis based on a deterministic approach only has identified some safety class functions which could elevate some items to a higher classification. Further safety class analysis is underway pursuing a probabilistic approach as defined in WHC Management Requirements and Procedures (MRP) 5.46, para 11(e). The outcome of this effort will be used as the basis of safety class assignment for the definitive design effort. The formal safety class determination for the mission will be part of the safety evaluation completed at the conclusion of definitive design.

7.8 RADIATION EXPOSURE

Current project direction for final waste disposition calls for the storage of the organic liquid in the trailer mounted container for as long as five years. A preliminary ISOSHIELD analysis (performed by Enserch Environmental, Corporation) of the radiation from a full 5,000 gal tanker truck indicates that the expected dose will exceed 100 mrem/hr, even if 100% organic separation was achieved. Calculations to determine the doses should be performed based on parametric characterization of shielding analyses and confirmation based on waste liquid analysis received in the trailer mounted container.

7.9 EQUIPMENT SUITABILITY

WHC has selected the skimmer, skimmer pump, and the coalescer to be used. The equipment is currently being tested utilizing simulants to determine their suitability for this application.

7.10 HYDRAULICS

The original design specified the use of an in-tank electric motor to power the skimmer pump. Due to concerns regarding electric components in a potentially flammable atmosphere, current designs identify the use of hydraulics to power the pump. Some elements of hydraulics usage inside Tank C-103 will require additional engineering evaluation. These elements include the potential for hydraulics leakage inside the tank and ensuring proper pressure and flow control of the hydraulic fluid to ensure proper skimmer pump operation. Equipment testing is scheduled.

7.11 DISPOSAL

Most equipment that comes in contact with Tank C-103 liquid will be identified as mixed-waste contaminated. The design of the equipment includes methods to ease disassembly and decontamination as feasible. Equipment that cannot be adequately decontaminated, either due to contamination inaccessibility, employee exposure concerns, or unsuccessful decontamination, will be packaged and disposed in accordance with established WHC procedures. This non-decontaminated equipment will be stored in approved containers and storage locations.

7.12 AMMONIA/ORGANIC VAPOR

A treatment system for removing organic and/or ammonia vapors is not currently envisioned for either the tanker truck or the separations enclosure. Provision is made to incorporate the existing carbon canisters in the vent system. However, there is an historical basis for failure of this method due to water vapor condensation. Other alternatives include using a desiccant or a resistance heater. If removal of ammonia/organic vapor becomes a safety issue, these other options will require review.

7.13 LIQUID DETECTION FOR RETENTION PAD

A leak detection capability will be integrated with the retrieval control system for monitoring/alarm purposes during retrieval operation. It will not be integrated with the pump shutdown. No leak detection capability will be provided as part of the organic storage, either in the C Tank Farm or B Tank Farm.

7.14 LINER COMPATIBILITY

The liner is provided with geotextile pad and a geomembrane cover. The selection of geomembrane may be high density polyethylene (HDPE), very low density polyethylene (VLDPE) or XR-5. A compatibility test of the membrane material with the waste to be stored in the tank will be necessary to select the material for the liner.

7.15 TOXIC AIR POLLUTANTS

Although only preliminary vapor space analyses exist for the tank, analyses of these constituents indicates that activities fall below small quantity generator requirements of WAC 173-460-080(2)(e) and require no further mitigation. Should later analyses of vapor phase emissions indicate other than de minimis emissions, carbon bed absorption should be reinstalled on the common vent header downstream of all breather vent lines.

7.16 REGULATORY APPROVAL

Obtaining approval from the several regulatory bodies involved in this project may impact both the schedule and the engineering of the design. Regulatory bodies include DOE, Washington State Department of Health, and Ecology. Pursuant to compliance with Public Law 101-510, Section 3137 (Wyden

Amendment), it is unclear at this time whether approval of the Secretary of DOE will be required to add the flush liquid back into Tank C-103. A decision will be made during definitive design and any impact to the mission will be addressed accordingly. Efforts have already begun to obtain all necessary approvals. Environmental regulators have already indicated favorable responses to current plans.

8.0 REFERENCES

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APPENDIX A

DRAWINGS

APPENDIX B

ENGINEERING ASSESSMENTS

B.0 INTRODUCTION

This appendix provides the technical details of the below listed engineering assessments that were performed. These assessments have also been briefly summarized in Section 6.0 of this report.

- Organic recovery flowsheet calculations
- Dose rate analysis
- Criticality analysis
- Safety assessment
- Fire hazard analysis
- Regulatory analysis.

B.1 ORGANIC RECOVERY FLOWSHEET CALCULATIONS

The physical and chemical characteristics of the material removed from Tank C-103 was developed from the Westinghouse Hanford Company (WHC) Chemical Engineering Laboratory (CEL) test (Attachment B-1) and the analysis of Tank C-103 aqueous and organic samples (Pool and Bean 1994). The WHC laboratory estimated the removal rate and the organic recovery. Both the removal rate and the organic recovery decrease as the depth of the organic layer is reduced. The flowsheet schematic, Figure B-1 and Table B-1 is keyed alphanumerically to the physical characteristics such as flow rate and the chemical composition at each phase in the recovery. The 1A labels the feed in the initial phase of the skimming when the operation is recovering all organic. This feed composition is also the composition, 2A, of the organic being collected in the tank truck. Composition 2A is also the composition produced in normal operation of the coalescer during all phases of the recovery operation when a mixture of aqueous and organic is being supplied to the coalescer. One can compare the normal operation composition, 2A, with the composition equivalent to the functional requirement of 2 wt% of the organic included as emulsified aqueous in the column adjacent to 2A.

Figure B-1. Flowsheet Schematic.

Table B-1. Tank C-103 Organic Recovery Flowsheet.

Stream Name	Feed	Feed	Feed	Feed	Feed	Organic Product (normal operations)	Organic Product (2% aqueous carryover)	Aqueous Return
Physical Characteristics Stream No.	1A	1B	1C	ID	IE	2A		3A
Flow Rate (L/min)	5.0 max, 0.3min 1.60 ave	0.3	0.3	0.3	0.3	5.0 max, 0.3 min 1.60 (ave)		
Organic/Aqueous	100	0.9	0.77	0.50	0.10	100		0.10 to
Temperature (C°)	44°	44°	44°	44°	44°	44°	44°	44°
Specific Gravity	0.868	0.889	0.916	0.972	1.055	0.868	0.871	1.076
Batch Size (L)	17,310	450	1,890	1,170	1,710			
Radionuclides $^{239-240}Pu$ (pCi/g)	194	5.06×10^3	1.11×10^4	2.25×10^4	3.71×10^4	194	982	4.04×10^4
^{241}Am (pCi/g)	179	157	131	79.9	14.7	179	175	
^{90}Sr (PCi/g)	5.5×10^5	8.41 x	1.81 x	3.65 x	6.03 x	5.5×10^5	1.82×10^6	6.55 x
^{60}Co (µCi/g)	$7.45 \times 10^-$	0.006	0.013	0.027	0.044	7.45×10^{-4}	0.002	0.0474
^{137}Cs (µCi/g)	$4.13 \times 10^-$	6.54	14.6	29.7	49.3	4.13×10^{-2}	1.09	53.7
^{154}Eu (µCi/g)	3.17×10^{-4}	$2.79 \times 10^-$	$2.31 \times 10^-$	$1.42 \times 10^-$	$2.61 \times 10^-$	3.17×10^{-4}	3.11×10^{-4}	
^{155}Eu (µCi/g	$3.15 \times 10^-$	$2.77 \times 10^-$	$2.30 \times 10^-$	$1.41 \times 10^-$	$2.59 \times 10^-$	3.15×10^{-4}	3.09×10^{-4}	
Aqueous - Cation/Anion Na^+ (wt%)								3.0
NO_2^- (wt%)								2.3
H_2O (emulsion-wt%)	0					0	2	

E-2-108

WHC-SD-WM-PLN-092 Rev. 0

Estimated feed compositions were made based on the CEL estimates of the total volumes of organic and aqueous removed by the Douglas Engineering Skim Pak Skimmer at percent organic recovery of 90%, 77%, 50%, 33%, and 10% and Tank C-103 sample results. The feed stream radionuclide curies-mass fraction, pCi/g or μCi/g is:

$$z_x^f = \frac{y_x^f V^f_{org} \rho^f_{org} + x_x^f V^f_{aq} \rho^f_{aq}}{V^f_{org} \rho^f_{org} + V^f_{aq} \rho^f_{aq}}$$

where:

z_x^f = curies-mass fraction of x in feed mixture
y_x^f = curies-mass fraction of x in organic (Pool and Bean 1994)
x_x^f = curies-mass fraction of x in aqueous (Pool and Bean 1994)
ρ^f_{org} = density (g/mL) of organic (Pool and Bean 1994)
ρ^f_{aq} = density (g/mL) of aqueous (Pool and Bean 1994)
V^f_{org} = volume (L) of organic in feed (WHC Lab Data)
V^f_{aq} = volume (L) of aqueous in feed (WHC Lab Data).

Plutonium, americium and strontium for both the aqueous and organic phase are reported in pCi/g and the other radionuclides listed are reported in μCi/g (both phases).

Recent laboratory analysis indicates that the organic passing through the coalescer is virtually water-free. If the coalescer performance should deteriorate, then the radionuclide concentration could be significantly higher. An estimated level of the radionuclides in the separated organic was made for the functional requirement of 2 wt% aqueous.

A material balance for each radionuclide is necessary to determine the radionuclide curie-mass fraction in the organic from the presence of 2 wt% of the organic as an aqueous emulsion.

$$y_x^f m_0^f + x_x^f m_a^f = y_x^P m_o^P + x_x^R m_a^R$$

where:

m = mass
a = aqueous
f = feed
p = separated organic product
o = organic
R = aqueous return
x = unspecified radionuclide

Solving for the curie-mass fraction in the separated organic gives the following equation:

$$y_x^p = \frac{y_x^f m_o^f + x_x^f m_a^f - x_x^R m_a^R}{m_o^p}$$

For the number of unknown variables to exactly balance the number of available equations, x_a^f, the radionuclide mass faction in the aqueous component of the feed, is assumed to be unchanged by the skimming operation. Hence, x_a^f is equivalent to x_a^R. The above equation can be solved by substituting laboratory estimates of volume and measured density for mass:

$$y_x^p = \frac{y_x^f V^f_{org} \rho^f_{org} + x_x^f V^f_{aq} \rho^f_{aq} - x_x^f (V^f_{org} \rho^f_{org} + V^f_{aq} \rho^f_{aq} - 1.02 V^f_{org} \rho^f_{org})}{1.02 V_{org} \rho_{org}}$$

Cancelling out the common terms gives the following relationship:

$$y_x^P = \frac{y_x^f + 0.02x^f}{1.02}$$

This equation is solved for the radionuclide curie-mass fraction in the organics for organic with aqueous carryover (Table B-1) by substituting the Tank C-103 analytical results.

B.2 DOSE RATE ANALYSIS

The various components comprising the waste removal system will contain high activity waste and may result in potential radiation exposure to operations and maintenance personnel that (1) exceeds radiological design criteria, (2) results in personnel exposures exceeding WHC Administrative Guides, and (3) is not As Low As Reasonably Achievable (ALARA). This section provides estimates of potential radiological dose rates from three process components of the separations enclosure (the coalescer, collection tank, and sintered metal filter) and analyzes the shielding required to reduce the calculated dose rates to acceptable levels. Worst-case exposure geometry and radionuclide concentrations are assumed in the interest of conservatism.

It should be noted that these calculations are to be considered preliminary in that they were based on early design concepts and based on software modeling approximations. These calculations are not to be used for design, but instead are to be used as initial indications of the amount of shielding that might be needed. A full analysis of shielding will be necessary as part of future definitive design activities.

B.2.1 Initial Conditions

Equipment

The coalescer, collection tank, and filter were configured as described in Section 4.2 and were assumed to be full of aqueous phase liquid from Tank C-103.

Aqueous Phase Radionuclide Concentrations - Inorganic salt solution, specific gravity 1.1 (Pool and Bean 1994).

- ^{60}Co: 5.1×10^{-2} µCi/mL
- ^{137}Cs: 5.8×10^{1} µCi/mL
- ^{137m}Ba: 5.8×10^{1} µCi/mL (decay product of ^{137}Cs)

Solid Phase Radionuclide Concentration - Inorganic salts, specific gravity 1.1 to 1.5 (source: average analytical results from two composite solid samples retrieved from Tank C-103 [Data Transmittal Package for Tank C-103 Waste Characterization, SD-RE-TI-203, 1988]). Note: The ^{137m}Ba percentage is assumed to be different in this case than in the case above. Both percentages are considered acceptable for these preliminary calculations.

- ^{90}Sr: 3.6×10^{3} µCi/mL
- ^{90}Y: 3.6×10^{3} µCi/mL (decay product of ^{90}Sr)
- ^{99}Tc: 4.2×10^{-1} µCi/mL
- ^{137}Cs: 1.4×10^{2} µCi/mL
- ^{137m}Ba: 1.2×10^{2} µCi/mL
- ^{60}Co: 6.3×10^{0} µCi/mL
- ^{241}Am: 2.0×10^{0} µCi/mL

B.2.2 Technical Approach and Assumptions

ISOSHIELD, a radiation shielding code, was used to compute the dose rates. This code does not have the ability to model complex exposure geometries, and is also limited in its ability to model multi-component shielding materials. Certain simplifying yet technically appropriate assumptions were made to accommodate these deficiencies.

- The shielding capability of 316 stainless steel was modeled as an alloy of iron (87 wt%), nickel (12 wt%), and aluminum (1 wt%). The assumption was necessary since the ISOSHIELD shielding material library did not contain stainless steel constituents, chromium, manganese, molybdenum, and silicon. The substitutions were based on similarities in density, atomic number, and atomic weight.

- A combinational geometry approach was used, which assumed the coalescer could be described by two right circular cylinders as shown in Figure B-2. The exposure was determined from each cylinder at the point indicated and summed. An additional exposure determination was made for the small area common to both cylinders and subtracted from the previous total to arrive at the exposure rate estimate for the coalescer. The coalescer wall thickness was assumed to be 0.7 cm.

Figure B-2. Coalescer Configuration.

- Due to design uncertainties, two collection tanks were modeled; one as a right rectangular solid with a working capacity (80%) of 25 gal, and the other as a rectangular solid with the dimensions 112 cm long, 40.1 cm high, and 86.3 cm deep, and a working

capacity of 80 gal. In the interest of conservatism, the tanks were assumed to be filled to 100% capacity with aqueous phase waste.

- The geometry assumed for the sintered metal filter and housing was a right circular cylinder with an interior annulus equal to the diameter of the filter. The exposure rate was determined for the aqueous contents as well as the solid material collected in the filter. These two values were summed to arrive at the total exposure rate.

- For self-shielding purposes, the solids collected on the filter were assumed to have a density of 1 g/cm^3 (i.e., water) since this was the closest value of those available in the code library to the actual range of 1.1 to 1.5 g/cm^3 of tank solids.

For the initial calculation of the dose, the assumptions and conversion factors were as follows.

1. The immersion (in water) surface gamma dose from ^{137}Cs (^{137m}Ba) is 1.1×10^7 mrem/yr/microcurie/cc (Kocher 1980).

2. Assume rem = rad for approximate conversion.

3. ^{137}Cs concentration is estimated at 60 $\mu Ci/cm^3$.

4. Beta dose assumed to be insignificant.

5. Results of conversion of dose rate is 75.3 rad/hr, which has been rounded up to 100 rad/hr for conservatism.

The estimated 100 rad/hr dose rate has subsequently been verified using the ^{137}Cs concentration reported in Pool and Bean (1994) and calculating a beta dose. Those calculations are as follows.

1. The ^{137}Cs concentration is 57.9 $\mu Ci/cm^3$ (Pool and Bean 1994). The gamma dose is 72.7 rad/hr.

2. Assume that half the gross beta at 3.53×10^{-5} Ci/cm^3 is ^{90}Y. The average dermal dose is 1.4×10^{-3} Sv/yr/Bq/cc (from Shleien 1992).

3. With the rad = rem assumption, the ^{90}Y dose is 5.18×10^9 $rad/yr/Ci/cm^3$.

4. By conversion of units of measurement, the ^{90}Y dose rate is 20.9 rad/hr.

5. Steps 2 through 4 above are repeated for the rest of the beta as ^{90}Sr. The dose rate factor is 6.6×10^{-05} $Sv/yr/Bq/cm^3$.

6. As a result, the dose is 1.0 rad/hr for ^{90}Sr.

7. Therefore the total dose to the surface of an object immersed in the aqueous phase is the sum of 72.7 plus 20.9 and 1.0 or 94.6 rad/hr. The interior dose would be slightly less than 72.7 rad/hr for a small, low density object due to gamma alone.

8. In conclusion, the initial rounded dose of 100 rad/hr is still an appropriate estimate.

B.2.3 Results of Dose Rate Analysis

Results of this analysis are shown in Table B-2. These results demonstrate that the unshielded, contact dose rate from these components would preclude hands-on maintenance while equipment is full of aqueous waste. Furthermore, the unshielded dose rate at 30 cm indicates that access would not be allowed to the equipment for inspection and maintenance according to current WHC and U.S. Department of Energy (DOE) radiological design criteria.

As shown in Table B-2, equipment access would be allowed if 2.5 cm lead shielding were used.

Table B-2. Shielded vs. Unshielded Dose Rate Analysis Results.

COMPONENT	UNSHIELDED DOSE RATE (R/hr)		CONTACT SHIELDED DOSE RATE (R/hr)	
	CONTACT	30 cm	2.5 cm Pb	5 cm Pb
Coalescer	12.4	2.1	4.5×10^{-02}	1.0×10^{-03}
25 gal Collection Tank*	20.5	3.4	7.2×10^{-02}	1.9×10^{-03}
80 gal Collection Tank*	25.3	4.6	7.5×10^{-02}	1.8×10^{-03}
Filter	6.6	0.3	4.4×10^{-02}	5.7×10^{-04}

* The size of the collection tank was not established at the time of the computer modeling. Twenty-give and 80 gal sizes were chosen to bound the likely collection tank size.

The gamma dose obtained from the ISOSHIELD output was 35 R/hr. This result is in close agreement with a calculated half-space dose of 36 R/hr, utilizing a gamma dose of 72.7 rad/hr as reported above in step 1.

B.2.4 Shielding Analysis

This section presents the results and discussion of the shielding analysis. The shielded exposure rate with 2.5 cm and 5 cm of lead are shown in Table B-3. It can be seen that 2.5 cm (approximately 1 in.) of lead placed on the outside of the components will reduce the contact (at the shielding) dose rate to acceptable levels, while 5 cm will reduce the contact exposure to about 1 mR/hr for each component. The exact amount of shielding required must be based on an analysis which will determine the extremity and whole body exposure rates that can be considered ALARA. The exposure rates at 30 cm and 100 cm from each component shielded with 2.5 cm of lead are shown in Table B-3. These values will also be used for final shielding requirements and component placement to ensure compliance with applicable radiological design criteria.

Table B-3. Shielded (2.5 cm Lead) Dose Rate Analysis Results.

COMPONENT	DOSE RATE (R/Hr) 2.5 cm Pb	
	30 cm	100 cm
Coalescer	$1.1x10^{-02}$	$3.7x10^{-03}$
25 gal Collection Tank*	$5.5x10^{-02}$	$1.8x10^{-02}$
80 gal Collection Tank*	$5.5x10^{-02}$	$1.8x10^{-02}$
Filter	$4.2x10^{-03}$	$5.4x10^{-04}$

* The size of the collection tank was not established at the time of the computer modeling. Twenty-five and 80 gal sizes were chosen to bound the likely collection tank size.

A simple calculation shows using the data in Table B-2 that the exposure reduction of 5 cm of lead, as compared to the unshielded dose is a factor of about 10:4 in each case. This reduction is about 50 times greater than would be expected using the linear transmission of the 0.661 MeV gamma from ^{137}Cs. This difference is attributed to geometry effects resulting from differences between the exposure geometry assumed for the shielded components as opposed to the "slab" shield configuration assumed.

Based on gamma ray transmission curves for iron and lead, 11.5 cm of iron is required to achieve the same level of shielding as 5 cm of lead (Shleien 1992). For comparison purposes, it can be shown that 5 cm thick lead shielding required to shield a 6-in. diameter by 12-in. long pipe would weigh approximately 47 kg. Iron shielding to achieve the same transmission would be 11.5 cm thick and would weigh about 89 kg. Thus, on a weight basis, lead is more efficient. However, iron is not a hazardous substance as is the case with lead.

B.3 CRITICALITY ANALYSIS

The mechanisms identified by which a criticality incident could occur during the pumping of organic from Tank C-103 are loss of mass control or loss of concentration control (DOE 1993). The possible loss of mass/concentration control results from the potential to extract plutonium from the aqueous during the aqueous/organic interface in the coalescer.

As demonstrated below the total quantity of plutonium (^{238}Pu, $^{239+240}Pu$, ^{241}Am) pumped will be 7.48 g under the worst expected case scenario. This is less than 2% of the minimum mass required to achieve criticality.

B.3.1 Plutonium Extraction

The quantity of plutonium in the aqueous was determined to ensure that in event of extraction of plutonium from the aqueous in the coalescer, the limiting subcritical value of 450 g of plutonium would still be maintained. It is important to note that the tributyl phosphate (TBP) extraction of plutonium from aqueous occurs much more readily in the presence of additional nitrate ions in the aqueous solution. This nitrate ion was normally supplied by nitric acid which was then normally recovered by distillation from the aqueous prior to transferring the remaining aqueous to storage tanks (WHC 1989). Pacific Northwest Laboratory (PNL) reported the pH of the aqueous to be 9.5 with concentrations of nitrite (NO^-_2) and nitrate (NO^-_3) of 23,000 µg/g and 2,400 µg/g respectively (Pool and Bean 1994). This results in approximately 0.5 *M* solution of nitrite and nitrate ions. Assuming the concentration of nitrate and nitrite ions is equivalent to a 0.5 *M* solution of nitric acid (conservative due to the alkaline nature of the aqueous) and equal volumes of organic and aqueous are pumped, the plutonium extraction factor "P" is less than 1, which is representative of conditions for stripping "back extraction" of plutonium from the organic to the aqueous (WHC 1989). Thus the extraction of plutonium from the aqueous is not expected to occur and this mechanism is addressed here as part of a worst case scenario.

B.3.2 Total Quantity of Plutonium Pumped

To determine the total plutonium pumped during the organic removal, the quantity of plutonium found in the organic along with the quantity of plutonium found in the aqueous solution expected to be pumped during the organic removal were calculated. As indicated below, the total mass of plutonium pumped is 7.48 g.

B.3.2.1 Calculation of Plutonium in Organic. The calculation of fissile nuclides contained in the organic layer is based upon PNL analyses, (Pool and Bean 1994) which showed the total alpha activity for the organic to be 547 pCi/g. Concentrations of specific radionuclides were reported as follows:

^{238}Pu	90.2 pCi/g
$^{239+240}Pu$	194 pCi/g
^{241}Am	179 pCi/g

The volume of organic in the tank was calculated to be 5,500 gal (2.09×10^7 mL) based on a 2 in. layer of organic floating on top of the aqueous (Huckaby 1993). The density of the organic is 0.868 g/mL (Pool and Bean 1994), which corresponds to 1.81×10^7 g of organic being pumped.

The total mass of each isotope was calculated using the specific activity of each isotope and Equation B-1.

Equation B-1.

$$\text{grams}_x = \frac{\text{Ci}_x}{\text{grams}_{org}} \times \left[\frac{T_{\frac{1}{2}} \times (\text{atomic mass})_x}{3.578E{+}05} \right] \times \text{grams}_{org}$$

For ^{238}Pu

$$\text{grams}_{238} = 90.2E{-}12 \times \left[\frac{87.74 \times 238.05}{3.578E{+}05} \right] \times 1.81E{+}07 = 95.3E{-}05 \text{ grams}$$

For $^{239+240}Pu$

$$grams^{(1)}_{239+240} = 194E{-}12 \times \left[\frac{2.411E{+}04 \times 239.05}{3.578E{+}05}\right] \times 1.81E{+}07 = 5.7E{-}02 \text{ grams}$$

(1) assumes all activity is from ^{239}Pu.

For ^{241}Am

$$grams_{241} = 179E{-}12 \times \left[\frac{4323.2 \times 241.06}{3.578E{+}05}\right] \times 1.81E{+}07 = 9.43E{-}04 \text{ grams}$$

Thus the total mass of all isotopes in the organic is 5.8×10^{-2} g.

B.3.2.2 Calculation of plutonium in the Aqueous Pumped during Organic Removal. The calculation of plutonium contained in the aqueous layer is based upon PNL laboratory analyses of the radioactivity of the layer. Based on these analyses the total alpha activity for the aqueous was determined to be 4.04×10^4 pCi/g. Detailed analyses for specific radionuclides were not provided; therefore all the activity was assumed to be from ^{239}Pu as a worst case.

Based on laboratory data, 100% organic would be pumped until a thickness of 10 mm was reached (Attachment B-1). The performance criteria calls for the organic to be removed to a thickness of 2 mm. Based on experimental data, the organic can be removed to a thickness of 1.5 mm. An organic/aqueous mixture is pumped during this final removal stage. Operating the skimmer pump at 0.5 gal/min results in approximately 2,800 gal (1.06×10^7 mL) of aqueous being pumped through the coalescer. Based on the laboratory data the quantity of aqueous pumped would be reduced at a lower pumping rate (Attachment B-1). The density of the aqueous is 1.076 g/mL (Pool and Bean 1994), which corresponds to 1.14×10^7 g of aqueous being pumped during the organic removal process.

The total mass of each ^{239}Pu was calculated using the specific activity and Equation B-2.

Equation B-2.

$$\text{grams}_x = \frac{Ci_x}{\text{grams}_{aqu}} \times \left[\frac{T_{\frac{1}{2}} \times (\text{atomic mass})_x}{3.578E{+}05}\right] \times \text{grams}_{aqu}$$

For ^{239}Pu

$$\text{grams}_{239} = 4.04E{-}08 \times \left[\frac{2.411E{+}04 \times 239.05}{3.578E{+}05}\right] \times 1.14E{+}07 = 7.42 \text{ grams}$$

B.3.3 Criticality Prevention

Protection against a criticality incident is provided by maintaining the total mass of fissile material less than the single-parameter limit for aqueous mixtures of 0.45 kg ^{239}Pu, as provided in ANSI/ANS Standard 8.1, "Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors."

As indicated above the total quantity of plutonium pumped is 7.48 g under the worst case scenario. This is less than 2% of the stated limiting mass of 450 g of ^{239}Pu.

In order to reach 0.45 kg ^{239}Pu would require the extraction of plutonium from approximately 172,000 gal of aqueous. The total volume of supernate (organic and aqueous) as reported in *Tank Farm Surveillance and Waste Status Summary Report for September 1993* (Hanlon 1993) is 133,000 gal. Thus no credible mechanism exists for reaching the limiting plutonium mass.

B.4 SAFETY ASSESSMENT

The Hanford Site Tank Farm Facilities Interim Safety Basis (WHC 1993) addresses accidents and hazards associated with the transfer of solutions and

daily operations with respect to single-shell tanks in *Section 3.3 Single-Shell Tank Hazards and Safety Bases Summary* and *Section 3.7 Watch List Tank Hazards - All Events Listing.* The pumping of organic from Tank C-103 falls within the identified scope of these operations and is bounded by the ISB analyses.

B.5 FIRE HAZARD ANALYSIS

This section (1) identifies the types of possible accidents involving fires during the pumping and transportation of organic from Tank C-103, and (2) presents resultant estimates of the source terms potentially released from those hypothetical accidents. Details on the specific dispersion calculations will be provided in the definitive design documentation.

As a result of the estimated source terms potentially released, additional fire protection measures may be required. An analysis of those additional fire protection requirements will be provided in the definitive design documentation.

The discussion herein addresses the possible accidents and associated consequences but does not address the probability of occurrence of the accident. The accidents presented are deemed to be the worst case scenarios which could reasonably be expected to occur and are thus considered as bounding events.

For an accident during the pumping of organic from Tank C-103 to the tanker truck the source term released was calculated as follows:

^{239}Pu	0.853 g
^{90}Sr	24.7×10^{-03} g
^{137}Cs	12.6×10^{-03} g

For an accident involved with the transportation of the organic from Tank C-103 to a storage/disposal area outside the C Tank Farm, the total source term released was calculated as follows:

^{239}Pu	0.853 g
^{90}Sr	15.8×10^{-03} g
^{137}Cs	1.03×10^{-03} g

B.5.1 Pumping Accident Analysis

The accident considered to determine the potential bounding source term of a fire involved with the pumping of organic from Tank C-103 is one in which a leak or rupture occurs while pumping the organic to the tanker truck. This leak or rupture is then ignited by an external source. The fire engulfs the tanker rupturing the fuel tank which provides additional fuel for the fire. The fire also spreads back to the pumping enclosure and breaches the coalescer and aqueous collection tank. The pumping enclosure is at the low point of the flow path; therefore, the fire does not spread back to Tank C-103.

B.5.1.1 Total Material at Risk. To determine the total material at risk for a fire during organic removal, the quantity of material initially in the organic along with the quantity of material extracted from the aqueous into the organic during the pumping and coalescing of the organic were determined. This quantity along with the quantity of material contained in the enclosure is the total material at risk during a fire while pumping the organic. To determine this quantity the following assumptions were made:

- The leak occurs when the tanker truck is nearly full (5,000 gal, 2.09×10^{7} mL)
- Approximately 2,800 gal (1.06×10^{7} mL) of aqueous were pumped during the removal of the 5,000 gal of organic, complete extraction of the plutonium from the aqueous to the organic occurs

- The coalescer contains 5 gal (1.89×10^4 mL) of organic and 5 gal (1.89×10^4 mL) of aqueous
- The aqueous collection tank contains 35 gal (1.32×10^5 mL) of aqueous
- Organic contained in the line from coalescer to tank truck is negligible
- Total alpha, beta, and gamma activities result from ^{239}Pu, ^{90}Sr, and ^{137}Cs respectively.

The specific activity of the organic was reported by PNL to be 547 pCi/g for alpha, 1.05×10^6 pCi/g for beta, and 4.29×10^{-2} µCi/g for gamma (Pool and Bean 1994). The specific activity of the aqueous was reported by PNL to be 4.04×10^4 pCi/g for alpha, 6.55×10^7 pCi/g for beta, and 53.7 µCi/g for gamma (Pool and Bean 1994). These activities were assumed to derive for ^{239}Pu, ^{90}Sr, and ^{137}Cs respectively. The density of the organic is 0.868 g/mL (Pool and Bean 1994), which corresponds to 1.81×10^7 g of organic at risk. The density of the aqueous is 1.076 g/mL (PNL 1994), which corresponds to 1.63×10^5 g of aqueous at risk.

The total mass of each isotope was calculated using the specific activity of each isotope, the total mass of organic and aqueous at risk, and Equation B-3.

Equation B-3.

$$grams_x = \frac{Ci_{x_{org}}}{grams_{org}} \times \left[\frac{T_{\frac{1}{2}} \times (\text{atomic mass})_x}{3.578E{+}05}\right] \times grams_{org} + \frac{Ci_{x_{aqu}}}{grams_{aqu}} \times \left[\frac{T_{\frac{1}{2}} \times (\text{atomic mass})_x}{3.578E{+}05}\right] \times grams_{aqu}$$

For ^{239}Pu the total material at risk, as previously calculated in Section B.3, is 7.48 g.

For ^{90}Sr

$$grams_{Sr} = 1.05E{-}06 \times \left[\frac{29.1 \times 89.91}{3.578E{+}05}\right] \times 1.81E{+}07$$

$$+ 6.55E{-}05 \times \left[\frac{29.1 \times 89.91}{3.578E{+}05}\right] \times 1.63E{+}05 = 2.17E{-}01 \text{ grams}$$

For ^{137}Cs

$$grams_{Cs} = 4.29E{-}08 \times \left[\frac{30.3 \times 136.91}{3.578E{+}05}\right] \times 1.81E{+}07$$

$$+ 53.7E{-}06 \times \left[\frac{30.3 \times 136.91}{3.578E{+}05}\right] \times 1.63E{+}05 = 1.10E{-}01 \text{ grams}$$

B.5.1.2 Calculation of Material Released. The calculation of material released during the fire is based upon total material at risk and a release factor associated with an identified release mechanism. The following mechanisms and associated release factors were identified.

Mechanism	Release Factor
Combustible material (organic) spilled over a large volume of aqueous (DOE 1993)	11.4%
Combustion of 30% n-TBP in a kerosine type diluent (uranium) (BWNL 1973a)	0.3%
Combustion of uranyl nitrate hexahydrate (UNH) in a gasoline fire in sandy soil/gravel (BNWL 1973b)	0.03%
Combustion of 30% n-TBP in a kerosine type diluent (cesium) (BNWL 1973a)	1.0%
Combustion of 30% n-TBP in a kerosine type diluent (strontium) (BNWL 1974)	0.22%

To simplify calculations and ensure conservatism only the release factor of 11.4% was used in calculating the sources released. This release factor is considered conservative for the following reasons:

- It is assumed all of the organic is available for combustion (forms a pool and no loss to the ground)
- The tanker truck fuel tank ruptures and the fuel forms a thin layer over the organic pool
- Complete combustion of the organic and fuel occurs with no response/mitigation.

Based upon the material at risk and identified release factor, the material released during a fire while pumping the organic was calculated to be:

^{239}Pu	0.853 g
^{90}Sr	24.7×10^{-03} g
^{137}Cs	12.6×10^{-03} g

B.5.1.3 Dispersion Calculations. The specific details of the calculations for dispersion will be provided in the definitive design documentation.

B.5.2 Transportation Accident Analysis

The accident considered to determine the potential source term of a fire involved with the transportation of organic from Tank C-103 is one in which the tanker truck is involved in an accident. The organic is released and is covered by a flammable liquid (gasoline/diesel) which then ignites.

To determine the source term for this analysis, the total quantity of plutonium bearing solution (organic and aqueous) at risk was determined.

B.5.2.1 Total Material at Risk. To determine the total material at risk for a fire during transportation of the organic, the quantity of material initially in the organic along with the quantity of material extracted from the aqueous into the organic during the pumping and coalescing of the organic were determined. To determine this quantity the following assumptions were made:

- The leak occurs when the tanker truck is nearly full (5,000 gal, 2.09×10^{7} mL)
- Approximately 2,800 gal (1.06×10^{7} mL) of aqueous were pumped during the removal of the 5,000 gal of organic, complete extraction of the plutonium from the aqueous to the organic occurs.

The total mass of each isotope was calculated using the specific activity of each isotope (Pool and Bean 1994), the total mass of organic at risk (see B.5.1.1), and Equation B-4.

Equation B-4.

$$\text{grams}_x = \frac{\text{Ci}_{x_{org}}}{\text{grams}_{org}} \times \left[\frac{T_{\frac{1}{2}} \times (\text{atomic mass})_x}{3.578E{+}05}\right] \times \text{grams}_{org}$$

For ^{239}Pu the total material at risk, as previously calculated in Section B.3, is 7.48 g.
For ^{90}Sr

$$\text{grams}_{Sr} = 1.05E{-}06 \times \left[\frac{29.1 \times 89.91}{3.578E{+}05}\right] \times 1.81E{+}07 = 139E{-}03 \text{ grams}$$

For ^{137}Cs

$$\text{grams}_{Cs} = 4.29E{-}08 \times \left[\frac{30.3 \times 136.91}{3.578E{+}05}\right] \times 1.81E{+}07 = 9.0E{-}03 \text{ grams}$$

B.5.2.2 Calculation of Material Released. The calculation of material released during the fire is based upon total material at risk and a release factor. The following mechanisms and associated release factors were identified.

Mechanism	Release Factor
Combustible material (organic) spilled over a large volume of aqueous (DOE 1993)	11.4%

Combustion of 30% n-TBP in a kerosine type diluent (uranium) (BNWL 1973a)	0.3%
Combustion of UNH in a gasoline fire on a road-like surface (BNWL 1973b)	0.16%

Combustion of 30% n-TBP in a kerosine type diluent (cesium) (BNWL 1973a)	1.0%
Combustion of 30% n-TBP in a kerosine type diluent (strontium) (BNWL 1974)	0.22%

To simplify calculations and ensure conservatism only the release factor of 11.4% was used in calculating the sources released. This release factor is considered conservative for the following reasons:

- It is assumed all of the organic is available for combustion (forms a pool with no loss to the ground)
- The tanker truck and auto fuel tanks rupture and the fuel forms a thin layer over the organic pool
- Complete combustion of the organic and fuel occurs with no response/mitigation.

Based upon the material at risk and associated release factors, the material released due to a transportation accident involving a fire was calculated to be:

^{239}Pu	0.853 g
^{90}Sr	15.8×10^{-03} g
^{137}Cs	1.03×10^{-03} g

B.5.2.3 Dispersion Calculations. The specific details of the calculations for dispersion will be provided in the definitive design documentation.

B.5.3 Fire Protection Requirements

As a result of the estimated source terms potentially released, additional fire protection measures may be required. An analysis of those additional fire protection requirements will be provided in the definitive design documentation.

B.6 REGULATORY ANALYSIS

Generally described in Section 3, compliance with appropriate environmental standards is fragmented into functional and administrative requirements. The functional requirements were described above in order to scope the applicable standards. This section contains specific detail on functional regulation requirements and a summary of administrative documentation required.

B.6.1 Environmental Regulation Detail

This section details and summarizes pertinent aspects of applicable functional environmental regulations to the proposed task. Such functional requirements mandate procedural or engineering development, application, and implementation.

B.6.1.1 General Requirements. General requirements are those to which any facility owner or operator must comply. In larger context, these requirements are those imposed upon owners and operators of Treatment, Storage, and Disposal facilities (TSDs) and upon hazardous waste generators.

B.6.1.1.1 Waste Generator Requirements. Waste generators must address the following general requirements:

- WAC 173-303-170 Requirements for Generators of Dangerous Waste.

In context, this requires that the operator (WHC) of this task designate the waste material generated following the standards provided in WAC-303-070 through -100.

- WAC 173-303-200 Accumulating Dangerous Waste Onsite.

  In context, this section allows, and places procedural requirements upon, the accumulation of dangerous waste on-site without a permit for periods of up to 90 days provided that the material is stored in a container compliant with container management standards.

- WAC 173-303-210 Generator Recordkeeping

  This section requires that procedures be in place and facilities be available for retention of waste manifests, annual reports, and waste designation records.

- WAC 173-303-220 Generator Reporting

  This section requires that procedures be in place for the preparation and submittal of annual and exception reports.

B.6.1.1.2 **Facility Operations Requirements.** Waste treatment, storage, and disposal operations must address the following general requirements:

- WAC 173-303-390 Facility Reporting

  This section, in context, duplicates the requirements of WAC 173-303-220.

- WAC 173-303-395 Other General Requirements

  This section requires that appropriate precautions exist to prevent accidental ignition or reaction of ignitable or reactive wastes, to prevent structural integrity damage of the facility or device containing the waste, and to document compliance with the precautionary methods.

Further, this section requires compliance with all other applicable environmental laws and regulations, that tanks and containers be appropriately labeled, and that loading and unloading be conducted in a manner, and in facilities, designed to protect the environment with regard to spill control and cleanup.

- WAC 173-303-400 Interim Status Facility Standards

  This section requires compliance with WAC 173-303-140 land disposal restrictions (affects disposal), with WAC 173-303-630 requirements upon the management of containers, and with WAC 173-303-640 requirements upon tank systems and ancillary equipment.

B.6.1.2 Requirements for Dangerous Waste Handling Equipment. Specific requirements for dangerous waste handling equipment fall under piping and tank systems of regulations. The appropriate reference is:

- WAC 173-303-640 Tank Systems

Because the process involved is that of removal and separation of material from a single-shell tank, all equipment contacting the waste material in the process from the tank is termed ancillary equipment. As such, an integrity assessment of the ancillary equipment must demonstrate that the equipment (piping and all internals of the separations module) is of sufficient structural strength and compatibility with the waste, that it is within appropriate secondary containment, that it is appropriately protected against corrosion, and that it be tested for leaks. Such tank systems must be able to contain, detect, and be able to remove releases within a short time. Inspections of piping, tanks, and cathodic systems are required. Upon closure, all contaminated equipment, soils, and structures must be either removed or decontaminated appropriately.

B.6.1.3 Requirements for Dangerous Waste Retention. Specific requirements for the retention of dangerous waste were briefly introduced above with respect to container management. The appropriate reference is:

- WAC 173-303-630 Use and Management of Containers

  This section requires that containers holding dangerous wastes be in good condition, that they be identified through labels, that they be visually inspected weekly and the inspections logged, that containers are compatible with the waste therein, and that a containment system be in place to collect and hold leaks and spills.

For secondary containment during the pumping operation, the equipment located outside of the tank will be housed in an enclosure and the flow lines will be double encased. There will be a temporary pad for the truck-mounted container and the design of the pad will be in compliance with regulatory requirements for the temporary storage (i.e., less than 90 days) of dangerous wastes.

There will also be a secondary containment storage pad at the B Tank Farm for the container. This pad will be designed for compliance with the regulatory requirements for long term storage, possibly up to five years, of dangerous wastes.

B.6.1.4 Requirements for Air Pollutant Abatement. Various regulations exist for the protection of the nation's air resources. The applicable regulations in the context of this task are:

- NESHAPs 40 CFR 61, Subpart H governs radionuclide emissions from DOE facilities. In this application, these standards will require that a minimum of HEPA filtration be applied.

- WAC 246-247 Radioactive Airborne Emission Program governs radioactive emissions within the state of Washington. It parallels the requirements of NESHAPs and will require a minimum of HEPA filtration.

- WAC 173-460 Controls for New Sources of Toxic Air Pollutants governs the release of toxic air pollutants. Analysis to support response to this regulation must detail the evaluation and selection of pollutant abatement. The primary TAPs pollutant under consideration at this time for the task is tri-butyl phosphate; of low volatility, it is expected that simple filtration will provide adequate to excellent abatement.

B.6.2 Administrative Requirements

Administrative requirements have been reviewed with respect to the proposed operations and environmental media impact. In addition to the media impacts and the derived permitting and approval requirements of media impacts, other requirements exist which will require administrative address. Table B-4 provides a summary of such applicable administrative requirements.

The consequential administrative and evaluative activities potentially required include preparation or conduct and submittal or implementation of:

- SEPA Checklist
- WAC 173-460 Construction approval request
- 40 CFR 61 Subpart H, Modification approval request
- WAC 246-247 Notice of Construction
- WAC 173-401 Air Operating Permit modification application
- WAC 173-303 Notice of Intent (to modify)
- WAC 173-303 Part A Notice modification
- 36 CFR 800 Cultural Resources Review
- 36 CFR 800 Excavation Permit request

- 50 CFR 402.6 Endangered Species approval
- DOE 5400.1 Preoperational Monitoring
- DOE 5400.5 Radiation Protection Standard environmental monitoring
- Public Law 101-510, Section 3137, approval.

B.6.2.1 Status of Fulfilling Administrative and Regulatory Requirements. The following is a partial listing of the activities ongoing for fulfillment of the regulatory and administrative requirements.

Table B-4. Summary of Applicable Administrative Requirements.

Environmental Media	Permit, Approval, or Requirement	Regulation	Regulatory Agency	Restriction
NEPA	NEPA Documentation	10 CFR 1021	DOE	Title II Design (Projects), Procurement
SEPA	SEPA	WAC 197-11	State Agency	License, Permit
Nonrad. Air Emissions	TAPs	WAC 173-460	Ecology BFCCAA	Construction
Radioactive Air Emissions	NESHAPs	40 CFR 61, Subpart H	EPA	Construction
	RAEP	WAC 246-247	DOH	Construction Operation
All Air Emissions	Air Operating Permit	WAC 173-401	Ecology DOH	Operation
Dangerous Waste	Dangerous Waste Permit (RCRA - A/B)	WAC 173-303; 40 CFR 264, 265, 270	Ecology	Construction of New Facilities or Expansion of Existing Facilities
All Media	Cultural Resource Review Clearance	36 CFR 800	DOE	Surface Disturbing Activities & Modification of Bldgs. Eligible for Listing on Historical Register
	Excavation Permit	36 CFR 800	DOE	Excavation Project
	Endangered Species Approval	50 CFR 402.6	Fish and Wildlife Service	Construction Habitat Modification
	Preoperation Monitoring of Facilities, Sites, & Operations	DOE Order 5400.1	DOE	Operation
	Secretary of DOE Approval	Public Law 101-510, Section 3137 (Wyden Amendment)	DOE	Any material added to a Watch List Tank requires approval.

Environmental Media	Permit, Approval, or Requirement	Regulation	Regulatory Agency	Restriction
	Radiation Protection Standards	DOE Order 5400.5	DOE	Construction

- A Notice of Construction has been drafted for compliance with NESHAP Subpart H and WAC 246-247.

- Revisions are being drafted for the Dangerous Waste Part A Permit Application.

- Pursuant to compliance with Public Law 101-510, Section 3137 (also known as the Wyden Amendment), it is unclear at this time whether approval of the Secretary of DOE will be required to allow equipment flushing agents to drain back into Tank C-103. A decision will be made during definitive design and any impact to the mission will be addressed accordingly.

B.7 REFERENCES

BNWL, 1974, *Fractional Airborne Release of Strontium During the Combustion of 30 Percent Normal Tributyl Phosphate in a Kerosine-Type Diluent*, BNWL-B-358, Battelle Northwest National Laboratory, Richland, Washington.

BNWL, 1973b, *Some Experimental Measurements of Airborne Uranium (Representing Plutonium) in Transportation Accidents*, BNWL-1732, Battelle Northwest National Laboratory, Richland, Washington.

BNWL, 1973a, *Interim Report: The Fractional Airborne Release of Dissolved Radioactive Materials During the Combustion of 30 Percent Normal*

Tributyl Phosphate in a Kerosine-Type Diluent, BNWL-B-274, Battelle Northwest National Laboratory, Richland, Washington.

DOE, 1993, *Criticality Safety Program Guide for DOE Nonreactor Nuclear Facilities*, DOE-STD-XXXX-93, Draft, April 12, 1993, U.S. Department of Energy.

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Schleien, B., 1992, *The Health Physics Radiological Health Handbook*, Scinta, Inc., Silver Springs, Maryland, p. 530.

WHC, 1993, *Hanford Site Tank Farm Facilities Interim Safety Basis*, Rev. 0A, WHC-SD-WM-ISB-001, Westinghouse Hanford Company, Richland, Washington.

WHC, 1989, *PUREX Technical Manual, Chapter 6.0 Solvent Extraction Technology*, WHC-SP-0479, Westinghouse Hanford Company, Richland, Washington.

ATTACHMENT B-1

DOUGLAS ENGINEERING SKIM PAK SKIMMER

APPENDIX C

ENGINEERING STUDIES

C.0 ENGINEERING STUDIES

C.1 ALTERNATIVES STUDY

A comprehensive engineering study was performed to evaluate alternative methods for removal of the organic from Tank C-103, separation of entrained aqueous, and separation of the organic from radionuclide impurities (SAIC 1994). The study was performed prior to the receipt of December 15, 1993 sample analyses of the Tank C-103 contents. Appropriately conservative assumptions regarding the radioactive content and physical properties of the organic restricted the initial option considerations to shielded facilities and the use of underground transfer lines.

The study considered three options for removal of the organic from the tank - large-scale pumping, surface skimming, and hydrophobic filter skimming. The first two options would remove some of the aqueous waste solution along with the organic, thus requiring a means of separating the phases. Three options were considered for phase separation: a gravity settler-decanter, a coalescer separator, and a liquid-liquid centrifuge. Skimming was selected as the most favorable removal option, with the type (surface or hydrophobic filter) to be determined by further studies. The coalescer was initially selected as the most favorable separation option and subsequent vendor tests with simulated Tank C-103 organic have verified the effectiveness of the coalescer for separating organic.

For separation of the organic from radionuclides, 12 options involving seven different facilities were considered (two options at the PUREX Plant and five options at the 204-AR Unloading Facility). All of these options assumed that at least some shielding would be required. An additional option, the use of an ion-exchange medium, was suggested too late to be included in the original study. This option is currently being evaluated. There is no organic/radionuclide separation alternative identified in the PDR, pending the results of this evaluation.

The December 15, 1993 sample analyses of the Tank C-103 contents indicated sufficiently low levels of radioactivity in the organic such that a decontamination step would not be required for the organic to meet the requirements of a low specific activity (LSA) substance. Shipping the organic by tank truck, however, requires radioactivity levels of less than 10% of LSA requirements. The preliminary analyses indicated that even this requirement might be satisfied without further cleanup of the organic; however, the followup analyses indicate the radioactivity of the organic is approximately a factor of two above the limits for bulk shipments. Entrained, fine droplets of the aqueous waste in the organic could also cause the shipping limits to be exceeded. However, results of the recent coalescer vendor test indicate that entrainment should not be a problem, provided the optimum operating conditions (temperature and flow rate) are maintained.

The low radioactivity of the organic and the effectiveness of removal devices in separating the organic and the aqueous motivated a re-examination of the separation of aqueous from the organic and also the separation of the radionuclides from the organic, as developed for each of the 12 options. The low radioactivity of the organic, the relatively low volume of organic, and the possibility of pumping less aqueous ruled against line transfers because of the line drainage to intermediate locations, such as the 244-A Lift Station. Loading the organic into a tank truck or a new tank at the site appeared much more attractive.

The disengaging rate of the Tank C-103 material is low and would require an excessively-large gravity settler decanter. A coalescer however, is relatively small and can be located near the Tank C-103 organic removal equipment, in or near the pump pit. The coalescer ensures that an organic stream with less than 0.2% aqueous entrainment can be produced at Tank C-103 and pumped into a tank truck. The function of the separate facility option, thus, is reduced from performing all separations to separating the radionuclides from the organic (if needed) and storing it until a waste management firm can receive it.

To ensure objectivity and consideration of a broad range of options, a small group of individuals with broad knowledge and experience in radiochemical processing operations was chosen to participate in a structured decision-making forum called Nominal Group Technique (NGT). Brainstorming, clarifying discourse, rating, and systematic conflict resolution were combined into a decision-making process focusing on the issues. The top-ranked option is selected by participants in the NGT decision-making forum similar to the Tank C-103 organic removal and aqueous separation facility described in this PDR. Both options include a skimmer, coalescer, aboveground lines, filter, and tank truck, with minor differences.

C.2 SUPPLEMENTAL TECHNICAL REPORTS

C.2.1 Summary of Organic Removal Studies

Four studies, which included testing of components and materials, were performed to assist in the design of an organic removal system. These included tests of hydrophobic skimmer materials from two vendors (ORS Environmental Equipment and Brainard-Kilman Equipment), testing of the Skim Pak skimmer from Douglas Engineering, and a series of material compatibility tests.

The skimmer tests were performed at the WHC Chemical Engineering Laboratory (CEL). Testing of the ORS oleophilic/hydrophobic skimmer revealed that a large percentage of the aqueous phase passed through the filter with the organic. Because of its poor selectivity, the CEL recommended that this technology not be pursued. Testing of the Brainard-Kilman FAP skimmer with the hydrophobic attachment determined that this skimmer system would likely result in the removal of 10 to 20 gal of aqueous waste for every gallon of organic removed. Therefore it was not recommended for further consideration. Testing of the Douglas Engineering Skim Pak Series 650 skimmer indicated that it is capable of retrieving 100% organic to an organic depth of 8 mm and then

removing only approximately 1 gal of aqueous phase for every 1 gal of organic down to an organic depth layer of 1.5 mm. Thus, this is the preferred skimmer alternative. These results were acceptable in terms of minimizing both residual organic depth and separation system equipment sizing and complexity.

The presence of tributyl phosphate and the high radiation field present in Tank C-103 present a difficult environment for most materials of construction. Tributyl phosphate tends to destroy the integrity of most plastics with the exception of Teflon (Teflon is a trademark of E.I. duPont de Nemours and Company), which has very poor radiation resistance. Due to the importance of using resistant compatible materials in the organic removal system, several plastics and elastomers were tested for compatibility with the tributyl phosphate/normal paraffin hydrocarbon mixture. It was determined that the only elastomer that may be suitable for use is Kalrez, a perfluoroelastomer manufactured by duPont. Kynar (Kynar is a trademark of ELF Atochem of North America, Inc.) was identified as an excellent material of construction with respect to its chemical compatibility with the organic simulant. In addition to these materials, 304 or 316 stainless steel is the preferred material of construction.

C.2.2 Summary of Osmonics Tests

The objectives of the experiments at the osmonics facility were to test the coalescing abilities of a small osmonics unbonded coalescer element with well-mixed Tank C-103 simulants at different feed ratios, flow rates, and temperatures. Test success was determined by the amount of aqueous carried over into the organic outlet stream.

Simulants were prepared as substitutes for the actual Tank C-103 aqueous and organic. Concentrations of compounds closely approximate the measured Tank C-103 aqueous phase.

The liquid phase simulants were mixed and run through a small osmonics coalescer using an unbonded coalescing cartridge element. The phases were mixed in 1:1, 4:1, and 1:4 ratios and run through the coalescer at flow rates between 0.2 and 2 gal/min/per foot of element. Liquid temperatures ranged between 25 and 40 °C. The coalescer gave cleanest separation at the lower flow rates and higher temperatures. At the upper flow rates and lower temperatures (i.e., 25 °C) the coalescer allowed large droplet emulsions to grow downstream of the element. This suggests heat tracing the line from the tank to the enclosure and controlling the process at a higher minimum temperature and lower maximum flow rate would be beneficial. The emulsion problem appeared at slightly lower flow rates in the four parts aqueous to one part organic ratio. At the best conditions only slightly cloudy liquids (probably <<1% microemulsions) came out of the coalescer. From these tests it is safe to conclude that the coalescer can be effectively used in the retrieval process, using a positive displacement pump with flow rate and temperature controls.

The final analyses of the two organic stream samples for aqueous phase carryover are not completed as yet. Visual inspection seems to indicate very little aqueous carryover.

C.3 REFERENCES

SAIC, 1994, Removal, Treatment, and Disposal of Floating Organic Layer in Tank 241-C-103, Science Applications International Corporation, February 28, 1994, Richland, Washington.

ATTACHMENT E-3

SAFETY ASSESSMENT FOR THE 241-C-103 ORGANIC REMOVAL TASK

-DRAFT-

1.0 SCOPE

BACKGROUND

The purpose of this document is to identify hazards and accident initiators related to the organic removal task for Hanford Site tank 241-C-103.

Tank farm 241-C was constructed during 1943-1944 and in August of 1946, tank 241-C-103 was placed into service, receiving metal waste solutions from the bismuth phosphate process. This was later removed and miscellaneous waste, including coating solutions, were discharged here from the PUREX process. In addition, the deposits here included the following wastes: Hot Semiworks, Cesium Recovery, Strontium Recovery, B-Plant High and Low-Level, PUREX high-level, Thoria, Strontium Semiworks, N Reactor, Battelle Northwest, and Decontamination. The tank was in active use until July, 1979. Since then, no wastes have been transferred to or from the tank (Carothers, 1988).

The approximately 2 inch layer (5,500 gal.) of organic liquid is composed of the following: 1-butanol, normal paraffin hydrocarbon (NPH), tri-butyl phosphate (TBP), acetone, and ammonia. This existence of this floating organic layer, together with the recent detection of combustible vapors in the headspace, caused C-103 to be placed on the watchlist.

An unreviewed safety question (USQ) was declared due the flammability of the organic and the potential for an in-tank fire/explosion. It has been determined that the most practical method for resolving the safety issue (SI) is to remove the organic layer from the tank. This is a Tri Party Agreement milestone.

SUMMARY

A preliminary design has been developed for the removal of the organic layer (2 to 5 mRad on contact); the separation of the underlying, highly radioactive (200 mRad on contact), aqueous waste inadvertently drawn up; and the transfer of the organic waste to a tanker trailer. A reduction of radionuclide levels in the organic waste may be necessary as a condition its subsequent disposal. Practical considerations dictate that a 2 mm layer of organic will remain after the retrieval activity. The possibility that this minimal amount could lead to fire or explosion is not considered credible (Burelbach, 1994).

2.0 DESCRIPTION OF ACTION

ORGANIC LAYER RETRIEVAL

The removal of the organic layer from the tank can be accomplished by means of a high volume pump or by "skimming" the surface. The former could be accomplished in approximately three hours, but would result in only about 20%

organic and the remainder, aqueous. This would greatly increase the separation requirements and radiological problems. The risk of fire, due to the increased fluid temperature, would also be a concern.

Organic skimming possibilities were evaluated by testing the most promising methods: two "hydrophobic" devices and a "Skimpak" (Douglas Engineering) skimmer. Test results showed that the hydrophobic systems removed a large percentage of aqueous along with the organic, while the Skimpak removed only about 15% of aqueous phase as the organic depth layer was reduced down to 1.5 mm. The Skimpak has been selected for this project.

The Skimpak energy source consists of a pressure-limited, positive displacement, electric motor-driven pump, energized by a variable-frequency power supply. The variable speed pump will have a flow rate adjustable from 0.1 to 5 gal/min. The pump assembly, which will be located approximately 3 feet above the liquid surface, will be supported by a solid mast inserted through 12 inch riser 02. A flexible line will connect the pump intake to the floating skimmer. A safety line will also be provided.

The liquid will be pumped 33 feet to the top of the riser and through a double-contained, shielded pipe to the separation enclosure. The tank riser will also be shielded.

The separator consists of pre-filters, a coalescer, an aqueous drain tank, and a drain tank pump. The coalescer operates by causing the droplets of organic and aqueous to "coalesce" or combine into larger droplets, through the forces of surface tension, while passing through a spun-glass element. A low fluid velocity allows the relatively large droplets to migrate, by gravity, to the respective phases prior to exiting the coalescer. The organic is carried, by the skimmer pump head, out of the separator and through a double-contained line to the tanker trailer for eventual disposal. The aqueous "falls" to the bottom of the coalescer and is collected in the drain tank to be pumped back to 241-C-103.

The total operation is expected to last approximately 40 days, operating 2 shifts/day. This is based on an initial pumping rate of 1.3 gal/min for the first 3 days, which is expected to remove half of the organic. The next 30 percent will take about 9 days, and the removal down to 2 mm should be accomplished in about 20 days. An additional 8 days is provided for contingencies.

HAZARD CONSIDERATIONS

The hazards are evaluated in eight nodes as follows:

1. Aqueous drain from coalescer and drain tank.

   This analysis covers failures that could result in release to the environment, personnel exposure, and pump damage. No additional controls are necessary.

2. Tank waste removal and feed to coalescer.

   This analysis covers failures that could result in personnel injury, release to the environment, fire/explosion, release of aqueous to tanker trailer, filter/coalescer contamination, equipment damage, and process delay. No additional controls, except for possible lightning strike evaluation, are necessary.

3. Organic discharge from coalescer to tanker trailer.

   This analysis covers failures that could result in personnel exposure, release to the environment, fire, aqueous/organic to tanker trailer, organic to flush source, equipment damage, and process delay. Additional controls include the following: evaluate the use of a quick disconnect valve for the flush connection and consider a safeguard against back-siphoning from the tanker trailer.

4. Trailer tank.

   This analysis covers failures that could result in personnel exposure/injury, release to environment, fire, regulatory infraction, equipment damage, and process delay. Additional controls include the following: consider a study on the foaming qualities of the organic.

5. Aqueous return pump and line to 241-C-103.

   This analysis covers failures that could result in personnel exposure/injury, release to environment, equipment damage, and process delay. Additional controls include the following: evaluate the use of a three-way valve at the aqueous discharge from the coalescer, consider the use of freeze protection on transfer lines, and evaluate the use of a spray ring on the encasement for D&D purposes.

6. Coalescer.

   This analysis covers failures that could result in personnel exposure/injury , release to the environment, fire, equipment damage, and process delay. Additional controls include the following: verify that maximum skimmer pump speed will not affect separator operation, evaluate need for thermal calculations for coalescer heat trace, verify that switching filters will not cause foaming and resultant problems in the coalescer leading to aqueous release to tanker trailer, and verify that loss of computer shuts system down.

7. Vent system for pump/skimmer, separation enclosure, tanker trailer, and return to 241-C-103.

   This analysis covers failures that could result in personnel exposure/injury, release to the environment, equipment damage, and process delay. Additional controls include the following: consider the use of flex hose to tanker trailer.

8. Separation enclosure structure.

   This analysis covers failures that could result in personnel exposure/injury, release to the environment, fire, equipment damage, and process delay. Additional controls include the following: verify that any failure of the leak detection will shut down pump.

DRAWINGS

1. Civil Site Plan-241-C-103.....ES-ER5602-C1, rev. 0
2. Civil Site Plan-Retention Pad-241-C-103.....ES-ER5602-C2, rev. 0
3. Flow Diagram-C-103 Organic Removal System.....ES-ER5602-M1, rev. 0
4. Piping Plans & Sections Transfer Pump, Riser 2.ES-ER5602-M2, rev. 0
5. Piping plans, Sect, Details-Separations Encl...ES-ER5602-M3, rev. 0
6. piping Plans, Sect, Details-Tank Truck Mods....ES-ER5602-M3, rev. 0

3.0 HAZARDS IDENTIFICATION

One of the main tasks of a Safety Assessment is to identify potential hazards (sources of harm to the facility worker, on-site worker and general public) arising from the installation, operation, and removal of a new system or system modification. A number of possible methods may be used for this purpose, including the Preliminary Hazards Analysis, the What-If Method, the Failure Modes and Effects Analysis, the Checklist Method, and the Hazards and Operability Study (HAZOP). For the C-103 organic layer removal project, the method chosen to identify hazards was the HAZOP. The HAZOP study for the 241-C-103 tank organic removal task has a two-fold purpose. First, the HAZOP study will identify potential hazards which are specific to the organic removal task. Hazard identification is the essential first step in the risk assessment process. Second, the HAZOP study will identify operability issues associated with the organic removal task. Operability issues, while not hazardous, may compromise the task's mission--organic removal. This two-fold purpose allows the HAZOP to provide input to the follow-on safety evaluation by way of hazard identification and input to the design and future procedures development by way of identification of operability issues.

HAZARD IDENTIFICATION TOOL

This section briefly discusses the appropriateness of using the HAZOP study to identify hazards for the organic removal task. The strengths and weaknesses of the HAZOP study are also presented.

Why the HAZOP Study was Selected

The thought process behind selecting hazard identification tools is complex, and a variety of factors can influence the decision-making process. Six categories an analyst should consider are discussed in CCPS 1992 and are as follows:

- motivation for the study
- type of results needed
- type of information available to perform the study
- characteristics of the analysis problem
- perceived risk associated with the subject process or activity
- resource availability and analyst/management preference

Motivation The motivation for the 241-C-103 organic removal task comes in the form of a Tri-Party Agreement milestone. Interim milestone M-40-04 concerns removal of the floating organic layer from tank 241-C-103 and represents a high level commitment between the U.S. Department of Energy, Richland Operations Office, the U.S. Environmental Protection Agency (EPA), and the State of Washington Department of Ecology (Ecology). Westinghouse Hanford Company (WHC), as the main operating contractor to the DOE, is faced with the task to meet the milestone.

Results needed Since the DOE must accept the risk of the activities which take place on the Hanford Site and approve operations which present risks greater than those in the existing safety basis, a safety evaluation must be conducted for the organic removal task. The safety evaluation will answer the three questions (1) what can go wrong, (2) how likely is it to go wrong, and

(3) what are the consequences if it does occur. The hazard identification tool answers question 1. In addition to hazards identification, the customer has asked that the design information be examined from the standpoint of operability. Therefore, the results needed include the identification of hazards and operability issues.

Information available The information made available for the organic removal task consisted of the preliminary design report documented in Enserch 1994.

Characteristics of the problem The organic removal task is a temporary modification the 241-C-103 single shell tank. Operation time will be on the order of two to three months. The equipment used for the task is not complex and is relatively small. The main components are the skimmer and pump, the separations enclosure, which contains three roughing filters, a coalescer, and a small drain tank, and tanker truck. Each of these items will be located within the area of the C tank farm. The typed of process involved is a liquid organic-aqueous separations process and involves flow of material between unit operations.

Perceived risk The perceived risk for the organic removal operation is moderate to low. No hazards are considered of a magnitude to impact the offsite public. Few, if any of the hazards are expected to impact collocated worker area outside of the C farm. The majority of the hazards concern damage to the existing C-103 tank with potential environmental release of tank contents and facility worker issues such as radiation exposures.

Resources The analysis team does have the support of the customer. The customer has supplied drawings, and more importantly, the customer has made it possible for a team of its engineers to work closely with the analysis team.

The major reasons driving the selection of the HAZOP study approach to hazards identification are:

- motivation: the project, because it is a TPA milestone will be very visible--using a chemical-industry accepted and widely recognized technique will aid in the overall project success; HAZOP is such a technique
- results needed: the safety evaluation requires that hazards be identified and the customer wishes to have operability issues addressed; HAZOP does meet this need
- information available: preliminary system drawings are defined; drawings are required for the HAZOP technique
- characteristics of problem: the type of process involves flow of material between unit operations; HAZOP is designed for this type of process
- perceived risk: HAZOP is able to work on projects ranging from low to high levels of risk
- resources: HAZOP does require a team approach involving several individuals.

Advantages and Disadvantages of HAZOP

The advantages and disadvantages of the HAZOP technique are listed in the following table.

Table

ADVANTAGES	DISADVANTAGES
• Most effective of available hazards analysis methods	• Effort involved can be significant and is proportional to the complexity of the system and the depth of detail
• Provide greatest assurance that all hazards have been identified	
• Can provide both hazard and operability information	

Source:SAIC 1989

HAZOP METHODOLOGY

A HAZOP study documents the effects of deviations from the design intent of the various "process" parameters (i.e., temperature, pressure, etc.). Design drawings were used to break the organic removal task design into nodes. Nodes are generally composed of a major piece of equipment and its surrounding associated piping, filters, valves, pumps, etc. Pertinent process parameters (guide words) such as flow, pressure, temperature, and level are chosen, and a series of questions are asked about each parameter. Each "question" concerns an abnormal condition of the process parameter (for example, 'no flow'). The HAZOP team, based on design knowledge and operational experience, postulate the causes and effects of the abnormal process condition. From this information, a qualitative estimate of the consequences of the abnormal condition was obtained. The consequence estimate can then be used as a screening tool later during the safety evaluation phase to determine which deviations require further analysis.

The HAZOP study is documented with a series of tables (see attachment) which are a recording of the HAZOP team discussions.

HAZOP TABLES

This section describes the format used to record the HAZOP team's discussions. The recording format is the same for each node and includes a header page and a logsheet.

Header Page

The header page provides a space for the project name, the node description, the design intention, normal process parameters, team members, and drawings used. The header page also contains areas where additional, administrative, information may be added. The key items are the node description, the design intention, and normal process parameters. Briefly, the node description describes the node by listing the equipment under consideration. The design intention describes how the equipment is intended to operate. The normal process parameters list any parameters such as pressure and temperature and shows their normal ranges.

Logsheet

The logsheet is where the team discussions are recorded. The column headings for the logsheet are

- process parameter
- guide word
- causes
- consequences
- safeguard
- rank
- remark
- remark number.

Process parameters which may be examined include flow, pressure, temperature, level, agitation, reaction, composition, structural integrity, etc. Guide words which are applied to process parameters and their meanings are listed below:

"no/none" --- negation of design intent
"Low/less" --- quantitative decrease
"More/high" --- quantitative increase
"Part of" --- qualitative decrease; intended element partially missing
"As Well As"--- qualitative increase; addition of unintended element
"Other" --- complete substitution; completely wrong element
"Reverse" --- logical opposite of intent

The first column, designated "PROCESS PARAMETER" states which parameter is being analyzed. The second column "GUIDE WORD" shows guide words or variants that apply to the process parameter. There are usually several guide words applied to a process parameter, forming different deviations. The next column, labeled "CAUSES" lists the potential cause or causes of the deviation. Though team participants generally considered even seemingly rare events, some common sense was used to avoid absurd or obviously impossible causes for the deviation.

The next column is labelled "CONSEQUENCES". The Consequence column contains a qualitative estimate of the result of the deviation without regard for safety features. Generally the potential release consequences or personnel harm issues are listed. The "RANK" column shows a "first cut" qualitative consensus estimate of the safety and operational severity of the consequences. An alphanumeric system was used to designate the severity, with the following "S" rankings characterizing safety consequences:

- S0 no effect outside the facility confinement systems and no safety concerns for the facility worker, the onsite worker, or members of the general public.
- S1 potential industrial injury, radiological dose consequences or chemical exposure to the facility worker
- S2 potential significant radiological dose consequences or chemical exposure to the onsite worker at the nearest adjacent facility
- S3 potential significant radiological dose consequences or chemical exposure to the offsite population

The "REMARKS" column will contain information that the team judges requires documentation. This includes (but is not limited to) assumptions about facility operation, questions on facility operation, or recommendations for changes in the planned design operation. The "REMARK #" column simply gives a number to the remarks for ease of reference.

HAZOP TEAM

A HAZOP study is accomplished through the interaction and synergy provided by team members of different disciplines and perspectives. It is always good to include team members form a variety of backgrounds. The following list shows the C-103 HAZOP team by role and organization of origin. Though not all of these team members participated in each session, a sufficient group of participants was always present.

Table: C-103 HAZOP Team

Name	Area	Mail Stop	Phone Number
Mike Reardon	HAZOP Leader/Safety Analysis	H4-66	376-1083
Mike Porten	HAZOP Scribe	H4-66	376-9236
Greg Henson	HAZOP Organizer and Scribe	H4-61	376-2119
Larry DellaRocco	Special Projects/Instrumentation and Electrical Lead	H5-09	373-4925

Table: C-103 HAZOP Team

Name	Area	Mail Stop	Phone Number
Tom Wilson	Special Projects/ Process Engineering	H5-09	376-5308
Kim Morris	TWRS Design Engineering	H5-09	376-8843
Kyle Hein	Test Engineering	R1-51	373-4760
Larry Thomas	TWRS Nuclear Safety	R1-51	372-2402
Yogi Ananda	Quality Assurance	S1-57	373-5091

HAZOP STUDY TEAM QUALIFICATIONS

The Hazard and Operability (HAZOP) study was developed by a team of individuals. The major contributors were Mike Reardon, Larry DellaRocco, Tom Wilson, Kim Morris, and Kyle Hein.

Mike Reardon, Risk Management Group, has a BS degree in Nuclear Engineering from Oregon State University. He has done analysis for a variety of projects including the 242-A evaporator restart, HWVP canister storage facility, Red Oil reactions in PFP Filtrate Evaporator, and the 241-C-103 organic removal layer effort. He is the author of publications on both generic component failure-rate and hazards identification.

Larry DellaRocco, Special Projects, a Purdue University graduate, received a Certificate in Practical Industrial Control Electronics. He has 26 years of experience in instrumention, control, and electrical systems. His experience encompasses activities at various Hanford facilities including PUREX, the Grout Facility, and N Reactor. Additionally, he has worked at BWR, PWR, and fossil power plants; chemical plants; and natural gas/oil pipelines.

Tom Wilson, Special Projects, has a BS degree in Mechanical Engineering from Montana State University. His most recent position is that of lead engineer for above ground equipment in the waste tank organic removal program. He is the author/co-author of publications on the removal of organic waste from tank 241-C-103, and is responsible for the design of parts of the proposed waste removal project on that tank.

Kim Morris, Development Engineering, has a BS degree in Mechanical Engineering from Washington State University. He has experience in design, cost estimating, structural analysis, and team management. He is the engineer responsible for organic layer removal equipment in tank 241-C-103. He is the author/co-author of several publications on measurements in waste tanks at Hanford site. Additionally, he was a member of the National Tank Waste

Characterization Workshop for the Department of Energy Underground Storage Tank Integrated Demonstration in 1991.

Kyle Hein, Test Engineering, has a BS degree in Mechanical Engineering from Montana State University. He has been associated with the hydrogen mitigation activity on tank 241-SY-101 and has written procedures for instrumentation installation. Previous experience includes semiconductor manufacturing, space shuttle launch sequence design, and guidance system design.

Comments of Interest From HAZOP Team

A number of remarks regarding the design and operability issues of the system came up during the conduction of the HAZOP. These comments can be valuable in further design modifications, safety barrier analysis, worker safety, ALARA, and operability. Because the system is still under design, many of the following comments are simple questions about the design and operation of the system. Some are design recommendations, and some are recommendations for further study on phenomena pertinent to the system's operation. Most of these comments are drawn for the REMARKS column in the HAZOP tables. Resolution of these recommendations are not required for the completion of this study. These recommendations are provided as a courtesy to the customer.

1. The operating status (shutdown, level interface, etc.) of the system during loss of computer control should be determined.

2. Determine whether filters (and coalescer) can be backflushed. If so, under what conditions?

3. If backflushing of the filters is performed, an isolation valve should be in place on the pressure indication sensing line to protect from extreme pressures.

4. Some temperature controls may be needed to protect the HALOR sheath over the interface level probe in the coalescer, which is temperature sensitive.

5. The potential for lightning strike on the system may need evaluation.

6. Some study on the potential of organic foaming in the system may be necessary.

7. Determine what kind of valves are on flush connections. Quick-connect type is advised.

8. More safeguards may be needed to prevent back-siphoning of the truck after system shutdown.

9. The organic discharge line vacuum breaker may be better operated automatically rather than manually.

10. Clarify flow control at aqueous discharge from coalescer (what valve or valves types?).

11. Some thermal protection on external transfer piping may be necessary.

12. A spray ring on the aqueous return line (inside C-103) may be necessary for D&D.

13. Determine effects of maximum skimmer pump overspeed (especially on gaskets, seals and coalescer interface level).

14. Thermal calculations on thermal shock of hot liquid into a cold vessel or piping may be needed if the system is started in very cold weather.

15. Study of coalescer heat trace overheating consequences may be necessary.

16. Determine if roughing filters are filled with liquid or air while on standby.

17. A pressure indicator on the tanker trailer could be helpful in determining dead-head situations in the truck.

18. A flex hose attachment from organic discharge to the tanker trailer could be safer in the event of minor truck movement (seismic event, etc.)

19. Verify system status on loss of electricity (fail safe?).

20. An evaluation of seismic suitability of system may be informative.

21. How good is the NPH (Kerosene) as a lubricant? Will the Waukesha be able to handle the pumping requirements with a potentially poor lubricant/coolant?

22. What happens to the pumping components at dead-head conditions? Is there a pressure limiting switch?

23. Will administrative controls prevent reverse flow/suction conditions?

24. What happens to the coalescer when flow is reversed at shutdown and fluid is flushed into the coalescer body? Without a motor valve at the organic discharge, system shutdown will produce this condition with fluid in the overground transfer lines.

25. At final system shutdown, backflow from the overground transfer lines may fill coalescer with unanticipated fluid, potentially contaminating personnel during the D&D process.

26. Exposure due to changeouts has not been fully explored.

27. Must re-investigate the "coalescer-effect" concerning foaming or organic filling the filter casing, complicating the separations process.

28. On shutdown, what is the exposure produced by radioactive overground transfer lines?

29. Control valve(s): Ensure that the fail positions are correct.

30. Piping: Investigate the valve and routing following aqueous discharge motor valve.

31. Piping: If recycle valve is misrouted, no return to C-103 may cause pressure buildup, drain tank overflow and similar accident scenarios.

32. Sump pump: Is the valve immediately following the sump pump capable of directing flow back to the coalescer?

33. Drain Tank: Is there a need for an overflow orifice?

34. Aside from level indication at the container, how do we know that flow is occurring between the coalescer and the container?

35. Vacuum Breaker: Must assure that manual vacuum breaker is utilized at system shutdown to prevent siphoning.

36. Storage Container: Siphoning is a possibility due to a manual vacuum breaker and full length discharge line. Now that flammable vapors are not an issue, is it possible to raise (shorten) the discharge line to the top of the container?

37. Drain Tank/Container: What are the contingencies for tank overfill conditions (e.g. PRVs)?

38. Storage Pad: Must take into account displacement by trailer wheels, etc.

4.0 HAZARD ANALYSIS

The hazards generated from the HAZOP process were analyzed using a qualitative method of frequency and consequence assessment. The Hazards Table in appendix B shows the results of this method.

The purpose of the Hazards Table in appendix B was to;

A) Sort accidents by phenomena type (release, fire, spray, etc.),
B) To estimate the frequency of the accidents,
C) To estimate the consequences of the accidents to the facility worker, nearby on-site facility worker, and to the general public (although emphasis should be placed on the facility worker's estimated consequences as the facility worker is not examined in Section 5.0, Consequences)
D) To list and assess barriers, mitigating features and other factors that would influence the frequency and consequences of the accidents.

As the Section 5.0, Accident Consequences shows, even worst case accidents such as spray release from the aqueous return line and burn of the entire inventory of organic (5500 gallons) do not result in doses of over 5 rem to the adjacent on-site worker or 500 mrem to the general public. The information in the Hazard Table, therefore, is provided to assist the project engineer in assessing hazards to the facility worker and accounting for barriers in the system design.

The following sections describes the Hazards Table.

4.1 HAZARDS TABLE (shown in Appendix B)

Only accidents of impact to human beings were included in the Hazards Table in appendix B. This excludes all events of consequence rank S0, which are equipment damage events.

The Hazards Table is composed of five columns and is separated into the HAZOP nodes. The columns are defined as follows:

EVNT - This column gives the event (accident) reference number from the HAZOP tables for the accident being analyzed. Each event number corresponds to a different Cause-Consequence combination from the HAZOP tables. The event number for each Cause-Consequence combination is given in the RANK column in the HAZOP tables. For example, event 1-01 from the EVNT column of the Hazards Table corresponds to the first accident with an S1 consequence ranking in the RANK column of the HAZOP tables. This accident is an overflow of aqueous caused by the addition of flush water to the drain tank during operation, through the drain tank flush connection. Descriptions of the sequences for the events listed in column EVNT are not given in the Hazards Table (appendix 2) and must be determined by referencing back to the HAZOP tables (appendix 1).

FREQ - This column gives a qualitative estimate of the frequency of each accident on a yearly basis (or in this case, the operating mission of the

system which is X-X months). The index numbers shown in this column refer to the following classes of frequency:

1	=	Frequency of less than		1.0E-06 per year, (incredible)
2	=	Frequency of 1.0E-04	to	1.0E-06 per year, (highly unlikely)
3	=	Frequency of 1.0E-02	to	1.0E-04 per year, (unlikely)
4	=	Frequency of 1.0	to	1.0E-02 per year, (anticipated)

It should be noted that the frequencies cited for each event reflect the frequency of the sequence actually resulting in harm, which is a function of both initiating event frequency and defeat of barriers and mitigating features. It is for this reason that many of the estimated frequencies are relatively low. The frequencies were estimated using the factors listed in the FACTOR column of the same table.

Many of the events show more than one frequency in the FREQ column. This is because a number of the Cause-Consequence combinations from the HAZOP tables list more than one type of potential consequence phenomena. The different types of consequence phenomena are defined below:

Release (REL) - This type of accident phenomena is a simple spill of liquid materials. It can be a result of tank overflows, pipe ruptures, or vessel failures. The result is a pool of liquid material at grade level that can be resuspended, spread as surface contamination or present direct radiation as shine to nearby personnel. There is no spray release component included in this category.

Fire (FIRE) - As the name implies, this is a fire. The fuel referred to in this study is most likely organic, although electrical fires are possible. Fire poses a hazard as an extreme heat source and breathing hazard from smoke, although its hazardous potential to other on-site worker and the general public arises from its ability to suspend airborne radioactive contamination.

Spray Release (SPRAY) - Because the separations system maintains the organic/aqueous liquid at a higher than atmospheric pressure (from the skimmer pump), the possibility of aerosol spray releases at fine cracks in transfer system components exists. A spray release is a hazard both to the facility worker as well as the on-site worker and general public because it creates a fine, airborne mist of liquid contaminants that can be respirable.

Exposure (EXP) - This is a non-contamination hazard in which facility personnel are exposed to direct radiation, possibly even through shielding. There is no threat to on-site personnel or the public.

Airborne Contamination (AIRBN) - This is airborne contamination other than that formed by pressurized spray release aerosols. The sources can be simple surface contamination suspended by an impact or the small amounts of airborne contamination that would escape from a non-filtered contaminated area. This material would also be respirable.

Industrial Accidents (IND) - These are simple impact, fall, shock and high heat accidents. There is no contamination or radiation involved,

and the on-site worker and public are not affected. Although consequences are confined to the facility worker, degree of consequence can be as extreme as death in some cases.

Each hazard phenomenon type within an event has a separate frequency index in order to account for the slightly different mechanisms responsible for each phenomenon type.

CONSEQUENCE COLUMNS (P,O,F) - These three small columns provide the estimated consequence index for three different groups; the off-site public (P), the on-site worker at the nearest adjacent facility (O), and the facility worker at C-103 (F). Because consequences to these three groups can vary widely on the type of accident in consideration, they are all treated separately for each event number.

The index numbers refer to a qualitative binning of consequence into four rough groups (1 to 4). These indexes are defined as follows:

1 = No harm to individuals, no dose limit violations
2 = No harm to individuals, probable dose limit violations (5 rem onsite, 500 mrem offsite)
3 = Harm to individuals in the form of injuries/illness/health effects, dose limit violations
4 = Severe harm to individuals in the form of injuries/illness/health effects, possibly leading to death, gross dose limit violations

No consequence above dose limits was found for the adjacent on-site worker or off-site public (see Section 5.0). Consequences were estimated for the facility worker, however, and were estimated on the following bases:

Releases were judged to be consequence group 1 for the facility worker (< 5 rem) unless it was thought that the worker could be directly splashed with a large amount of waste, as from a flush connection leak during flush procedures, in which it was estimated to be group 2.

Fires were taken as consequence group 3 because of there straightforward burn potential to the worker. In the cases of massive fires (the burn of the entire organic inventory above ground), consequences were estimated to be possibly fatal (group 4).

Spray releases were judged to be a higher radioactive hazard for their respirable component and were estimated to be capable of delivering over 5 rem to a facility worker (group 2).

Most airborne releases were judged to give little dose to the facility worker and were classed in group 1, unless a massive amount of contamination were released as in a C-103 dome failure (group 2).

Exposures to the facility worker were estimated to deliver less than 5 rem, except in the case of the trailer tank filling with aqueous which was estimated to exceed that dose (group 2).

Industrial accidents were evaluated individually and are self-explanatory.

FACTORS - This column lists both engineered barriers to the accident or hazard listed, and also any other circumstances that could be taken into account when estimating an accident's likelihood and consequence. These factors were taken into account when estimating the frequency indexes in the FREQ column.

5.0 CONSEQUENCES OF ACCIDENTS

CONSEQUENCE ANALYSIS FOR ORGANIC LAYER REMOVAL

PROJECT FOR SINGLE-SHELL TANK C-103

1.0 INTRODUCTION

This analysis analyzes the consequences associated with the removal of organic from the tank 241-C-103. Although the organic layer on the tank waste cannot support combustion, evaluation of potential scenarios that could lead to an organic fire or explosion need to be evaluated. Furthermore, dose consequences need to be evaluated for several scenarios:

- Resuspension of radionuclides from an organic pool
- Resuspension of radionuclides from an aqueous pool
- Suspension of radionuclides from a burning organic pool
- Suspension of radionuclides from an aqueous spray release

2.0 BACKGROUND

Tank C-103 is a single-shell tank that contains a floating layer of organic liquid composed of tributyl phosphate (TBP) and normal paraffin hydrocarbons (NPH). TBP is an organic that formerly was used in the extraction processes. It has a vapor pressure somewhere between 0.024 and 0.029 mmHg at 41 °C (106 °F) (CRC 1991).

NPH is a combination of alkanes (C_{10} - C_{15}). All of these alkanes are insoluble in water. The boiling points range from 174 °C (345 °F) for decane (C-10) to 271 °C (520 °F) for pentadecane (C-15). Again, specific gravities range from 0.73 to 0.77; therefore, the mixture is expected to form a layer of insoluble organic at the air-waste interface. Vapor pressures of 1 mmHg are attained for undecane (at 32.7 °C [90.9 °F]), dodecane (at 47.8 °C [118 °F]), tridecane (at 59.4 °C [139 °F]), tetradecane (at 76.4 °C [170 °F]) and pentadecane (at 91.6 °C [197 °F]). The lighter constituent, decane, has a vapor pressure of 5 mmHg at 30.6 °C (87.1 °F).

For the purposes of this consequence analysis, the organic is considered to be dodecane and TBP. Table 1 shows the physical parameters associated with these organics, as well as the reactive hazards associated with these organics. An Unreviewed Safety Question (USQ) was declared September 21, 1992 because of the existence of this floating organic layer in Tank 241-C-103. Of particular concern was the possibility of potential accidents not bounded by the facility-identified safety envelope. For instance, there was the potential that the headspace of Tank 103-C could accumulate enough organic fuel to constitute a flammable condition, which led to consequences not previously analyzed. Responses to these concerns were prepared to close this USQ (Postma 1994).

Closure of the USQ did take place and was based on results such as a measured flash point of 119 ± 2 °C (246 ± 4 °F) for the organic layer contents, the current tank temperature of 40 ± 4 °C, current organic vapor sample results totaling only 5% LFL, and other sample analyses for hydrogen and ammonia

totaling another 2% LFL. Organic vapor found in the tank does consist of normal paraffin hydrocarbons (NPH) constituents with small amounts of tributyl phosphate (TBP). While these organics are flammable, the flashpoint is 2.89 times higher than the tank temperature.

Controls were identified for the continual monitoring and continuous filtered (passive) ventilation of the headspace to ensure combustible species are maintained below 25% LFL. Furthermore, controls were identified to preclude fuel spills into the tank through the risers and inclusion of heat or spark sources into the tank (Postma 1994).

Being in a static configuration, the tank waste evaporates and diffuses through the headspace. A deflagration is highly unlikely with these chemicals at these concentrations with the tank in this configuration. Furthermore, current adiabatic calorimetry test performed on samples of the organic liquid demonstrate that the liquid phase will not support propagation (Postma 1994). However, with the advent of this project, the tank surface will undergo chemical and physical changes as the organic is removed. Evaporation of the aqueous liquid could increase, or the corrosion rate at the air-waste-tank wall interface could increase. With this project, for the first time, there is a potential for producing a spray release inside of the tank, which could raise the fuel concentration to a flammable regime.

TABLE 1-- SOME PHYSICAL AND CHEMICAL PARAMETERS OF ORGANIC LAYER CONSTITUENTS

CHEMICAL	PHYSICAL PARAMETERS	REACTION INFORMATION
Dodecane	MP -10 °C LFL 0.6 % BP 216 °C UFL none listed FP 165 °F Density 0.75 Insoluble in water. However, additional solubility information shows dodecane to be very soluble in acetone, carbon tetrachloride and chloroform.	Flammable/combustible material; may be ignited by heat, sparks or flames. Vapors may travel to a source of ignition and flash back. Container may explode in heat of fire. Vapor explosion hazard indoors, outdoors or in sewers. Contained vapor in sewers or tanks may create fire or explosion hazard. A Henry's Law Constant of 5.15 atm-m^3/mole at 25 °C, suggests rapid volatilization of n-decane from environmental waters and surface soils. Reactions with photochemically produced hydroxyl radicals in the atmosphere have been shown to be important (estimated half life of 1.4 days). Photolysis or hydrolysis of n-decane is not expected to be important in soils.
TBP	MP -80 °C LFL none listed decomp. 289 °C UFL none listed FP 146 °C Density 0.972 Vapor Density 3.14 Soluble in water (about 0.043 g/100 cc at 25 °C).	Normally stable even under fire exposure conditions. When heated to decomposition, can emit highly toxic fumes of PO_x.

3.0 CALCULATIONS

3.1 Dose Calculations

A unit release approach was used to determine a conservative estimate of committed dose (in sieverts). The assumption is made that the amount of material released from a unit release is linearly (1:1 ratio) related to the amount of material released. Therefore, the release of 1 liter of liquid material (see the attached GENII program output files) was used to determine dose consequences onsite and offsite. Releases were run for both organic and aqueous phases.

DOSE CONSEQUENCES FOR 1 LITER RELEASE				
Receptor Location	Organic Phase Source Term		Aqueous Phase Source Term	
	Inhalation (Sv)	Ingestion (Sv)	Inhalation (Sv)	Ingestion (Sv)
100 m, onsite	2.9 E-05	N/A	2.0 E-04	N/A
offsite	1.5 E-08	5.0 E-07	1.0 E-07	6.2 E-05

3.1.1 Burning Combustible Liquid

To determine the burn rate the following equation is used (Ayer 1988):

$$\dot{M}_b = (\dot{Q}_e'' + \dot{Q}_{fc}'' + \dot{Q}_{fr}'' + \dot{Q}_{rr}'') \cdot \frac{A}{L}$$

where: $\dot{M}$ = burn fuel rate, g/sec
$\dot{q}_e''$ = external heat flux per unit fuel surface area, kW/m^2
$\dot{q}_{fc}''$ = external heat flux per unit fuel surface area, kW/m^2
$\dot{q}_{fr}''$ = external heat flux per unit fuel surface area, kW/m^2
$\dot{q}_{rr}''$ = external heat flux per unit fuel surface area, kW/m^2
A = burning surface area of fuel, m^2
L = heat required to generate a unit mass of fuel vapors, kJ/g

Assuming that there is sufficient oxygen to prevent smoldering, that the external heat flux is negligible ($\dot{q}''_e \approx 0$), and that the parameters for kerosene fit those of dodecane:

$$\dot{M}_b = \left((11\ \frac{kW}{m^2}) + (14\ \frac{kW}{m^2}) + (8\ \frac{kW}{m^2})\right) \cdot \left(\frac{A\ m^2}{1.5\ \frac{kJ}{g}}\right)$$

$$\dot{M}_b = 22\ \left(\frac{g}{m^2\text{-sec}}\right) \cdot A\ \ (m^2)$$

The assumption is made that the bermed surface area for an organic spill is about 92.9 m^2 (1000 ft^2).

$$\dot{M}_b = 2044\ \left(\frac{g}{sec}\right)$$

Given that the maximum volume expected in the organic tank is 20.8 m^3 (5500 gal), the pool formed with this surface area would be 0.224 m deep and contain enough fuel to support combustion for 2.83 hrs. The fraction of semivolatiles suspended into the air from the burning of the pool is assumed 1% (Ayer 1988). The radiological dose is calculated using:

$$D_{onsite}\ (sieverts) = \frac{\dot{M}_b\ (\frac{g}{sec})}{\rho\ (\frac{g}{L})} \cdot t\ (sec) \cdot \psi\ (\frac{Sv}{L}) \cdot \phi\ (\frac{g\ soluce\ airborne}{g\ solvent\ burned})$$

RADIOLOGICAL DOSE FOR ORGANIC FIRE		
Receptor Location	Inhalation (Sv)	Ingestion (Sv)
100 m, onsite	6.04 E-03	N/A
offsite	3.12 E-06	1.04 E-04

3.1.2 Liquid Spray Release

The scenario is that a spray leak develops from a pipe. Assumptions made for the analysis of these scenario is that pipe is a nominal 2" schedule 40 pipe and that the pressure in the pipe is 60 psig. The program Spray (version 3.0) was used to determine the amount of respirable material that initially becomes airborne (see attached Spray output files). The radiological dose is calculated using the worse case inventory (aqueous phase) and the following equation:

$$D\ (sieverts) = \dot{V}\ (\tfrac{L}{sec}) \cdot t\ (sec) \cdot F(\tfrac{Sv}{L})$$

where $\dot{V}$ ≡ respirable leak rate
t = time
F = dose per unit release (from GENII)

Orifice Spray Leak (orifice size is optimized by the program):

$\dot{V}$ = 5.67 E-07 L/s
t = 345600 sec (4 days)

Slit Spray Leak (slit length is taken as ($\frac{1}{2}\pi$) times the inside diameter and the depth of the slit is taken as the wall thickness):

$\dot{V}$ = 3.28 E-05 L/s
t = 345600 sec (4 days)

DOSE CONSEQUENCES FOR SPRAY RELEASE OF AQUEOUS PHASE				
Receptor Location	Orifice Spray ReTease		Slit Spray ReTease	
	Inhalation (Sv)	Ingestion (Sv)	Inhalation (Sv)	Ingestion (Sv)
100 m. onsite	3.92 E-05	N/A	2.27 E-03	N/A
offsite	1.96 E-08	1.21 E-05	1.13 E-06	7.03 E-04

3.1.3 Wind Resuspended Contamination

Resuspension rates for wind resuspension of material from pools varies greatly. However, the maximum experimentally determined value was 1.11×10^{-9} sec^{-1} (9×10^{-6} hr^{-1}) for resuspension from large outdoor pools with wind speeds up to 13.4 m/s (30 mph). The total volume is assumed to be 20.8 m^3 (5500 gal) for either the aqueous or the organic phase. This assumes an operational error filling up the organic tank with the aqueous phase. The assumed time of 4 days exposure was used again. The radiological dose is calculated using the worse case inventory (aqueous phase) and the following equation:

$$D\ (sieverts) = V\ (L) \cdot t\ (\text{sec}) \cdot RF\ \left(\frac{1}{\text{sec}}\right) \cdot F\ \left(\frac{Sv}{L}\right)$$

where V = volume of pool, L
t = time exposed to wind, sec
RF = resuspension factor, dimensionless
F = dose per unit release (from GENII), Sv/L

DOSE CONSEQUENCES FOR WIND RESUSPENSION				
Receptor Location	Organic Pool		Aqueous Pool	
	Inhalation (Sv)	Ingestion (Sv)	Inhalation (Sv)	Ingestion (Sv)
100 m, onsite	2.32 E-04	N/A	1.60 E-03	N/A
offsite	1.20 E-07	4.00 E-06	8.00 E-07	4.95 E-04

3.2 Other Calculations

3.2.1 Smoke Yield

The following assumptions are pertinent to this calculation:

1. Sufficient oxygen is present to prevent smoldering
2. The external heat flux is negligible
3. The parameters for kerosene fit those of the organic
4. The bermed surface area for an organic spill is 92.9 m^2
5. The maximum volume 20.8 m^3

Following from these assumptions and the above determined burn rate, there is enough fuel to support combustion for 2.83 hrs. The fractional yield of smoke for TBP/kerosene is 0.087. The smoke release rate can be determined using the following:

$$\dot{G}_s = Y_s \cdot \dot{M}_b$$

where $\dot{G}_s$ = smoke release rate
Y_s = fractional yield of smoke
M_b = burn rate

$$\dot{G}_s = 178 \ (\frac{g}{sec})$$

3.2.2 Heat Release

The same assumptions for section 3.2.1 apply to this calculation. Following from these assumptions and the above determined burn rate, there is enough fuel to support combustion for 2.83 hrs. The fraction of heat released compared to the theoretical calculations for a fire involving TBP/kerosene is 0.91. The heat of combustion of kerosene is considered to be 47.9 kJ/g. The actual heat release rate can be determined using the following:

$$\dot{G}_a = X_a \cdot H_c \cdot \dot{M}_b$$

where $\dot{Q}_a$ = actual heat release, kW
X_a = fraction of total theoretical heat release
H_c = heat of combustion, kJ/g
M_b = burn rate, g/sec

$$\dot{Q}_s = 8.91 \ X \ 10^4 \ kW$$

4.0 CONCLUSIONS

The consequences stemming from reaching a flammable region inside of the tank with subsequent combustion were analyzed in section 3.1.1, 3.2.1 and 3.2.2. In order for a fire to occur, the current configuration of the tank has to change. Therefore a pool fire of the organic was evaluated at a collection point outside of the tank 241-C-103. The above listed sections analyze the dose that could be received by onsite and offsite individuals from the organic burning, the smoke production rate, and the amount of heat during the burn.

The consequences stemming from a spray release associated with the organic removal system was analyzed in section 3.1.2. The consequences stemming from a wind resuspension release associated with the organic removal system was analyzed in section 3.1.3.

The dose consequences comes from the various scenarios are listed in the table below:

RADIOLOGICAL DOSE FOR PROJECT				
Scenario	Inhalation (Sv)		Ingestion (Sv)	
	Onsite	Offsite	Onsite	Offsite
Organic Fire	6.04 E-03	3.12 E-06	N/A	1.04 E-04
Optimized Orifice Spray Release of Aqueous Phase	3.92 E-05	1.96 E-08	N/A	1.21 E-05
Slit Spray Release of Aqueous Phase	2.27 E-03	1.13 E-06	N/A	7.03 E-04
Wind Resuspension of Organic Phase	2.32 E-04	1.20 E-07	N/A	4.00 E-06
Wind Resuspension of Aqueous Phase	1.60 E-03	8.00 E-07	N/A	4.95 E-04

Lastly, it is recommended that potential impact stemming the evaporation of the aqueous phase and the corrosion rate at the air-waste-tank wall interface be evaluated further. However, these items are not currently viewed as having potential safety impact to the project.

5.0 REFERENCES

Ayer, J.E., A.T. Clark, P. Loysen, M.Y. Ballinger, J. Mishima, P.C. Owczarski, W.S. Gregory, B.D. Nichols, *Nuclear Fuel Cycle Facility Accident Analysis Handbook*, NUREG 1320, Pacific Northwest Laboratory, Los Alamos National Laboratory, 1988.

Postma, A. K., 1994, *Safety Basis for Interim Storage of Floating Organic Liquid in Tank C-103*, WHC-SD-WM-SARR-001, Draft, Westinghouse Hanford Company, Richland, Washington.

Sax, N. I., and R. J. Lewis, Sr., 1992, *Dangerous Properties of Industrial Materials*, 8th ed., Vols. 1-3, Van Nostrand Reinhold, New York.

Schulz, W. W., J. D. Navratil, and A. S. Kertes, (Ed.), 1991, *Science and Technology of Tributyl Phosphate*, Vol. 1 to 4, CRC Press, Inc., Boca Raton, Florida.

ATTACHMENT

GENII (VERSION 1.485)

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: C-103 Retrieval; E/Q 99.5 max 100m onsite ind.; Aqueous Phase Unit Release
Executed on: 09/19/94 at 12:03:49

This is a far-field (wide-scale release, multiple site) scenario.
Release is acute
Individual dose

THE FOLLOWING TRANSPORT MODES ARE CONSIDERED
Air

THE FOLLOWING EXPOSURE PATHS ARE CONSIDERED:
Infinite plume, external
Inhalation uptake

THE FOLLOWING TIMES ARE USED:
Intake ends after (yr): 1.0
Dose calculations ends after (yr): 50.0

FILENAMES AND TITLES OF FILES/LIBRARIES USED

Input file name: \GENII\c-103aq.in
GENII Default Parameter Values (28-Mar-90 RAP)
Radionuclide Library - Times<100 years (23-July-93 PDR)
External Dose Factors for GENII in person Sv/yr per Bq/n (8-May-90 R
Worst-Case Solubilities, Yearly Dose Increments (23-Jul-93 PDR)

Release Radio-nuclide	Air Ci/yr	Surface Water Ci/yr	Buried Source Ci/m3
	----Release Terms----		
CO60	5.1E-05	0.0E+00	0.0E+00
CS137	5.8E-02	0.0E+00	0.0E+00

AIR TRANSPORT

3.4E-02 Input E/Q value (s/m3)

EXTERNAL EXPOSURE

1.0E+00 Fraction of time spent in cloud

INHALATION

Resuspension not considered

Input prepared by: _____ Date: _____

Input checked by: _____ Date: _____

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: C-103 Retrieval: E/Q 99.5 max 100m onsite ind.; Aqueous Phase; Unit re
Executed on: 09/19/94 at 12:03:53

Acute release
Uptake/exposure period: 1.0
Dose commitment period: 50.0
Dose units: Rem

Organ	Committed Dose Equivalent	Weighting Factors	Weighted Dose Equivalent
Gonads	2.2E-02	2.5E-01	5.4E-03
Breast	1.9E-02	1.5E-01	2.9E-03
R Marrow	2.1E-02	1.2E-01	2.5E-03
Lung	2.2E-02	1.2E-01	2.7E-03
Thyroid	1.9E-02	3.0E-02	5.8E-04
Bone Sur	2.0E-02	3.0E-02	5.9E-04
LL Int.	2.2E-02	6.0E-02	1.3E-03
S Int.	2.2E-02	6.0E-02	1.3E-03
UL Int.	2.2E-02	6.0E-02	1.3E-03
Stomach	2.1E-02	6.0E-02	1.3E-03
Liver	7.3E-05	6.0E-02	4.4E-06
Internal Effective Dose Equivalent			2.0E-02
External Dose			2.3E-04
Annual Effective Dose Equivalent			2.0E-02

Controlling Organ: Lung
Controlling Pathway: Inh
Controlling Radionuclide: CS137

Total Inhalation EDE: 2.0E-02
Total Ingestion EDE: 0.0E+00

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: C-103 Retrieval; E/Q 99.5 max 100m onsite ind.; Aqueous Phase Unit release
Executed on: 09/19/94 at 12:03:53

Acute release
Uptake/exposure period: 1.0
Dose commitment period: 50.0
Dose units: Rem

	Intake Year	Dose Commitment Year 1	2	3	...		
Internal	3			0.0E+00	...		
	2		0.0E+00	0.0E+00	...		Internal Effective Dose Equivalent
	1	1.8E-02 +	1.7E-03 +	1.9E-04 +	...	= 2.0E-02	
Internal Annual Dose		1.8E-02 +	1.7E-03 +	1.9E-04 +	...	= 2.0E-02	Cumulative Internal Dose
External Annual Dose		2.3E-04	0.0E+00	0.0E+00	...	2.3E-04	
Annual Dose		1.8E-02 +	1.7E-03 +	1.9E-04 +	...	= 2.0E-02	Cumulative Dose
						1.8E-02	Maximum Annual Dose Occurred In Year 1

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: C-103 Retrieval; E/Q 99.5 max 100m onsite ind.; Aqueous Phase: Unit re
Executed on: 09/19/94 at 12:03:53

Acute release
Uptake/exposure period: 1.0
Dose commitment period: 50.0
Dose units: Rem

Radio-nuclide	Inhalation Effective Dose Equivalent	Ingestion Effective Dose Equivalent	External Dose	Internal Effective Dose Equivalent	Annual Effective Dose Equivalent
CO 60	1.2E-04	0.0E+00	8.9E-07	1.2E-04	1.2E-04
CS 137	2.0E-02	0.0E+00	2.3E-04	2.0E-02	2.0E-02

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: C-103 Retrieval- E/Q 99.5 max onsite ind.- 1 Liter Release.
Organic Phase
Executed on: 09/19/94 at 11:56:42 Page A. 1

This is a far-field (wide-scale release, multiple site) scenario.
Release is acute
Individual dose

THE FOLLOWING TRANSPORT MODES ARE CONSIDERED
Air

THE FOLLOWING EXPOSURE PATHS ARE CONSIDERED:
Infinite plume, external
Inhalation uptake

THE FOLLOWING TIMES ARE USED:
Intake ends after (yr): 1.0
Dose calculations ends after (yr): 50.0

FILENAMES AND TITLES OF FILES/LIBRARIES USED

Input file name: \GENII\c-103.in
GENII Default Parameter Values (28-Mar-90 RAP)
Radionuclide Library - Times<100 years (23-July-93 PDR)
External Dose Factors for GENII in person Sv/yr per Bq/n (8-May-90 R
Worst-Case Solubilities, Yearly Dose Increments (23-Jul-93 PDR)

Release Radio-nuclide	----Release Terms---- Air Ci/yr	Surface Water Ci/yr	Buried Source Ci/m3
CO60	6.5E-07	0.0E+00	0.0E+00
SR90	3.2E-04	0.0E+00	0.0E+00
Y 90	3.2E-04	0.0E+00	0.0E+00
CS137	3.8E-05	0.0E+00	0.0E+00
EU154	2.8E-07	0.0E+00	0.0E+00
EU155	2.8E-07	0.0E+00	0.0E+00
PU238	7.9E-08	0.0E+00	0.0E+00
PU239	1.6E-07	0.0E+00	0.0E+00
AM241	1.9E-07	0.0E+00	0.0E+00

AIR TRANSPORT

3.4E-02 Input E/Q value (s/m3)

EXTERNAL EXPOSURE

1.0E+00 Fraction of time spent in cloud

INHALATION

Resuspension not considered

Input prepared by: _____ Date: _____

Input checked by: _____ Date: _____

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: C-103 Retrieval- E/Q 99.5 max onsite ind.- 1 Liter Release
Organic Phase
Executed on: 09/19/94 at 11:56:52

Acute release
Uptake/exposure period: 1.0
Dose commitment period: 50.0
Dose units: Rem

Organ	Committed Dose Equivalent	Weighting Factors	Weighted Dose Equivalent
Gonads	5.6E-04	2.5E-01	1.4E-04
Breast	1.8E-05	1.5E-01	2.8E-06
R Marrow	6.9E-03	1.2E-01	8.3E-04
Lung	5.0E-04	1.2E-01	5.9E-05
Thyroid	1.8E-05	3.0E-02	5.5E-07
Bone Sur	4.7E-02	3.0E-02	1.4E-03
Liver	6.9E-03	6.0E-02	4.1E-04
LL Int.	2.3E-04	6.0E-02	1.4E-05
UL Int.	9.9E-05	6.0E-02	5.9E-06
S Int.	3.5E-05	6.0E-02	2.1E-06
Stomach	2.6E-05	6.0E-02	1.6E-06

Internal Effective Dose Equivalent	2.9E-03
External Dose	1.8E-07
Annual Effective Dose Equivalent	2.9E-03

Controlling Organ:	Bone Sur
Controlling Pathway:	Inh
Controlling Radionuclide:	AM241
Total Inhalation EDE:	2.9E-03
Total Ingestion EDE:	0.0E+00

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: C-103 Retrieval- E/Q 99.5 max onsite ind.- 1 Liter Release Organic Phase
Executed on: 09/19/94 at 11:56:52

Acute release
Uptake/exposure period: 1.0
Dose commitment period: 50.0
Dose units: Rem

	Dose Commitment Year 1	2	3	...		
Internal Intake Year: 3			0.0E+00	...		
2		0.0E+00	0.0E+00	...		Internal Effective Dose Equivalent
1	2.5E-04 +	1.4E-04 +	1.3E-04 +	...	= 2.9E-03	
Internal Annual Dose	2.5E-04 +	1.4E-04 +	1.3E-04 +	...	= 2.9E-03	Cumulative Internal Dose
External Annual Dose	1.8E-07	0.0E+00	0.0E+00	...	1.8E-07	
Annual Dose	2.5E-04 +	1.4E-04 +	1.3E-04 +	...	= 2.9E-03	Cumulative Dose
					2.5E-04	Maximum Annual Dose Occurred In Year 1

Acute release
Uptake/exposure period: 1.0
Dose commitment period: 50.0
Dose units: Rem

Radio-nuclide	Inhalation Effective Dose Equivalent	Ingestion Effective Dose Equivalent	External Dose	Internal Effective Dose Equivalent	Annual Effective Dose Equivalent
CO 60	1.5E-06	0.0E+00	1.1E-08	1.5E-06	1.5E-06
SR 90	7.3E-04	0.0E+00	4.5E-10	7.3E-04	7.3E-04
Y 90	3.1E-05	0.0E+00	1.6E-08	3.1E-05	3.1E-05
CS 137	1.3E-05	0.0E+00	1.5E-07	1.3E-05	1.3E-05
EU 154	8.8E-07	0.0E+00	2.4E-09	8.8E-07	8.8E-07
EU 155	1.3E-07	0.0E+00	8.2E-11	1.3E-07	1.3E-07
PU 238	3.5E-04	0.0E+00	8.7E-14	3.5E-04	3.5E-04
AM 241	9.7E-04	0.0E+00	1.5E-11	9.7E-04	9.7E-04
PU 239	7.8E-04	0.0E+00	1.1E-13	7.8E-04	7.8E-04

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Offsite- X/Q=1.8E-5 from SAR-16: Inhalation: Aqueous Phase

Executed on: 09/21/94 at 14:59:21

This is a far-field (wide-scale release, multiple site) scenario.
Release is acute
Individual dose

THE FOLLOWING TRANSPORT MODES ARE CONSIDERED
Air

THE FOLLOWING EXPOSURE PATHS ARE CONSIDERED:
Infinite plume, external
Inhalation uptake

THE FOLLOWING TIMES ARE USED:
Intake ends after (yr): 1.0
Dose calculations ends after (yr): 50.0

FILENAMES AND TITLES OF FILES/LIBRARIES USED

Input file name: \GENII\choffaq.in
GENII Default Parameter Values (28-Mar-90 RAP)
Radionuclide Library - Times<100 years (23-July-93 PDR)
External Dose Factors for GENII in person Sv/yr per Bq/n (8-May-90 R
Worst-Case Solubilities, Yearly Dose Increments (23-Jul-93 PDR)

Release Radionuclide	Release Terms: Air Ci/yr	Surface Water Ci/yr	Buried Source Ci/m3
CO60	5.1E-05	0.0E+00	0.0E+00
CS137	5.8E-02	0.0E+00	0.0E+00

AIR TRANSPORT

1.8E-05 Input E/Q value (s/m3)

EXTERNAL EXPOSURE

1.0E+00 Fraction of time spent in cloud

INHALATION

Resuspension not considered

Input prepared by: _____ Date: _____

Input checked by: _____ Date: _____

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Offsite- X/Q=1.8E-5 from SAR-16: Inhalation: Aqueous Phase

Executed on: 09/21/94 at 14:59:25 Page C. 1

Acute release
Uptake/exposure period: 1.0
Dose commitment period: 50.0
Dose units: Rem

Organ	Committed Dose Equivalent	Weighting Factors	Weighted Dose Equivalent
Gonads	1.1E-05	2.5E-01	2.8E-06
Breast	1.0E-05	1.5E-01	1.5E-06
R Marrow	1.1E-05	1.2E-01	1.3E-06
Lung	1.2E-05	1.2E-01	1.4E-06
Thyroid	1.0E-05	3.0E-02	3.0E-07
Bone Sur	1.0E-05	3.0E-02	3.1E-07
LL Int.	1.1E-05	6.0E-02	6.9E-07
S Int.	1.1E-05	6.0E-02	6.9E-07
UL Int.	1.1E-05	6.0E-02	6.8E-07
Stomach	1.1E-05	6.0E-02	6.6E-07
Liver	3.8E-08	6.0E-02	2.3E-09
Internal Effective Dose Equivalent			1.0E-05
External Dose			1.2E-07
Annual Effective Dose Equivalent			1.0E-05

Controlling Organ: Lung
Controlling Pathway: Inh
Controlling Radionuclide: CS137

Total Inhalation EDE: 1.0E-05
Total Ingestion EDE: 0.0E+00

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Offsite- X/Q=1.8E-5 from SAR-16: Inhalation: Aqueous Phase

Executed on: 09/21/94 at 14:59:25

Acute release
Uptake/exposure period: 1.0
Dose commitment period: 50.0
Dose units: Rem

	Dose Commitment Year 1	2	3	...		
Internal Intake Year: 3			0.0E+00	...		
			÷			
2		0.0E+00	0.0E+00	...		Internal Effective Dose Equivalent
		÷	÷			
1	9.3E-06	+ 9.0E-07	+ 1.0E-07	+ ...	= 1.0E-05	
	||	||	||			
Internal Annual Dose	9.3E-06	+ 9.0E-07	+ 1.0E-07	+ ...	= 1.0E-05	Cumulative Internal Dose
	+	+	+		+	
External Annual Dose	1.2E-07	0.0E+00	0.0E+00	...	1.2E-07	
	||	||	||		||	
Annual Dose	9.4E-06	+ 9.0E-07	+ 1.0E-07	+ ...	= 1.0E-05	Cumulative Dose
					9.4E-06	Maximum Annual Dose Occurred In Year 1

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Offsite- X/Q=1.8E-5 from SAR-16: Inhalation : Aqueous Phase

Executed on: 09/21/94 at 14:59:25

Acute release
Uptake/exposure period: 1.0
Dose commitment period: 50.0
Dose units: Rem

Radio-nuclide	Inhalation Effective Dose Equivalent	Ingestion Effective Dose Equivalent	External Dose	Internal Effective Dose Equivalent	Annual Effective Dose Equivalent
CO 60	6.0E-08	0.0E+00	4.6E-10	6.0E-08	6.1E-08
CS 137	1.0E-05	0.0E+00	1.2E-07	1.0E-05	1.0E-05

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Offsite- X/Q = 1.8E-5 from SAR-16: Ingestion- Unit Release Aqueous Phase
Executed on: 09/21/94 at 15:11:52

This is a far-field (wide-scale release, multiple site) scenario.
Release is acute
Individual dose

THE FOLLOWING TRANSPORT MODES ARE CONSIDERED
Air

THE FOLLOWING EXPOSURE PATHS ARE CONSIDERED:
Ground, external
Terrestrial foods ingestion
Animal product ingestion
Inadvertent soil ingestion

THE FOLLOWING TIMES ARE USED:
Intake ends after (yr): 50.0
Dose calculations ends after (yr): 50.0

FILENAMES AND TITLES OF FILES/LIBRARIES USED

Input file name: \GENII\ingoffaq.in
GENII Default Parameter Values (28-Mar-90 RAP)
Radionuclide Library - Times<100 years (23-July-93 PDR)
PNL Food Transfer Factor Library (by Z, with Fr&Os 7/19/93 PDR)
External Dose Factors for GENII in person Sv/yr per Bq/n (8-May-90 R
Worst-Case Solubilities, Yearly Dose Increments (23-Jul-93 PDR)

Release Radio-nuclide	Release Terms Air Ci/yr	Surface Water Ci/yr	Buried Source Ci/m3
C060	5.1E-05	0.0E+00	0.0E+00
CS137	5.8E-02	0.0E+00	0.0E+00

AIR TRANSPORT

1.8E-05 Input E/Q value (s/m3)

EXTERNAL EXPOSURE

4.4E+03 Hours of exposure to ground contamination

INGESTION POPULATION

1 Atmospheric production definition: 1 - Use population-weighted chi/Q

TERRESTRIAL FOOD INGESTION

FOOD TYPE	GROW TIME d	IRRIGATION S RATE * in/yr	IRRIGATION TIME mo/yr	YIELD kg/m2	PROD-UCTION kg/yr	CONSUMPTION HOLDUP d	CONSUMPTION RATE kg/yr
		-		E-3=42			

Leaf Veg	90.0	0	0.0	0.0	0.0	1.0	3.0E+01
Oth. Veg	90.0	0	0.0	0.0	0.0	5.0	2.2E+02
Fruit	90.0	0	0.0	0.0	2.0	5.0	3.3E+02
Cereals	90.0	0	0.0	0.0	0.8	180.0	8.0E+01

ANIMAL FOOD INGESTION

FOOD TYPE	---HUMAN---- CONSUMPTION RATE kg/yr	HOLDUP d	TOTAL PROD-UCTION kg/yr	DRINK WATER CONTAM FRACT.	STORED FEED DIET FRAC-TION	GROW TIME d	-IRRIGATION-- S *	RATE in/yr	TIME mo/yr	YIELD kg/m3	STOR-AGE d
Meat	8.0E+01	15.0		0.00	0.3	90.00	0	0.0	0.0	0.80	0.0
Poultry	1.8E+01	1.0		0.00	1.0	90.00	0	0.0	0.0	0.80	0.0
Cow Milk	2.7E+02	1.0		0.00	0.3	45.00	0	0.0	0.0	2.00	0.0
Eggs	3.0E+01	1.0		0.00	1.0	90.00	0	0.0	0.0	0.80	0.0
					FRESH FORAGE						
Meat					0.75	45.0	0	0.0	0.0	2.00	0.0
Cow Milk					0.75	30.0	0	0.0	0.0	1.50	0.0

Note: Animal diet fraction for years 2 through 50.0000

Input prepared by: _____ Date: _____

...put checked by: _____ Date: _____

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Winter: Offsite- X/Q = 1.8E-5 from SAR-16: Ingestion- Unit Release Aqueous
Executed on: 09/21/94 at 15:12:03

Acute release
Uptake/exposure period: 50.0
Dose commitment period: 50.0
Dose units: Rem

Organ	Committed Dose Equivalent	Weighting Factors	Weighted Dose Equivalent
Gonads	2.0E-06	2.5E-01	5.0E-07
Breast	1.8E-06	1.5E-01	2.7E-07
R Marrow	1.9E-06	1.2E-01	2.2E-07
Lung	1.8E-06	1.2E-01	2.2E-07
Thyroid	1.8E-06	3.0E-02	5.4E-08
Bone Sur	1.8E-06	3.0E-02	5.5E-08
LL Int.	2.0E-06	6.0E-02	1.2E-07
UL Int.	2.0E-06	6.0E-02	1.2E-07
S Int.	2.0E-06	6.0E-02	1.2E-07
Stomach	2.0E-06	6.0E-02	1.2E-07
Liver	4.0E-09	6.0E-02	2.4E-10
Internal Effective Dose Equivalent			1.8E-06
External Dose			7.2E-06
Annual Effective Dose Equivalent			9.0E-06

Controlling Organ:	LL Int.
Controlling Pathway:	Ext
Controlling Radionuclide:	CS137
Total Inhalation EDE:	0.0E+00
Total Ingestion EDE:	1.8E-06

Case title: Winter: Offsite- X/Q = 1.8E-5 from SAR-16: Ingestion- Unit Release Aqueous
Executed on: 09/21/94 at 15:12:03

Acute release
Uptake/exposure period: 50.0
Dose commitment period: 50.0
Dose units: Rem

	Dose Commitment Year 1	2	3	...		
Internal Intake Year: 3			6.9E-07	...		
2		7.0E-07	6.8E-08	...		Internal Effective Dose Equivalent
1	1.6E-06 +	1.5E-07 +	3.5E-08 +	...	= 1.8E-06	
Internal Annual Dose	1.6E-06 +	8.6E-07 +	7.9E-07 +	...	= 2.5E-05	Cumulative Internal Dose
External Annual Dose	7.2E-06	7.0E-06	6.8E-06	...	2.1E-04	
Annual Dose	8.9E-06 +	7.8E-06 +	7.6E-06 +	...	= 2.4E-04	Cumulative Dose
					8.9E-06	Maximum Annual Dose Occurred In Year 1

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Spring: Offsite- X/Q = 1.8E-5 from SAR-16: Ingestion- Unit Release Aqueous
Executed on: 09/21/94 at 15:12:07

Acute release
Uptake/exposure period: 50.0
Dose commitment period: 50.0
Dose units: Rem

Organ	Committed Dose Equivalent	Weighting Factors	Weighted Dose Equivalent
Gonads	3.0E-04	2.5E-01	7.4E-05
Breast	2.7E-04	1.5E-01	4.0E-05
R Marrow	2.8E-04	1.2E-01	3.3E-05
Lung	2.7E-04	1.2E-01	3.3E-05
Thyroid	2.7E-04	3.0E-02	8.1E-06
Bone Sur	2.7E-04	3.0E-02	8.2E-06
LL Int.	3.0E-04	6.0E-02	1.8E-05
UL Int.	3.0E-04	6.0E-02	1.8E-05
S Int.	3.0E-04	6.0E-02	1.8E-05
Stomach	3.0E-04	6.0E-02	1.8E-05
Liver	1.1E-07	6.0E-02	6.6E-09
Internal Effective Dose Equivalent			2.7E-04
External Dose			7.2E-06
Annual Effective Dose Equivalent			2.8E-04

Controlling Organ:	LL Int.
Controlling Pathway:	Ing
Controlling Radionuclide:	CS137
Total Inhalation EDE:	0.0E+00
Total Ingestion EDE:	2.7E-04

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Spring: Offsite- X/Q = 1.8E-5 from SAR-16: Ingestion- Unit Release Aqueous
Executed on: 09/21/94 at 15:12:07

Acute release
Uptake/exposure period: 50.0
Dose commitment period: 50.0
Dose units: Rem

	Dose Commitment Year 1	2	3	...		
Internal Intake Year: 3			6.9E-07	...		
2		7.0E-07	+ 6.8E-08	...		Internal Effective Dose Equivalent
1	2.4E-04	+ 2.3E-05	+ 5.2E-06	+ ...	= 2.7E-04	
	||	||	||			Cumulative Internal Dose
Internal Annual Dose	2.4E-04	+ 2.4E-05	+ 6.0E-06	+ ...	= 2.9E-04	
	+	+	+		+	
External Annual Dose	7.2E-06	7.0E-06	6.8E-06	...	2.1E-04	
	||	||	||		||	Cumulative Dose
Annual Dose	2.5E-04	+ 3.1E-05	+ 1.3E-05	+ ...	= 5.0E-04	
					2.5E-04	Maximum Annual Dose Occurred In Year 1

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Summer: Offsite- X/Q = 1.8E-5 from SAR-16: Ingestion- Unit Release Aqueous
Executed on: 09/21/94 at 15:12:11

Acute release
Uptake/exposure period: 50.0
Dose commitment period: 50.0
Dose units: Rem

Organ	Committed Dose Equivalent	Weighting Factors	Weighted Dose Equivalent
Gonads	6.4E-04	2.5E-01	1.6E-04
Breast	5.8E-04	1.5E-01	8.6E-05
R Marrow	5.9E-04	1.2E-01	7.1E-05
Lung	5.9E-04	1.2E-01	7.0E-05
Thyroid	5.8E-04	3.0E-02	1.7E-05
Bone Sur	5.9E-04	3.0E-02	1.8E-05
LL Int.	6.4E-04	6.0E-02	3.8E-05
UL Int.	6.4E-04	6.0E-02	3.8E-05
S Int.	6.4E-04	6.0E-02	3.8E-05
Stomach	6.4E-04	6.0E-02	3.8E-05
Liver	3.3E-07	6.0E-02	2.0E-08
Internal Effective Dose Equivalent			5.7E-04
External Dose			7.2E-06
Annual Effective Dose Equivalent			5.8E-04

Controlling Organ:	LL Int.
Controlling Pathway:	Ing
Controlling Radionuclide:	CS137
Total Inhalation EDE:	0.0E+00
Total Ingestion EDE:	5.7E-04

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Summer: Offsite- X/Q = 1.8E-5 from SAR-16: Ingestion- Unit Release Aqueous
Executed on: 09/21/94 at 15:12:11

Acute release
Uptake/exposure period: 50.0
Dose commitment period: 50.0
Dose units: Rem

	Dose Commitment Year 1	2	3	...		
Internal Intake Year: 3			6.9E-07	...		
2		7.0E-07	+ 6.8E-08	...		Internal Effective Dose Equivalent
1	5.1E-04	+ 4.9E-05	+ 1.1E-05	+ ... =	5.7E-04	
	||	||	||			
Internal Annual Dose	5.1E-04	+ 5.0E-05	+ 1.2E-05	+ ... =	6.0E-04	Cumulative Internal Dose
	+	+	+		+	
External Annual Dose	7.2E-06	7.0E-06	6.8E-06	...	2.1E-04	
	||	||	||		||	
Annual Dose	5.2E-04	+ 5.7E-05	+ 1.9E-05	+ ... =	8.1E-04	Cumulative Dose
					5.2E-04	Maximum Annual Dose Occurred In Year 1

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Autumn: Offsite- X/Q = 1.8E-5 from SAR-16: Ingestion- Unit Release Aqueous
Executed on: 09/21/94 at 15:12:15

Acute release
Uptake/exposure period: 50.0
Dose commitment period: 50.0
Dose units: Rem

Organ	Committed Dose Equivalent	Weighting Factors	Weighted Dose Equivalent
Gonads	6.6E-03	2.5E-01	1.7E-03
Breast	6.0E-03	1.5E-01	9.0E-04
R Marrow	6.2E-03	1.2E-01	7.4E-04
Lung	6.1E-03	1.2E-01	7.3E-04
Thyroid	6.0E-03	3.0E-02	1.8E-04
Bone Sur	6.1E-03	3.0E-02	1.8E-04
LL Int.	6.7E-03	6.0E-02	4.0E-04
UL Int.	6.7E-03	6.0E-02	4.0E-04
S Int.	6.7E-03	6.0E-02	4.0E-04
Stomach	6.6E-03	6.0E-02	4.0E-04
Liver	2.8E-06	6.0E-02	1.7E-07
Internal Effective Dose Equivalent			6.0E-03
External Dose			7.2E-06
Annual Effective Dose Equivalent			6.0E-03

Controlling Organ:	LL Int.
Controlling Pathway:	Ing
Controlling Radionuclide:	CS137
Total Inhalation EDE:	0.0E+00
Total Ingestion EDE:	6.0E-03

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Autumn: Offsite- X/Q = 1.8E-5 from SAR-16: Ingestion- Unit Release Aqueous
Executed on: 09/21/94 at 15:12:15

Acute release
Uptake/exposure period: 50.0
Dose commitment period: 50.0
Dose units: Rem

	Dose Commitment Year 1	2	3	...		
Internal Intake Year: 3			6.9E-07	...		
2		7.0E-07	+ 6.8E-08	...		Internal Effective Dose Equivalent
1	5.4E-03	+ 5.2E-04	+ 1.2E-04	+ ...	= 6.0E-03	
	||	||	||			
Internal Annual Dose	5.4E-03	+ 5.2E-04	+ 1.2E-04	+ ...	= 6.0E-03	Cumulative Internal Dose
	+	+	+		+	
External Annual Dose	7.2E-06	7.0E-06	6.8E-06	...	2.1E-04	
	||	||	||		||	
Annual Dose	5.4E-03	+ 5.2E-04	+ 1.2E-04	+ ...	= 6.2E-03	Cumulative Dose
					5.4E-03	Maximum Annual Dose Occurred In Year 1

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Offsite Boundary: X/Q = 1.8E-5 from SAR-16: Inhalation: Unit Release
Organic Phase
Executed on: 09/22/94 at 07:33:35 Page A. 1

This is a far-field (wide-scale release, multiple site) scenario.
Release is acute
Individual dose

THE FOLLOWING TRANSPORT MODES ARE CONSIDERED
Air

THE FOLLOWING EXPOSURE PATHS ARE CONSIDERED:
Infinite plume, external
Inhalation uptake

THE FOLLOWING TIMES ARE USED:
Intake ends after (yr): 1.0
Dose calculations ends after (yr): 50.0

FILENAMES AND TITLES OF FILES/LIBRARIES USED

Input file name: \GENII\choffor.in
GENII Default Parameter Values (28-Mar-90 RAP)
Radionuclide Library - Times<100 years (23-July-93 PDR)
External Dose Factors for GENII in person Sv/yr per Bq/n (8-May-90 R
Worst-Case Solubilities, Yearly Dose Increments (23-Jul-93 PDR)

Release Radio-nuclide	Air Ci/yr	Surface Water Ci/yr	Buried Source Ci/m3
	----Release Terms----		
CO60	6.5E-07	0.0E+00	0.0E+00
SR90	3.2E-04	0.0E+00	0.0E+00
Y 90	3.2E-04	0.0E+00	0.0E+00
CS137	3.8E-05	0.0E+00	0.0E+00
EU154	2.8E-07	0.0E+00	0.0E+00
EU155	2.8E-07	0.0E+00	0.0E+00
PU238	7.9E-08	0.0E+00	0.0E+00
PU239	1.6E-07	0.0E+00	0.0E+00
AM241	1.9E-07	0.0E+00	0.0E+00

AIR TRANSPORT

1.8E-05 Input E/Q value (s/m3)

EXTERNAL EXPOSURE

1.0E+00 Fraction of time spent in cloud

INHALATION

Resuspension not considered

Input prepared by: _____ Date: _____

Input checked by: _____ Date: _____

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Offsite Boundary: X/Q = 1.8E-5 from SAR-16: Inhalation: Lite r Release
Executed on: 09/22/94 at 07:33:43

Acute release
Uptake/exposure period: 1.0
Dose commitment period: 50.0
Dose units: Rem

Organ	Committed Dose Equivalent	Weighting Factors	Weighted Dose Equivalent
Gonads	2.9E-07	2.5E-01	7.2E-08
Breast	9.8E-09	1.5E-01	1.5E-09
R Marrow	3.6E-06	1.2E-01	4.3E-07
Lung	2.6E-07	1.2E-01	3.1E-08
Thyroid	9.7E-09	3.0E-02	2.9E-10
Bone Sur	2.4E-05	3.0E-02	7.3E-07
Liver	3.5E-06	6.0E-02	2.1E-07
LL Int.	1.2E-07	6.0E-02	7.3E-09
UL Int.	5.2E-08	6.0E-02	3.1E-09
S Int.	1.9E-08	6.0E-02	1.1E-09
Stomach	1.4E-08	6.0E-02	8.4E-10
Internal Effective Dose Equivalent			1.5E-06
External Dose			9.6E-11
Annual Effective Dose Equivalent			1.5E-06

Controlling Organ:	Bone Sur
Controlling Pathway:	Inh
Controlling Radionuclide:	AM241
Total Inhalation EDE:	1.5E-06
Total Ingestion EDE:	0.0E+00

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

'ase title: Offsite Boundary: X/Q = 1.8E-5 from SAR-16: Inhalation: Lite
r Release
Executed on: 09/22/94 at 07:33:43

Acute release
Uptake/exposure period: 1.0
Dose commitment period: 50.0
Dose units: Rem

	Dose Commitment Year 1	2	3	...		
Internal Intake Year: 3			0.0E+00	...		
			+			
2		0.0E+00	0.0E+00	...		Internal Effective Dose Equivalent
		+	+			
1	1.3E-07	+ 7.5E-08	+ 6.8E-08	+ ...	= 1.5E-06	
	||	||	||			
Internal Annual Dose	1.3E-07	+ 7.5E-08	+ 6.8E-08	+ ...	= 1.5E-06	Cumulative Internal Dose
	+	+	+		+	
External Annual Dose	9.6E-11	0.0E+00	0.0E+00	...	9.6E-11	
	||	||	||		||	
Annual Dose	1.3E-07	+ 7.5E-08	+ 6.8E-08	+ ...	= 1.5E-06	Cumulative Dose
					1.3E-07	Maximum Annual Dose Occurred In Year 1

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Offsite Boundary: X/Q = 1.8E-5 from SAR-16: Inhalation: Lite
r Release
Executed on: 09/22/94 at 07:33:43

Acute release
Uptake/exposure period: 1.0
Dose commitment period: 50.0
Dose units: Rem

Radio-nuclide	Inhalation Effective Dose Equivalent	Ingestion Effective Dose Equivalent	External Dose	Internal Effective Dose Equivalent	Annual Effective Dose Equivalent
CO 60	7.8E-10	0.0E+00	5.9E-12	7.8E-10	7.9E-10
SR 90	3.9E-07	0.0E+00	2.3E-13	3.9E-07	3.9E-07
Y 90	1.7E-08	0.0E+00	8.5E-12	1.7E-08	1.7E-08
CS 137	6.9E-09	0.0E+00	8.0E-11	6.9E-09	7.0E-09
EU 154	4.7E-10	0.0E+00	1.3E-12	4.7E-10	4.7E-10
EU 155	6.9E-11	0.0E+00	4.3E-14	6.9E-11	7.0E-11
PU 238	1.8E-07	0.0E+00	4.5E-17	1.8E-07	1.8E-07
AM 241	4.9E-07	0.0E+00	7.6E-15	4.9E-07	4.9E-07
PU 239	4.1E-07	0.0E+00	6.1E-17	4.1E-07	4.1E-07

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Offsite Boundary: X/Q = 1.8E-5 from SAR-16: Ingestion: Liter Release: Organic Phase
Executed on: 09/22/94 at 07:46:22

This is a far-field (wide-scale release, multiple site) scenario.
Release is acute
Individual dose

THE FOLLOWING TRANSPORT MODES ARE CONSIDERED
Air

THE FOLLOWING EXPOSURE PATHS ARE CONSIDERED:
Ground, external
Terrestrial foods ingestion
Animal product ingestion
Inadvertent soil ingestion

THE FOLLOWING TIMES ARE USED:
Intake ends after (yr): 50.0
Dose calculations ends after (yr): 50.0

FILENAMES AND TITLES OF FILES/LIBRARIES USED

Input file name: \GENII\ingoffor.in
GENII Default Parameter Values (28-Mar-90 RAP)
Radionuclide Library - Times<100 years (23-July-93 PDR)
PNL Food Transfer Factor Library (by Z, with Fr&Os 7/19/93 PDR)
External Dose Factors for GENII in person Sv/yr per Bq/n (8-May-90 R
Worst-Case Solubilities, Yearly Dose Increments (23-Jul-93 PDR)

Release Terms

Radionuclide	Air Release Ci/yr	Surface Water Ci/yr	Buried Source Ci/m3
CO60	6.5E-07	0.0E+00	0.0E+00
SR90	3.2E-04	0.0E+00	0.0E+00
Y 90	3.2E-04	0.0E+00	0.0E+00
CS137	3.8E-05	0.0E+00	0.0E+00
EU154	2.8E-07	0.0E+00	0.0E+00
EU155	2.8E-07	0.0E+00	0.0E+00
PU238	7.9E-08	0.0E+00	0.0E+00
PU239	1.6E-07	0.0E+00	0.0E+00
AM241	1.9E-07	0.0E+00	0.0E+00

AIR TRANSPORT

1.8E-05 Input E/Q value (s/m3)

EXTERNAL EXPOSURE

4.4E+03 Hours of exposure to ground contamination

INGESTION POPULATION

E-3-57

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Winter: Offsite Boundary: X/Q = 1.8E-5 from SAR-16: Ingestion: Liter Release
Executed on: 09/22/94 at 07:47:06 Page C. 1

Acute release
Uptake/exposure period: 50.0
Dose commitment period: 50.0
Dose units: Rem

Organ	Committed Dose Equivalent	Weighting Factors	Weighted Dose Equivalent
Gonads	7.0E-09	2.5E-01	1.7E-09
Breast	6.8E-09	1.5E-01	1.0E-09
R Marrow	4.5E-06	1.2E-01	5.4E-07
Lung	6.9E-09	1.2E-01	8.2E-10
Thyroid	6.8E-09	3.0E-02	2.1E-10
Bone Sur	1.0E-05	3.0E-02	3.0E-07
LL Int.	1.3E-06	6.0E-02	7.5E-08
UL Int.	4.3E-07	6.0E-02	2.6E-08
S Int.	8.2E-08	6.0E-02	4.9E-09
Stomach	4.0E-08	6.0E-02	2.4E-09
Liver	1.7E-10	6.0E-02	1.0E-11
Internal Effective Dose Equivalent			9.5E-07
External Dose			5.5E-09
Annual Effective Dose Equivalent			9.6E-07

Controlling Organ:	Bone Sur
Controlling Pathway:	Ing.
Controlling Radionuclide:	SR90
Total Inhalation EDE:	0.0E+00
Total Ingestion EDE:	9.5E-07

1 Atmospheric production definition: 1 - Use population-weighted cm/Q

TERRESTRIAL FOOD INGESTION

FOOD TYPE	GROW TIME d	S *	--IRRIGATION-- RATE in/yr	TIME mo/yr	YIELD kg/m2	PROD-UCTION kg/yr	--CONSUMPTION-- HOLDUP d	RATE kg/yr
Leaf Veg	90.0	0	0.0	0.0	1.5		1.0	3.0E+01
Oth. Veg	90.0	0	0.0	0.0	4.0		5.0	2.2E+02
Fruit	90.0	0	0.0	0.0	2.0		5.0	3.3E+02
Cereals	90.0	0	0.0	0.0	0.8		180.0	8.0E+01

ANIMAL FOOD INGESTION

FOOD TYPE	---HUMAN---- CONSUMPTION RATE kg/yr	HOLDUP d	TOTAL PROD-UCTION kg/yr	DRINK WATER CONTAM FRACT.	STORED FEED DIET FRAC-TION	GROW TIME d	-IRRIGATION-- S *	RATE in/yr	TIME mo/yr	YIELD kg/m3	STOR-AGE d
Meat	8.0E+01	15.0		0.00	0.3	90.00	0	0.0	0.0	0.80	0.0
Poultry	1.8E+01	1.0		0.00	1.0	90.00	0	0.0	0.0	0.80	0.0
Cow Milk	2.7E+02	1.0		0.00	0.3	45.00	0	0.0	0.0	2.00	0.0
Eggs	3.0E+01	1.0		0.00	1.0	90.00	0	0.0	0.0	0.80	0.0
					FRESH FORAGE						
Meat					0.75	45.0	0	0.0	0.0	2.00	0.0
Cow Milk					0.75	30.0	0	0.0	0.0	1.50	0.0

Note: Animal diet fraction for years 2 through 50.0000

Input prepared by: _____ Date: _____

Input checked by: _____ Date: _____

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Winter: Offsite Boundary: X/Q = 1.8E-5 from SAR-16: Ingestion: Liter Release

Executed on: 09/22/94 at 07:47:06

Acute release
Uptake/exposure period: 50.0
Dose commitment period: 50.0
Dose units: Rem

Organ	Committed Dose Equivalent	Weighting Factors	Weighted Dose Equivalent
Gonads	7.0E-09	2.5E-01	1.7E-09
Breast	6.8E-09	1.5E-01	1.0E-09
R Marrow	4.5E-06	1.2E-01	5.4E-07
Lung	6.9E-09	1.2E-01	8.2E-10
Thyroid	6.8E-09	3.0E-02	2.1E-10
Bone Sur	1.0E-05	3.0E-02	3.0E-07
LL Int.	1.3E-06	6.0E-02	7.5E-08
UL Int.	4.3E-07	6.0E-02	2.6E-08
S Int.	8.2E-08	6.0E-02	4.9E-09
Stomach	4.0E-08	6.0E-02	2.4E-09
Liver	1.7E-10	6.0E-02	1.0E-11
Internal Effective Dose Equivalent			9.5E-07
External Dose			5.5E-09
Annual Effective Dose Equivalent			9.6E-07

Controlling Organ:	Bone Sur
Controlling Pathway:	Ing
Controlling Radionuclide:	SR90
Total Inhalation EDE:	0.0E+00
Total Ingestion EDE:	9.5E-07

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Winter: Offsite Boundary: X/Q = 1.8E-5 from SAR-16: Ingestion: Liter Release
Executed on: 09/22/94 at 07:47:06

Acute release
Uptake/exposure period: 50.0
Dose commitment period: 50.0
Dose units: Rem

	Dose Commitment Year 1	2	3	...		
Internal Intake Year: 3			1.7E-07	...		
2		1.8E-07	7.8E-08	...		Internal Effective Dose Equivalent
1	2.3E-07	+ 9.1E-08	+ 7.7E-08	+ ...	= 9.5E-07	
	||	||	||			
External Annual Dose	2.3E-07	+ 2.7E-07	+ 3.3E-07	+ ...	= 1.9E-05	Cumulative Internal Dose
	+	+	+		+	
External Annual Dose	5.5E-09	5.3E-09	5.1E-09	...	1.5E-07	
	||	||	||		||	
Annual Dose	2.3E-07	+ 2.8E-07	+ 3.3E-07	+ ...	= 1.9E-05	Cumulative Dose
					5.2E-07	Maximum Annual Dose Occurred In Year 13

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Spring: Offsite Boundary: X/Q = 1.8E-5 from SAR-16: Ingestion: Liter Release

Executed on: 09/22/94 at 07:47:23

Acute release
Uptake/exposure period: 50.0
Dose commitment period: 50.0
Dose units: Rem

Organ	Committed Dose Equivalent	Weighting Factors	Weighted Dose Equivalent
Gonads	2.1E-07	2.5E-01	5.1E-08
Breast	1.9E-07	1.5E-01	2.8E-08
R Marrow	7.0E-06	1.2E-01	8.4E-07
Lung	1.9E-07	1.2E-01	2.3E-08
Thyroid	1.9E-07	3.0E-02	5.6E-09
Bone Sur	1.6E-05	3.0E-02	4.8E-07
LL Int.	2.0E-06	6.0E-02	1.2E-07
UL Int.	8.2E-07	6.0E-02	4.9E-08
S Int.	3.1E-07	6.0E-02	1.9E-08
Stomach	2.5E-07	6.0E-02	1.5E-08
Liver	3.5E-08	6.0E-02	2.1E-09
Internal Effective Dose Equivalent			1.6E-06
External Dose			5.5E-09
Annual Effective Dose Equivalent			1.6E-06

Controlling Organ:	Bone Sur
Controlling Pathway:	Ing
Controlling Radionuclide:	SR90
Total Inhalation EDE:	0.0E+00
Total Ingestion EDE:	1.6E-06

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Spring: Offsite Boundary: X/Q = 1.8E-5 from SAR-16: Ingestion: Liter Release
Executed on: 09/22/94 at 07:47:23

Acute release
Uptake/exposure period: 50.0
Dose commitment period: 50.0
Dose units: Rem

	Dose Commitment Year 1	2	3	...		
Internal Intake Year: 3			1.7E-07	...		
2		1.8E-07	+ 7.7E-08	...		Internal Effective Dose Equivalent
1	4.9E-07 +	1.5E-07 +	1.2E-07 +	...	= 1.6E-06	
	||	||	||			Cumulative Internal Dose
Internal Annual Dose	4.9E-07 +	3.3E-07 +	3.7E-07 +	...	= 2.0E-05	
	+	+	+		+	
External Annual Dose	5.5E-09	5.3E-09	5.1E-09	...	1.5E-07	
	||	||	||		||	Cumulative Dose
Annual Dose	5.0E-07 +	3.4E-07 +	3.8E-07 +	...	= 2.0E-05	
					5.3E-07	Maximum Annual Dose Occurred In Year 12

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Summer: Offsite Boundary: X/Q = 1.8E-5 from SAR-16: Ingestio
n: Liter Release
Executed on: 09/22/94 at 07:47:41

Acute release
Uptake/exposure period: 50.0
Dose commitment period: 50.0
Dose units: Rem

Organ	Committed Dose Equivalent	Weighting Factors	Weighted Dose Equivalent
Gonads	4.9E-07	2.5E-01	1.2E-07
Breast	4.1E-07	1.5E-01	6.2E-08
R Marrow	2.5E-05	1.2E-01	3.0E-06
Lung	4.2E-07	1.2E-01	5.0E-08
Thyroid	4.1E-07	3.0E-02	1.2E-08
Bone Sur	5.9E-05	3.0E-02	1.8E-06
LL Int.	7.6E-06	6.0E-02	4.6E-07
UL Int.	2.9E-06	6.0E-02	1.7E-07
S Int.	8.9E-07	6.0E-02	5.3E-08
Stomach	6.4E-07	6.0E-02	3.8E-08
Liver	4.8E-07	6.0E-02	2.9E-08
Internal Effective Dose Equivalent			5.8E-06
External Dose			5.5E-09
Annual Effective Dose Equivalent			5.8E-06

Controlling Organ:	Bone Sur
Controlling Pathway:	Ing
Controlling Radionuclide:	SR90
Total Inhalation EDE:	0.0E+00
Total Ingestion EDE:	5.8E-06

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Summer: Offsite Boundary: X/Q = 1.8E-5 from SAR-16: Ingestio
n: Liter Release

Executed on: 09/22/94 at 07:47:41

Acute release
Uptake/exposure period: 50.0
Dose commitment period: 50.0
Dose units: Rem

	Dose Commitment Year 1	2	3	...		
Internal Intake Year: 3			1.7E-07	...		
2		1.8E-07	+ 7.7E-08	...		Internal Effective Dose Equivalent
1	1.6E-06	+ 5.4E-07	+ 4.3E-07	+ ...	= 5.8E-06	
	||	||	||			
Internal Annual Dose	1.6E-06	+ 7.2E-07	+ 6.8E-07	+ ...	= 2.4E-05	Cumulative Internal Dose
	+	+	+		+	
External Annual Dose	5.5E-09	5.3E-09	5.1E-09	...	1.5E-07	
	||	||	||		||	
Annual Dose	1.6E-06	+ 7.2E-07	+ 6.9E-07	+ ...	= 2.4E-05	Cumulative Dose
					1.6E-06	Maximum Annual Dose Occurred In Year 1

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Autumn: Offsite Boundary: X/Q = 1.8E-5 from SAR-16: Ingestion: Liter Release

Executed on: 09/22/94 at 07:47:58

Acute release
Uptake/exposure period: 50.0
Dose commitment period: 50.0
Dose units: Rem

Organ	Committed Dose Equivalent	Weighting Factors	Weighted Dose Equivalent
Gonads	4.7E-06	2.5E-01	1.2E-06
Breast	4.1E-06	1.5E-01	6.2E-07
R Marrow	1.3E-04	1.2E-01	1.6E-05
Lung	4.2E-06	1.2E-01	5.0E-07
Thyroid	4.1E-06	3.0E-02	1.2E-07
Bone Sur	3.1E-04	3.0E-02	9.2E-06
LL Int.	4.0E-05	6.0E-02	2.4E-06
UL Int.	1.6E-05	6.0E-02	9.8E-07
S Int.	6.6E-06	6.0E-02	4.0E-07
Stomach	5.4E-06	6.0E-02	3.3E-07
Liver	2.6E-06	6.0E-02	1.6E-07
Internal Effective Dose Equivalent			3.2E-05
External Dose			5.5E-09
Annual Effective Dose Equivalent			3.2E-05

Controlling Organ:	Bone Sur
Controlling Pathway:	Ing
Controlling Radionuclide:	SR90
Total Inhalation EDE:	0.0E+00
Total Ingestion EDE:	3.2E-05

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Autumn: Offsite Boundary: X/Q = 1.8E-5 from SAR-16: Ingestion: Liter Release
Executed on: 09/22/94 at 07:47:58

Acute release
Uptake/exposure period: 50.0
Dose commitment period: 50.0
Dose units: Rem

	Dose Commitment Year 1	2	3	...		
Internal Intake Year: 3			1.7E-07	...		
2		1.8E-07	+ 7.7E-08	...		Internal Effective Dose Equivalent
1	9.9E-06	+ 3.0E-06	+ 2.3E-06	+ ...	= 3.2E-05	
	||	||	||			
Internal Annual Dose	9.9E-06	+ 3.1E-06	+ 2.5E-06	+ ...	= 5.0E-05	Cumulative Internal Dose
	+	+	+		+	
External Annual Dose	5.5E-09	5.3E-09	5.1E-09	...	1.5E-07	
	||	||	||		||	
Annual Dose	9.9E-06	+ 3.1E-06	+ 2.5E-06	+ ...	= 5.0E-05	Cumulative Dose
					9.9E-06	Maximum Annual Dose Occurred In Year 1

```
c SPRAY Version 3 Input Deck
c   mode iflow iopt
    1    0     t
c
c MODEL OPTIONS:
c mode = 1 then orifice leak with friction assumed
c        2 then slit leak with friction assumed
c iflow= 0 Reynold's number determines friction relation (i.e. laminar or turb.)
c      = 1 friction based on laminar relation
c      = 2 friction based on turbulent relation
c iopt = T then optimal diameter search performed
c      = F then no optimal search
c
c PARAMETER INPUT:
c
c   Initial Slit                          Slit or
c   Width or        Slit                  Orifice
c   Orifice Dia.    Length                Depth
c   (in)            (in)                  (in)
c
    .0197           1.098                 0.133
c
c                   Absolute
c                   Surface
c                   Roughness             Contraction      Velocity
c                   (in)                  Coefficient      Coefficient
c   Pressure        0.00006 tube ,        0.61   and       0.98  for sharp edge orifice
c   Differential    0.0018  steel         1.00   and       0.98  for rounded orifice
c   (psi)           0.0102  iron          1.00   and       0.82  for square edge orifice
c
    60              0.0018                .750             .82
c
c   Fluid           Dynamic               Respirable       RR Fitting
c   Specific        Viscosity             Diameter         Constant
c   Gravity         (centi-poise)         (μm)             (q)
c
    1.0             1.0                   20               2.4
```

SPRAY Version 3.0
May 3, 1994

Spray Leak Code
Produced by Radiological & Toxicological Analysis
Westinghouse Hanford Company

Run Date = 09/28/94/
Run Time = 09:16:50.13

INPUT ECHO:

```
c SPRAY Version 3 Input Deck
c   mode iflow iopt
    1    0     T
c
c MODEL OPTIONS:
c mode = 1 then orifice leak with friction assumed
c        2 then slit leak with friction assumed
c iflow= 0 Reynold's number determines friction relation (i.e. laminar or turb.
c      = 1 friction based on laminar relation
c      = 2 friction based on turbulent relation
c iopt = T then optimal diameter search performed
c      = F then no optimal search
c
c PARAMETER INPUT:
c
c   Initial Slit                    Slit or
c   Width or        Slit            Orifice
c   Orifice Dia.    Length          Depth
c   (in)            (in)            (in)
c
    1.97000E-02     1.09800E+00     1.33000E-01
c
c                   Absolute
c                   Surface
c                   Roughness       Contraction     Velocity
c                   (in)            Coefficient     Coefficient
c   Pressure        0.00006 tube    0.61    and     0.98  for sharp edge orifice
c   Differential    0.0018  steel   1.00    and     0.98  for rounded orifice
c   (psi)           0.0102  iron    1.00    and     0.82  for square edge orifice
c
    6.00000E+01     1.80000E-03     7.50000E-01     8.20000E-01
c
c   Fluid           Dynamic         Respirable      RR Fitting
c   Specific        Viscosity       Diameter        Constant
c   Gravity         (centi-poise)   (μm)            (q)
c
    1.00000E+00     1.00000E+00     2.00000E+01     2.40000E+00
```

MESSAGES:
Orifice Model
Code search for optimal equivalent diameter.

OUTPUT:

Liquid Velocity =	6.33E+01	ft/s	1.93E+01 m/s	
Reynolds Number =	9.01E+03	Turbulent Flow		
Sauter Mean Diameter =	1.65E+02	μm		
Optimum Diameter =	1.84E-02	in	4.67E-04 m	
Respirable Fraction =	2.28E-03			
Total Leak Rate =	3.93E-02	gpm	2.48E-06 m3/s	2.48E+00 g/s
Respirable Leak Rate =	8.98E-05	gpm	5.67E-09 m3/s	5.67E-03 g/s

SPRAY Version 3.0
May 3, 1994

Spray Leak Code
Produced by Radiological & Toxicological Analysis
Westinghouse Hanford Company

Run Date = 09/28/94/
Run Time = 09:13:56.73

INPUT ECHO:

```
c SPRAY Version 3 Input Deck
c   mode iflow iopt
    2    0     T
c
c MODEL OPTIONS:
c mode = 1 then orifice leak with friction assumed
c        2 then slit leak with friction assumed
c iflow= 0 Reynold's number determines friction relation (i.e. laminar or turb.
c      = 1 friction based on laminar relation
c      = 2 friction based on turbulent relation
c iopt = T then optimal diameter search performed
c      = F then no optimal search
c
c PARAMETER INPUT:
c
c   Initial Slit                        Slit or
c   Width or        Slit                Orifice
c   Orifice Dia.    Length              Depth
c   (in)            (in)                (in)
c
    1.97000E-02     1.09800E+00         1.33000E-01
c
c                   Absolute
c                   Surface
c                   Roughness           Contraction     Velocity
c                   (in)                Coefficient     Coefficient
c   Pressure        0.00006 tube        0.61   and      0.98  for sharp edge orifice
c   Differential    0.0018  steel       1.00   and      0.98  for rounded orifice
c   (psi)           0.0102  iron        1.00   and      0.82  for square edge orifice
c
    6.00000E+01     1.80000E-03         7.50000E-01     8.20000E-01
c
c   Fluid           Dynamic             Respirable      RR Fitting
c   Specific        Viscosity           Diameter        Constant
c   Gravity         (centi-poise)       (μm)            (q)
c
    1.00000E+00     1.00000E+00         2.00000E+01     2.40000E+00
```

MESSAGES:
Slit Model
Code search for optimal equivalent diameter.

OUTPUT:

Liquid Velocity =	4.64E+01 ft/s	1.41E+01 m/s	
Reynolds Number =	3.02E+03 Critical Flow		
Sauter Mean Diameter =	8.77E+01 μm		
Optimum Slit Width =	4.21E-03 in	1.07E-04 m	
Respirable Fraction =	1.94E-02		
Total Leak Rate =	5.02E-01 gpm	3.17E-05 m3/s	3.17E+01 g/s
Respirable Leak Rate =	5.20E-03 gpm	3.28E-07 m3/s	3.28E-01 g/s

```
c SPRAY Version 3 Input Deck
c   mode iflow iopt
    2    0     t
c
c MODEL OPTIONS:
c mode = 1 then orifice leak with friction assumed
c        2 then slit leak with friction assumed
c iflow= 0 Reynold's number determines friction relation (i.e. laminar or turb.)
c      = 1 friction based on laminar relation
c      = 2 friction based on turbulent relation
c iopt = T then optimal diameter search performed
c      = F then no optimal search
c
c PARAMETER INPUT:
c
c   Initial Slit                          Slit or
c   Width or        Slit                  Orifice
c   Orifice Dia.    Length                Depth
c   (in)            (in)                  (in)
c   ____________    ____________          ____________
    .0197           1.098                 0.133
c
c                   Absolute
c                   Surface
c                   Roughness             Contraction     Velocity
c                   (in)                  Coefficient     Coefficient
c   Pressure        0.00006 tube          0.61   and      0.98  for sharp edge orifice
c   Differential    0.0018  steel         1.00   and      0.98  for rounded orifice
c   (psi)           0.0102  iron          1.00   and      0.82  for square edge orifice
c   ____________    ____________          ____________    ____________________________
    60              0.0018                .750            .82
c
c   Fluid           Dynamic               Respirable      RR Fitting
c   Specific        Viscosity             Diameter        Constant
c   Gravity         (centi-poise)         (μm)            (q)
c   ____________    ____________          ____________    ____________
    1.0             1.0                   20              2.4
```

6.0 CONTROLS

As shown in Section 5.0, Consequences, there are no accidents that deliver over 5 rem to the on-site, adjacent worker, and no accidents that deliver over 500 mrem to the general public, so no safety class 1 or 2 controls are called for on this system design. It should be noted however, that a possibility of a spray release of organic in the C-103 tank space from the skimmer pump line could result in a fire or explosion. Though it is believed that the dose from this accident is bounded by the complete burn of the organic studied in Section 5.0, an explosion could be a threat to the integrity of the C-103 tank, which is safety class 1. This accident is prevented by a sleeve around the skimmer pump line which would prevent escaping aerosols from entering the vapor space of the tank. As this feature is present in the current design, the accident in question may be ruled out. Further study of this scenario may be informative, however.

APPENDIX 1
HAZOP TABLES

Project: C-103 ORGANIC REMOVAL	Revision: 0923-D Date: 07/15/94	Node: 001 Page: 1 Time: 10:18:54
	Session:	Team: (see below)
Node Description: DRAIN TANK INCLUDING AQUEOUS DISCHARGE LEG, DRAIN TANK VENT LINE WITH HEPA FILTER, DRAIN TANK FLUSH CONNECTION, AND ASSOCIATED INSTRUMENTATION	Leader: MFR	Recorder: MP
	Organization: RISK ASSESMENT	
	Location: 450 HILLS	
	P&ID's: #X	Rev #'s: 0
Design Intention: RECEIVING OF AQUEOUS DISCHARGE FROM COALESCER, STORAGE OF AQUEOUS UNTIL TRANSFER BACK TO C-103		
Team Members:		

Node Description: DRAIN TANK INCLUDING AQUEOUS DISCHARGE LEG, DRAIN TANK VENT LINE WITH HEPA FILTER, DRAIN TANK FLUSH CONNECTION, AND ASSOCIATED INSTRUMENTATION

PROCESS PARAMET	GUIDE WORD	CAUSES	CONSEQUENCES	SAFEGUARD	RANK	REMARK	RM#
PRESSURE	HIGH	sump pump failure or level switch failure (tank high level)	probably no effect	tank ventilation (through HEPA) tank is structurally strong (walls are 1" thick steel)	N/A		
		addition of flush water through flush connection	rupture of HEPA, subsequent overflow of aqueous	Sump leak detection, separations enclosure provides containment	S1 (1-01)		
	REVERSE	plug of HEPA, subsequent drop in liquid level creates vacuum	open pathway to enclosure (HEPA collapses)	enclosure vent is filtered	S1 (1-02)		
TEMPERATURE	NO	cold weather	freezing in tank, lines(possible leak)	liquid is hot double encased lines and protective wrapped enclosure warm from process	S1 (1-03)		
		thermal shock (hot liquid in cold tank)	leak	separations enclosure provides containment sump pump, sump leak detection	S1 (1-04)		
	HIGH	overheating of liquid by heat trace on coalescer	boiling of liquid results in soaking of HEPA, release of contaminated vapors to enclosure	heat trace breaks at high temperature setpoint control on heat trace electrical current enclosure vented by HEPAs	S2 (1-05)		
LEVEL	NO	low level switch fails	pump damage (sump pump)	liquid level monitored remotley	SO		
		tank leak of aqueous	release	enclosure, sump pump, leak detection	S1 (1-06)		
	LOW	None separate from 'NO' guideword	None separate from 'NO' guideword	None separate from 'NO' guideword	See 'NO'		
	HIGH	pump fails (pump or switch failure)	HEPA damage (overflowing aqueous passes through HEPA)	Separation enclosure vented through redundant HEPA filters	SO		
			tank overflow (release)	Seperation enclosure provides containment, leak detection	S1 (1-07)		

Node Description: DRAIN TANK INCLUDING AQUEOUS DISCHARGE LEG, DRAIN TANK VENT LINE WITH HEPA FILTER, DRAIN TANK FLUSH CONNECTION, AND ASSOCIATED INSTRUMENTATION

OCESS PARAMET	GUIDE WORD	CAUSES	CONSEQUENCES	SAFEGUARD	RANK	REMARK	RM#
LEVEL (con't)	HIGH	downstream valve closed	tank overflow (release)	separation enclosure provides containment, leak detection	S1 (1-08)		
		downstream line plugged	tank overflow (release)	separation enclosure provides containment, leak detection	S1 (1-09)		
		addition of water through flush connection	tank overflow (release)	separation enclosure provides containment, leak detection	S1 (1-10)		
	AS WELL AS,OTHER THAN	organic enters through aqueous line	None of concern identified	Interface control module prevents organic from discharging through aqueous line	N/A		
REACTION	LOW	corrosion, rust	leak, release	walls of the tank are 1 inch thick steel short operating life prevents long-term corrosion	S1 (1-11)		
SPECIAL	NO (loss of utilities)	loss of power	aqueous drainback to drain tank from sump pump (No effect)	Planned occurence	SO		
		loss of computer	potentail tank overflow HEPA damage, release (because of loss of monitoring)	seperation enclosure provides containment	S1 (1-12)	check on operating status w/loss of computer	R1
	OTHER THAN (startup, shutdown, maintenance)	Contamination during D&D	personnel exposure	administrative controls	S1 (1-13)		
		repair of failed instruments	personnel exposure	administrative controls	S1 (1-14)		
		tank not empty during D&D (aqueous spill)	personnel exposure	administrative controls normal sump pump operation prevents aqueous build-up	S1 (1-15)		
COMPOSITION	AS WELL AS	shutdown sends organic into tank (gravity drain of coalescer)	None of concern	planned event discharge is to C-103	N/A		
		26% unknown compounds in organic	Corrosion of tank and subsequent leak	tank is 1" thick steel and corrosion resistant	S1 (1-16)		
	OTHER THAN	metals shaving from tank fabrication remains in tank	sump pump damage	adminstrative controls on manufacture and installation	SO		

Node Description: DRAIN TANK INCLUDING AQUEOUS DISCHARGE LEG, DRAIN TANK VENT LINE WITH HEPA FILTER, DRAIN TANK FLUSH CONNECTION, AND ASSOCIATED INSTRUMENTATION

PROCESS PARAMET	GUIDE WORD	CAUSES	CONSEQUENCES	SAFEGUARD	RANK	REMARK	RM#
COMPOSITION (con't)	OTHER THAN	metals shaving from tank fabrication remains in tank	sump pump damage	inspection of new equipment pump probably would not draw out shavings (outlet is a vertical line)			
		introduction of dead insects or rodents	posssible sump pump damage	probably would do no damage. HEPA would provide only means of entry and would be difficult for small animals to penetrate	S0		

Project: C-103 ORGANIC REMOVAL	Revision: C103-D	Node: 002 Page: 1
WHC-SD-WM-PLN-092 Rev 0	Date: 07/18/94	Time: 08:33:38
	Session:	Team: (see below)
Node Description: C-103 WASTE REMOVAL LINE INCLUDING SKIMMER, SKIMMER PUMP, TRANSFER LINES, VALVES, FILTERS F0101, F0102, F0103, FLUSH CONNECTION, INLET TO COALESCER, AND ASSOCIATED INSTRUMENTS	Leader: MFR	Recorder: MP
	Organization: RISK ASSESMENT	
	Location: 450 HILLS	
	P&ID's: #X	Rev #'s: 0
Design Intention: REMOVAL OF ORGANIC LAYER FROM C-103, FILTER FOR PARTICULATES, AND TRANSFER TO COALESCER		
Team Members:		

Node Description: C-103 WASTE REMOVAL LINE INCLUDING SKIMMER, SKIMMER PUMP, TRANSFER LINES, VALVES, FILTERS F0101, F0102, F0103, FLUSH CONNECTION, INLET TO COALESCER, AND ASSOCIATED INSTRUMENTS

PROCESS PARAMET	GUIDE WORD	CAUSES	CONSEQUENCES	SAFEGUARD	RANK	REMARK	RM#
FLOW	NO	planned operational delay	None	none	N/A		
		line plug	potential skimmer pump damage	flow indicator on inlet line skimmer pump hydraulic overpressure shutdown interlock	SO		
		skimmer blocked or upside down	potential skimmer pump damage	flow indicator on inlet line administrative controls on skimmer installation skimmer pump hydraulic overpressure shutdown interlock	SO		
		in-line manual valve closed	potential skimmer pump damage	administrative controls on valving configuration flow indicator on inlet line skimmer pump hydraulic overpressure shutdown interlock	SO		
		filters F0101, F0102, or F0103 plugged	potential skimmer pump damage	pressure differential guages across filters redundant filters skimmer pump hydraulic overpressure shutdown interlock	SO	team unsure as to whether filters can be backflushed	R3
		skimmer pump failure	operational delay	flow indicator on inlet line	SO		
		transfer line leak or rupture	release/fire	administrative controls over heavy equipment near C-103 flow indicator on inlet line	S1/S2 (2-01)		
		instrument malfunction activates shutdown interlock	operational delay	short operating life should minimize instrument failures	SO		
		drain tank high level interlock shut off	operational delay	sump pump drains drain tank prior to high level situation	SO		

Node Description: C-103 WASTE REMOVAL LINE INCLUDING SKIMMER, SKIMMER PUMP, TRANSFER LINES, VALVES, FILTERS F0101, F0102, F0103, FLUSH CONNECTION, INLET TO COALESCER, AND ASSOCIATED INSTRUMENTS

JCESS PARAMET	GUIDE WORD	CAUSES	CONSEQUENCES	SAFEGUARD	RANK	REMARK	RM#
FLOW (con't)	NO	organic discharge line high radiation (shutdown interlock)	operational delay (high radiation in organic line discussed later)	organic-aqueous interface controlled automatically by interface controller prevents radiation in organic line radiation detection on organic discharge line	---	High radiation in organic line discussed elsewhere	
		loss of electricity to pump instruments	operational delay	None	S0		
	LOW	refer to causes in 'NO FLOW'	same as 'NO FLOW'	same as 'NO FLOW'	see 'NO FLOW'		
		skimmer pump out of specifications	operational delay	administrative controls on procurement	S0		
		pressure indicator rupture causes flow misdirection	release to environment	process control on max. pumping pressure of 60 psi	S1 (2-02)	check to make sure that an isolation valve is on the pressure indicator sensing line to prevent overpressure during backflushing	R4
	HIGH	skimmer pump overspeed	improper separation of organic and aqueous because of creation of emulsions, possible aqueous to truck	radiation detection on organic discharge line	S1 (2-03)		
	PART OF	No items of concern	No items of concern	N/A	N/A		
	AS WELL AS (excessive aqueous)	skimmer upset, organic layer thin	potential discharge of aqueous to tanker truck	radiation detector on organic discharge line automatic coalescer interface control	S1 (2-04)		
	AS WELL AS (solids)	uncertainty in the composition of the tank	filter and coalescer contamination	redundant filters coalescer sized to accomodate larger flow capacity than required	S0		
			operational problems (filters, coalescer)	filters and coalescer flushable	S0		
	OTHER THAN (100% aqueous)	improper skimmer operation	potential aqueous discharge to tanker truck	radiation detectors on organic discharge line automatic coalescer interface control	S1 (2-05)		

Node Description: C-103 WASTE REMOVAL LINE INCLUDING SKIMMER, SKIMMER PUMP, TRANSFER LINES, VALVES, FILTERS F0101, F0102, F0103, FLUSH CONNECTION, INLET TO COALESCER, AND ASSOCIATED INSTRUMENTS

PROCESS PARAMET	GUIDE WORD	CAUSES	CONSEQUENCES	SAFEGUARD	RANK	REMARK	RM#
FLOW (con't)	REVERSE	drainback to C-103 during shut down	none of concern	anticipated event	N/A		
		pump runs backwards	waste returns to C-103, potential pump damage	administrative controls on installation and operation	S0		
PRESSURE	NO	skimmer pump stop	process delay	anticipated event	S0		
		transfer line severed	release/fire	double encased transfer line	S1/S2 (2-06)		
				administrative controls on heavy equipment near C-103			
	LOW	line/filter plug	process delay	redundant filters	S0		
			potential skimmer pump damage	skimmer pump hydraulic overpressure shut down interlock			
		pipe leak/rupture	release/fire	double-encased line	S1/S2 (2-07)		
		pump running at low speed	process delay	flow indicator at coalescer inlet	S0		
		misrouting (to flush connection)	release/fire	multiple isolation valves on line	S1/S2 (2-08)		
				administrative controls on valve configuration			
				quick connect valve prevents release from flush connection			
		misroutings (to sump pump recirculation line)	sump filled with liquid (by either routing to sump or overflow of drain tank)	sump leak detection	S1 (2-09)		
				administrative controls on valve configuration			
	HIGH	line/filter plug	process delay	redundant filters	S0		
		pump overrun (up to 200 Psi)	overcome containment capabilities, potential release from blown gaskets or seals	skimmer pump hydraulic overpressure shut down interlock	S1 (2-10)		
				seperation enclosure provides containment			
		valve closing	process delay/pump damage	administrative controls on valve positioning	S0		
		spurious flush procedure during operation	process delay/equipment damage	administrative controls on flush procedure	S0		

Node Description: C-103 WASTE REMOVAL LINE INCLUDING SKIMMER, SKIMMER PUMP, TRANSFER LINES, VALVES, FILTERS F0101, F0102, F0103, FLUSH CONNECTION, INLET TO COALESCER, AND ASSOCIATED INSTRUMENTS

CESS PARAMET	GUIDE WORD	CAUSES	CONSEQUENCES	SAFEGUARD	RANK	REMARK	RM#
PRESSURE (con't)							
TEMPERATURE	NO	cold weather	brittle fracture of lines	waste is thermally hot coming from C-103 lines slope to drain to prevent stagnant liquid from collecting	S1 (2-11)		
		thermal shock (hot liquid through cold line)	crack in line (release)	double encased line	S1 (2-12)		
	HIGH	sunshine	halor sheath on coalsecer interface level probe breaks down at 150 degrees F losing instrumentation capability and allow aqueous to flow to the tanker truck--possible increased radiation exposure	moving liquid (organic/aqueous) will act as a coolant	S1 (2-13)	halor sheath protects the equipment from corrosiveness of liquid--cause the instrument to malfunction and lose indication capability	R5
		external fire	unknown possibility of fire/line explosion	vehicle access controlled, controlling potential fire sources minimal combustibles in area	S3 (2-14)	might need to evaluate lightning strike	R6
AGITATION	HIGH	pumping malfunction (too turbulent/fast)	possible emulsions resulting in release of aqueous to truck	radiation detection on organic discharge line	S1 (2-15)		
		skimmer malfunction	possible emulsions created resulting in release of aqueous to truck	postive displacement pump, designed to prevent agitation	S1 (2-16)		
		filter partially plugged	possible emulsions created resulting in release of aqueous to truck	redundant filters radiation detection on organic discharge line	S1 (2-17)		
		partially open valve	possible emulsions created resulting in release of aqueous to truck	administrative controls on valve configuration radiation detection on organic discharge line	S1 (2-18)		
	AS WELL AS (foaming)	poor seal or leak in flex tubing allows air in	see REMARKS	short operating life should minimize passive component failures		Some study on the potential of organic foaming might be necssary	R7

Node Description: C-103 WASTE REMOVAL LINE INCLUDING SKIMMER PUMP, TRANSFER LINES, VALVES, FILTERS F0101, F0102, F0103, FLUSH CONNECTION, INLET TO COALESCER, AND ASSOCIATED INSTRUMENTS

PROCESS PARAMET	GUIDE WORD	CAUSES	CONSEQUENCES	SAFEGUARD	RANK	REMARK	RM#
REACTION	LOW	degradation due to radiation and/or chemicals (none-steel components)	leak from system causing release/fire	administrative controls on materials compatibility during procurement short operating life should minimize corrosion effects double encased lines	S1/S2 (2-19)		
	HIGH	None identified	None identified	N/A	N/A		
SPECIAL	NO (loss of utilities)	loss of electrical power	process delay	none	S0		
	OTHER THAN (start up, maintenance shutdown)	drop of pump structrue during installation	puncture tank bottom, release to ground	"Critical Lift" administrative controls in effect weight of pump structure designed to prevent tank floor damage in case of drop	S3 (2-20)		
		potential exposure or release during D&D	personnel injury	anticipated event	S1 (2-21)		
		exposure from hot equipment during maintenance especially if system is still operating	personnel injury	administrative controls - system must be shut down to work on hot equipment	S1 (2-22)		

Project: C-103 ORGANIC REMOVAL	WHC-SD-WM-PLN-092 Revision: 0103-0 Rev 0	Node: 003	Page: 1
	Date: 07/18/94	Time: 09:55:10	
	Session:	Team:	(see below)
Node Description: ORGANIC DISCHARGE LINE INCLUDING TRANSFER PIPING FROM COALESCER TO TANKER TRAILER, RETURN LINE TO DRAIN TANK, AND ASSOCIATED INSTRUMENTS	Leader: MFR	Recorder: MP	
	Organization: RISK ASSESMENT		
	Location: 450 HILLS		
	P&ID's:	Rev #'s:	
	#X	0	
Design Intention: TRANSFER OF SEPARATED ORGANIC TO TANKER TRAILER, AND RETURN CAPABILITY TO DRAIN TANK IN THE EVENT OF EXCESS AQUEOUS CONTENT			
Team Members:			

Node Description: ORGANIC DISCHARGE LINE INCLUDING TRANSFER PUMP FROM COALESCER TO TANKER TRAILER, RETURN LINE TO DRAIN TANK, AND ASSOCIATED INSTRUMENTS

PROCESS PARAMETER	GUIDE WORD	CAUSES	CONSEQUENCES	SAFEGUARD	RANK	REMARK	RM#
FLOW	NO	pump stop	process delay	none	S0		
		discharge valve closed	coalescer level interface upset, potential organic to drain tank	coalescer level interface monitoring	S0		
		filter plugged	see "NO FLOW" node 2	see "NO FLOW" node 2	---		
		organic discharge line plugged	see "discharge valve closed" above	see "discharge valve closed" above	S0		
		coalescer plugged	potential skimmer pump damage	skimmer pump hydraulic overpressure shutdown interlock flow indicator on coalescer inlet line	S0		
		line break	release/fire?	double-encased line administrative controls over heavy equipment near C-103	S1/S2 (3-01)		
		system down	process delay	N/A	S0		
		misrouting (to flush connect)	release/fire	administrative controls on valve configuring	S1/S2 (3-02)		
				self-sealing quick-connect valve (to prevent release)		determine if flush connection has quick connect valve	R8
			possible entry of organic to flush source	administrative controls on flush procedures	S1 (3-03)		
		misrouting (to drain tank)	organic returns to C-103, process delay	administrative controls on valve configuring	S0		
	LOW	same as 'NO' above	same as 'NO' above	same as 'NO' above			
		misrouting to vacuum breaker (manual breaker left open)	HEPA damage	direct return to truck rather than pathway to filter	S0		
	HIGH	loss of aqueous discharge from coalescer (valve closed, line plugged, etc.)	possible release of aqueous to truck	radiation monitor on organic line interface control monitoring	S1 (3-04)		
		introduction of liquid through flush connector	truck overflow?	administrative controls on flush procedure, valving configurations	S1 (3-05)		
		skimmer pump overspeed	see "HIGH FLOW" node 2	see "HIGH FLOW" node 2	---		

Node Description: ORGANIC DISCHARGE LINE INCLUDING TRANSFER PIPING FROM COALESCER TO TANKER TRAILER, RETURN LINE TO DRAIN TANK, AND ASSOCIATED INSTRUMENTS

.OCESS PARAMET	GUIDE WORD	CAUSES	CONSEQUENCES	SAFEGUARD	RANK	REMARK	RM#
FLOW (con't)	AS WELL AS	aqueous in organic line	increased exposure from truck	radiation detector on organic line	---	Causes of aqueous in organic discharge discussed elsewhere	
				interface control monitoring			
	OTHER THAN	pure aqueous in organic line	increased exposure from truck	radiation detector on organic line	---	Causes of aqueous in organic discharge discussed elsewhere	
				interface control monitoring			
	REVERSE	shutdown, vacuum breaker not open.	could potentially siphon tank truck back to C-103	level indicator on truck	S0	May need better safeguards against back-siphoning	R10
			possible damage to pumping equipment				
PRESSURE	NO	line rupture	release/fire	administrative controls over heavy equipment near C-103	S1/S2 (3-06)		
		process stopped	process delay	N/A	S0		
		upstream flow stoppage	process delay (other consequences discussed under "NO FLOW" above	see "NO FLOW" above	S0		
	LOW	skimmer pump problems	see "NO FLOW" above	see "NO FLOW" above	---		
		misrouting upstream	see "NO FLOW" above	see "NO FLOW" above	---		
		flush line open	see "HIGH FLOW" above	see "HIGH FLOW" above	---		
	HIGH	skimmer pump overspeed	see "HIGH FLOW" above	see "HIGH FLOW" above	---		
		truck is overfilled	release/fire	truck intentionally over-sized to accomodate larger volume than organic waste volume	S1/S2 (3-07)		
				truck tank designed to handle pressure: (3/8) inch steel			
				berm around truck area would contain spill release			
		downstream flow blockage	skimmer pump damage due to dead-head	tank pump hydraulic overpressure switch	S0		
		liquid introduced through flush line	see "HIGH FLOW" above	see "HIGH FLOW" above	---		

Node Description: ORGANIC DISCHARGE LINE INCLUDING TRANSFER PIPING FROM COALESCER TO TANKER TRAILER, RETURN LINE TO DRAIN TANK, AND ASSOCIATED INSTRUMENTS

PROCESS PARAMET	GUIDE WORD	CAUSES	CONSEQUENCES	SAFEGUARD	RANK	REMARK	RM#
PRESSURE (con't)	REVERSE	backflow after shutdown (vacuum breaker does not open)	truck contents siphoned back into C-103	administrative controls over vacuum breaker usage	S0		
			possible skimmer pump damage due to liquid travelling backwards through pump	pump is reversible	S0		
		pump runs backward	truck contents siphoned into C-103	administrative controls over pump usage	S0		
TEMPERATURE	NO	cold weather	see "NO TEMPERATURE" node 2	see "NO TEMPERATURE" node 2	---		
	HIGH	external fire	see "HIGH TEMPERATURE" node 2	see "HIGH TEMPERATURE" node 2	---		
		hot weather	operations personnel heat hazards	administrative controls on hot weather work	S1 (3-08)		
		coalescer overheating organic	Probably no adverse effects	flash point is 135C ignition point very high	N/A		
SPECIAL	NO	loss of power	backflow (syhons truck)	vacuum breaker	S0	should vacuum breaker be automatically operated	R11
		loss of computer	system shutdown (backflow) siphoning of truck	vacuum breaker	S0		
	OTHER THAN	shutdown	siphoning of truck	vacuum breaker	S0		
		flush connection left open after startup	release/fire	administrative controls on valving configuration during operation self-sealing quick connect prevents leakage	S1/S2 (3-09)		
		increased exposure during repair if line damaged	personnnel exposure	system designed to operate for short life without maintanance administrative controls on repair actions to reduce exposure	S1 (3-10)		
		truck rolls forward/back after hook-up, causing damage to lines	release/fire	wheels blocked while parked administrative controls	S1/S2 (3-11)		

Project: C-103 Organic Layer Removal and Seperation	Revision: 0003-0	Node: 004 Page: 1
	Date: 07/18/94	Time: 14:48:16
	Session:	Team: (see below)
Node Description: TANKER TRAILER INCLUDING OUTSIDE CONCRETE SHIELDING, TRAILER CHASSIS, TANK, SAMPLE PIPING AND ASSOCIATED INSTRUMENTATION	Leader: MFR	Recorder: MP
	Organization:	
	Location: me	
	P&ID's: #X	Rev #'s: 0
Design Intention: RECEIVING OF SEPARATED ORGANIC AND STORAGE BEFORE AND OURING TRANSPORTATION		
Team Members:		

WHC-SD-WM-PLN-092
Rev 0

Node Description: TANKER TRAILER INCLUDING OUTSIDE CONCRETE SHIELDING, TRAILER CHASSIS, TANK, SAMPLE PIPING AND ASSOCIATED INSTRUMENTATION

PROCESS PARAMET	GUIDE WORD	CAUSES	CONSEQUENCES	SAFEGUARD	RANK	REMARK	RM#
PRESSURE	HIGH	tank overfill	leakage (via sample valves)/fire	level/temperature indicators on tank	S1/S2 (4-01)	no pressure sources identified that could rupture tank	R12
				administrative controls on tank filling			
			tank rupture/leak	tank structure is heavy steel, can withstand overfill pressure			
		sunlight	probably no consequence of concern	N/A	N/A		
		external fire	leakage (via sample valves)/fire	vehicle access controlled, limiting potential fire sources	S1/S2 (4-02)		
			tank rupture/leak with possible fire	minimal combustibles in area			
	REVERSE	vacuum breaker not open when transfer stopped	backflow, potential siphoning of tanker back to C-103	administrative controls on use of vacuum breaker	SO		
		skimmer pump reversed	backflow, potential siphoning of tanker back to C-103	administrative controls on operation of pump	SO		
TEMPERATURE	NO	cold weather	None identified	N/A	N/A		
	HIGH	see "PRESSURE: HIGH" above	see "PRESSURE: HIGH" above	see "PRESSURE: HIGH" above	---		
LEVEL	LOW/NO	fill line blocked	operational delay	level indication on tank	SO		
		skimmer pump not operational	operational delay	N/A	SO		
		leak or rupture from truck tank	release/fire	leak detection on pad	S1/S2 (4-03)		
				bermed area that holds 110% of tank volume			
				sampling			
	HIGH	more organic in tank C-103 than expected	overflow of tank, release/fire	level indication on tank	S1/S2 (4-04)		
				leak detection on pad			
				bermed area holds 110% of tank volume			
		flushwater added to or leaks into tank inlet line	overflow of tank, release/fire	administrative controls on flush valving	S1/S2 (4-05)		

Node Description: TANKER TRAILER INCLUDING OUTSIDE CONCRETE SHIELDING, TRAILER CHASSIS, TANK, SAMPLE PIPING AND ASSOCIATED INSTRUMENTATION

JCESS PARAMET	GUIDE WORD	CAUSES	CONSEQUENCES	SAFEGUARD	RANK	REMARK	RM#
LEVEL (con't)	HIGH	flushwater added to or leaks into tank inlet line	increased waste volume, regulatory infraction process delay	sampling of truck contents			
		failure of interface control (aqueous to truck)	high dose rate from tank	radiation monitoring of organic discharge line	S1 (4-06)		
			overflow of tank	level indication on tank	S1 (4-07)		
	PART OF and AS WELL AS	failure of interface control (aqueous in truck)	high dose rate from tank	radiation monitoring of organic discharge line	S1 (4-08)		
		skimmer suctions only aqueous (aqueous in truck)	high dose rate from tank	organic monitoring of organic discharge line	S1 (4-09)		
AGITATION	AS WELL AS (foaming)	excessive mixing from falling liquid	foam enters vent line, contaminates vent line & HEPA	organic released below liquid level in tank	S1 (4-10)	study on foaming qualities of organic may be helpfull	R13
REACTION	LOW	corrosion of tank shell	tank leak (release/fire)	tank designed with high corrosion allowances bermed area around truck short operating life prevents long-term corrosion	S1 (4-11)		
	HIGH	reaction with chemicals left in tank from previous use/manufacture	tank leak (release/fire)	tank manufactured for this mission, no previous use administrative controls on manufacture and inspection	S1 (4-12)		
SPECIAL	NO (Utility Failure)	None of concern identified	None of concern identified	N/A	N/A		
	OTHER THAN (startup, shutdown, maintenance)	truck rolls forward or backward, damaging organic transfer line	release/fire	wheels blocked while parked	S1/S2 (4-13)		
		failure to disconnect organic line before trailer removal	damage to truck, potential release/fire	administrative controls on shutdown and trailer removal	S1/S2 (4-14)		
		release of residual organic during disconnection of organic line	exposure and contamination of personnel	flexible splash guard on connect nozzle to prevent spillage flush performed prior to disconnect	S1 (4-15)		

Node Description: TANKER TRAILER INCLUDING OUTSIDE CONCRETE SHIELDING, TRAILER CHASSIS, TANK, SAMPLE PIPING AND ASSOCIATED INSTRUMENTATION

PROCESS PARAMET	GUIDE WORD	CAUSES	CONSEQUENCES	SAFEGUARD	RANK	REMARK	RM#
SPECIAL (con't)	OTHER THAN (startup, shutdown, maintenance)	contamination of personnel during sampling	exposure and contamination of personnel	administrative controls on sampling procedures	S1 (4-16)		
		failure to connect HEPA line during installation	contaminated vapor release to atmosphere	administrative controls on installation pretesting	S1 (4-17)		
STRUCTURAL INTRERITY	NO	truck bed failure	tank failure (release/fire)	packaging safety analysis, inspection	S1/S2 (4-18)		
		axle failure	tank failure (release/fire)	packaging safety analysis, inspection	S1/S2 (4-19)		
		shielding failure (inward fall, damages tank)	tank failure (release/fire) exposure from tank due to loss of shielding	packaging safety analysis, inspection	S1/S2 (4-20)		
		shielding failure (outward fall)	personnel injury	packaging safety analysis, inspection	S1 (4-21)		
		tire failure	tank tips, possible failure resulting in release/fire and process delay	12 tires on trailer provide redundancy	S1 (4-22)		
		berm failure	spread of release/fire	only a hazard given tank failure	S1/S2 (4-23)		
		tank failure (weld failure)	release/fire	leak detection on pad bermed area holds 110% of tank capacity	S1/S2 (4-24)		

Project: C-103 Organic Layer Removal and Seperation	Revision: C103-0	Node: 005 Page: 1
WHC-SD-WM-PLN-092 Rev. 0	Date: 07/19/94	Time: 14:07:24
	Session:	Team: (see below)
.ode Description: AQUEOUS RETURN LINE INCLUDING SUMP RECYCLE PUMP, AQUEOUS DISCHARGE/PUMP BYPASS LINE, SUMP PUMPOUT LEG, AND ASSOCIATED VALVES AND INSTRUMENTS	Leader: MFR	Recorder: MP
	Organization:	
	Location: me	
	P&ID's:	Rev #'s:
Design Intention: TRANSFER OF SEPARATED AQUEOUS BACK TO C-103 AND PUMPOUT OF SUMP IN THE EVENT OF A LEAK	#X	0

Team Members:

Node Description: AQUEOUS RETURN LINE INCLUDING SUMP RECYCLE PUMP AQUEOUS DISCHARGE/PUMP BYPASS LINE, SUMP PUMPOUT LEG, AND ASSOCIATED VALVES AND INSTRUMENTS

PROCESS PARAMETI	GUIDE WORD	CAUSES	CONSEQUENCES	SAFEGUARD	RANK	REMARK	RM#
FLOW	NO	system down	process delay	anticipated event	S0		
		sump pump failure	process delay	short operating life should minimize pump failure probability	S0		
		aqueous return line valves erroneously closed	drain tank overflow	administrative controls on valve configurations	S1 (S-01)		
				drain tank level interlocks shut down skimmer pump on high level			
				separations enclosure provides containment			
		misrouting to coalescer	aqueous to truck	radiation monitor on organic line	S1 (S-02)	A 3-way valve at aqueous discharge from coalescer may result in flow control problems (aqueous released down gravity drain leg)	R14
		misrouting to filters	overflow of drain tank	drain tank level indicator	S1 (S-03)		
				high level interlock shuts down skimmer pump			
				separations enclosure provides containment			
				leak detection and sump pump capability			
		aqueous return line severed	release	separations enclosure provides containment	S1 (S-04)		
				double encased line			
		aqueous return line plugged	drain tank overflow	filters remove solids	S1 (S-05)		
				separations enclosure provides containment			
				leak detection and sump pump capability			
			potential sump pump damage	filters remove solids			
		no aqueous from coalescer	process delay	flow indicator on organic discharge line out of coalescer	S0		

Node Description: AQUEOUS RETURN LINE INCLUDING SUMP RECYCLE PUMP, AQUEOUS DISCHARGE/PUMP BYPASS LINE, SUMP PUMPOUT LEG, AND ASSOCIATED VALVES AND INSTRUMENTS

OCESS PARAMET	GUIDE WORD	CAUSES	CONSEQUENCES	SAFEGUARD	RANK	REMARK	RM#
FLOW (con't)	NO						
	LOW	sump pump running at abnormally low speed	potential build up of aqueous in drain tank (possible overflow)	drain tank high level interlocks	S1 (5-06)		
				sump leak detection			
				separations enclosure provides containment			
		pluggage in line	potential buildup of aqueous in drain tank (possible overflow)	filters remove solids	S1 (5-07)		
				inspection of lines prior to use			
		partially open 3-way valves	cycling of sump pump	administrative controls on valving configuration	S0		
			process delay		S0		
		leak in aqueous return line	release	double-encased line	S1 (5-08)		
				separations enclosure provides containment			
				line gravity drains to drain tank			
	HIGH	sump pump overspeed	splashing, mixing, emulsifying of tank waste, causing further problems in removal of organic by skimmer	sump pump maximum flow rate is 3gpm	S1 (5-09)		
				aqueous return positioned far from skimmer 32ft.			
		addition through aqueous bypass line (3-way valve configured to flow directly from skimmer pump to C-103)	possible pumping of excessive aqueous to C-103, emulsions possible (no effect as flow is not to coalescer)	aqueous return is below liquid surface	---		
	AS WELL AS and other than	organic in aqueous return line	process delay	administrative control (planned event)	S0		
	REVERSE	miswired sump pump (pump runs backwards)	prevent aqueous from returning to C-103, drain tank overflow	operations test procedure (OTP)	S1 (5-10)		
				separations enclosure provides containment			
				leak detection in sump			

Node Description: AQUEOUS RETURN LINE INCLUDING SUMP RECYCLE PUMP AQUEOUS DISCHARGE/PUMP BYPASS LINE, SUMP PUMPOUT LEG, AND ASSOCIATED VALVES AND INSTRUMENTS

PROCESS PARAMET	GUIDE WORD	CAUSES	CONSEQUENCES	SAFEGUARD	RANK	REMARK	RM#
FLOW (con't)	REVERSE	aqueous line filter return valve configured for flow to drain tank	drain tank filled with C-103 waste	drain tank high level shutdown interlock	S0		
PRESSURE	NO (atmospheric)	system down	process delay	planned event	S0		
		sump pump failure	see "NO FLOW" above	see "NO FLOW" above	---		
		aqueous return line pluggage	see "NO FLOW" above	see "NO FLOW" above	---		
		aqueous return line valve closed	see "NO FLOW" above	see "NO FLOW" above	---		
		aqueous return line ruptured/severed	see "NO FLOW" above	see "NO FLOW" above	---		
	LOW	see "LOW FLOW" above	see "LOW FLOW" above	see "LOW FLOW" above	---		
	HIGH	aqueous return line pluggage	see "NO FLOW" above	see "NO FLOW" above	---		
		aqueous return line valve closed	see "NO FLOW" above	see "NO FLOW" above	---		
		sump pump overspeed	see "HIGH FLOW" above	see "HIGH FLOW" above	---		
	REVERSE (vacuum)	none of concern identified	no of concern identified	N/A	N/A		
TEMPERATURE	NO (freezing)	cold weather	freezing of liquid in pipe (due to cooling between batches) (fracture of lines)	double encased line line gravity drains to C-103	S1 (S-11)	thermal protection may be advisable	R15
			thermal shock (hot liquid entering cold piping)	double encased line	S1 (S-12)		
			line fracture due to freezing	aqueous is warmed in coalescer, keeps line warm double encased lines	S1 (S-13)		
	HIGH	water hammer due to rapid condensation of hot vapor	aqueous return line leak or rupture	double encased line	S1 (S-14)	team cannot identify a sufficient heat source in the system	R16
AGITATION	MORE/HIGH	excessive agitation from aqueous return distrubs organic liquid surface in C-103	skimmer picks up aqueous emulsions (possible aqueous to truck)	sump pump only provides 3 gpm of flow, which team believes to be insufficient to disturb skimmer function	S1 (S-15)		
REACTION	LOW/SLOW	corrosion of aqueous return line piping	leak from line	short mission time minimizes corrosion	S1 (S-16)		

Node Description: AQUEOUS RETURN LINE INCLUDING SUMP RECYCLE PUMP, AQUEOUS DISCHARGE/PUMP BYPASS LINE, SUMP PUMPOUT LEG, AND ASSOCIATED VALVES AND INSTRUMENTS

OCESS PARAMET	GUIDE WORD	CAUSES	CONSEQUENCES	SAFEGUARD	RANK	REMARK	RM#
REACTION (con't)	LOW/SLOW	corrosion of aqueous return line piping	leak from line	double encased line			
	HIGH/FAST	seals in place are incompatible with organic. seal dissolves when exposed to organic in aqueous return line	leak	separations enclosure provides containment double encased line administrative control prevents incompatibility situation (material compatibility list)	S1 (5-17)	team feels this event is highly unlikely	R17
SPECIAL	NO (utility failure)	loss of power to project site	sump pump stops (process delay)	line gravity drains to C-103	SO		
		loss of computer control	no issues identified	N/A	N/A		
OTHER THAN (startup, shutdown, maintenance)	OTHER THAN (startup, shutdown, maintance)	line dropped in C-103 during installation	process delay	administrative controls on installation pipe flange wider than riser and will not allow pipe to fall into tank unless weld fails	SO		
		Decontamination and Decommisioning	exposure of personnel	Admin controls (anticipated event) PPE	S1 (5-18)	spray ring on encasement might be helful for O&D	R18
		damage to line during installation (bending, braking, etc.)	process delay	admin controls on installation	SO		
		line not flushed prior to removal	exposure of personnel	admin controls on O&D	S1 (5-19)		
		repair of damaged sump pump	exposure of personnel	short mission time minimizes probability of failure pump selected to be maintenance free for intented purpose	S1 (5-20)		
		industrial incidents	personnel injuries	prejob planning training correct tools and equipment admin controls on operations	S1 (5-21)		

Project: C-103 Organic Layer Removal and Seperation WHC-SD-WM-PLN-093-0 Rev 0		Node: 006 Page: 1
	Date: 06/24/94	Time: 11:31:41
	Session:	Team: (see below)
Node Description: COALESCER, INCLUDING INTERFACE CONTROL INSTRUMENTATION AND OTHER INSTRUMENTATION	Leader: MFR	Recorder: MP
	Organization:	
	Location: me	
	P&ID's:	Rev #'s:
Design Intention: SEPARATION OF ORGANIC AND AQUEOUS PHASES OF C-103 ORGANIC LAYER WASTE	#X	0
Team Members:		

Node Description: COALESCER, INCLUDING INTERFACE CONTROL INSTRUMENTATION AND OTHER INSTRUMENTATION

ROCESS PARAMETI	GUIDE WORD	CAUSES	CONSEQUENCES	SAFEGUARD	RANK	REMARK	RM#
PRESSURE	NO (atmosphric press.)	system down	process delay	anticipated event	SO		
		inlet valve closed	possible skimmer pump damage	Administrative control for valving	SO		
				pressure limiting switch?			
			process delay				
		inlet fluid misrouted to flush connection	release/fire?	multiple valves isolate flush line, quick-connect valve prevents leakage	S1/S2 (6-01)		
	LESS/LOW	both aqueous and organic discharge valves wide open	Process delay	interface control over discharge valves	SO		
			possible loss of interface(aqueous to truck)(organic to tank)	radiation detection on organic discharge line	S1 (6-02)		
		filters plugged	see "NO FLOW" node 2	see "NO FLOW" node 2	---		
		line leak/rupture	see "NO FLOW" node 2	see "NO FLOW" node 2	---		
		skimmer pump failure	see "NO FLOW" node 2	see "NO FLOW" node 2	---		
		inlet line valve closed	see "NO FLOW" node 2	see "NO FLOW" node 2	---		
		fill-up during start up	None of concern identified	anticipated event	N/A		
		leak from coalescer	release/fire	seperation enclosure provides containment	S1/S2 (6-03)		
				sump leak detection			
				sump pump			
				lack of ignition sources in enclosure			
		inlet valve only partially open	change in interface level, possible aqueous to truck	Administrative controls on valving configuration	S1 (6-04)		
				inlet flow indicator			
	MORE/HIGH	both outlet valves closed or nearly closed (possible interface control failure)	process delay	flow element on aqueous discharge line	SO		
			potential skimmer pump damage due to deadhead	hydraulic pressure interlock shuts down skimmer pump on high pressure	SO		
			rupture seals-release/fire (in the event of skimmer pump overspeed)	separation enclosure provides containment	S1/S2 (6-05)		
				leak detection in sump			

Node Description: COALESCER, INCLUDING INTERFACE CONTROL INSTRUMENTATION AND OTHER INSTRUMENTATION

PROCESS PARAMET	GUIDE WORD	CAUSES	CONSEQUENCES	SAFEGUARD	RANK	REMARK	RM#
PRESSURE (con't)	MORE/HIGH	both outlet valves closed or nearly closed (possible interface control failure)	rupture seals-release/fire (in the event of skimmer pump overspeed)	sump pump			
		plugging of coalescer media	process delay	coalescer sized to handle much greater flow volume than used in process filters remove particulates upstream of coalescer	S0		
			potential skimmer pump damage due to deadhead	skimmer pump hydraulic motor overpressure shutoff interlock	S0		
			release-seal rupture (in the event of skimmer pump overspeed)	separations enclosure provides containment sump provided with pump and leak detection	S1/S2 (6-06)		
			interface change-possible aqueous transfer to truck	interface monitored radiation detection on organic discharge line	S1 (6-07)		
		skimmer pump overspeed	drain tank pump overcome by volume of aqueous from coalescer - eventual drain tank overflow through HEPA filter	separations enclosure provides containment sump equipped leak detection Hi-Hi drain tank alarm	S1/S2 (6-08)	find out if interface is changed by maximum skimmer pump overrun	R19
		addition of flush water during operation	same as skimmer pump overspeed	Hi-hi drain tank alarm administrative controls on valving configuration	S1/S2 (6-09)		
			interface change-aqueous sent to truck	radiation detection on organic discharge line	S1 (6-10)		
		overfill of drain tank	release	hi-hi drain tank alarm drain tank pump activates automatically on high level	S1/S2 (6-11)		

Node Description: COALESCER, INCLUDING INTERFACE CONTROL INSTRUMENTATION AND OTHER INSTRUMENTATION

PROCESS PARAMET	GUIDE WORD	CAUSES	CONSEQUENCES	SAFEGUARD	RANK	REMARK	RM#
PRESSURE (con't)	MORE/HIGH	overfill of drain tank	release	separations enclosure provides containment leak detection in sump			
	REVERSE (vacumn)	None of concern identified	None of concern identified	N/A	N/A		
TEMPERATURE	NO (freezing)	thermal shock (hot liquid into cold vessel)	potential vessel damage(release)	heat trace on coalescer warms liquid waste and keeps vessel heated	S1/S2 (6-12)	thermal calculations might need to be performed	R20
			spray release	separations enclosure provides containment	S2 (6-13)		
		embrittlement of flange gaskets	release/fire, possible spray release	heat trace on coalescer warms liquid waste and keeps vessel heated waste is already warm coming from C-103 separations enclosure provides containment leak detection and pump in sump	S1/S2 (6-14)		
		possible break due to embrittlement	same as embrittlement of gaskets	same as embrittlement of gaskets	S1/S2 (6-15)		
	LESS/LOW (<40 C)	Heat trace failure on coalescer	diminished organic/ aqueous separation capability, aqueous sent to truck	coalsecer temp monitored in control trailer	S1 (6-16)		
			possible changing of interface or organic content (more viscous) aqueous sent to truck	radiation detection on organic discharge line	S1 (6-17)		
	MORE/HIGH	Heat trace setpoint too high	process delay	administative control on setting of setpoints	S0		
		heat trace overheat (high current)	see REMARKS	ground fault interrupter prevents high current heating elements burnout at pre-set temp	S0	some attention to consequences of coalescer heat trace overheat may be necessary	R21

Node Description: COALESCER, INCLUDING INTERFACE CONTROL INSTRUMENTATION AND OTHER INSTRUMENTATION

PROCESS PARAMET	GUIDE WORD	CAUSES	CONSEQUENCES	SAFEGUARD	RANK	REMARK	RM#
SPECIAL (con't)	OTHER THAN (startup, shutdown, maintnance)	contamination during D&D	personnel exposure	administrative controls on D&D	S1 (6-35)		
				PPE			
		repair of failed instruments	personnel exposure	administrative controls on D&D	S1 (6-36)		
				PPE			
		vessel not empty during D&D (aqueous spill)	personnel exposure	admininstrative controls on D&D	S1 (6-37)		
				PPE			
COMPOSITION	AS WELL AS	26% unknown compounds in organic	potential damage to gaskets or ccalescer vessel due to corrosion (leak and release)	administrative controls on procurement of gaskets and coalescer (corrosion resistant)	S1/S2 (6-38)		

Node Description: COALESCER, INCLUDING INTERFACE CONTROL INSTRUMENTATION AND OTHER INSTRUMENTATION

PROCESS PARAMET	GUIDE WORD	CAUSES	CONSEQUENCES	SAFEGUARD	RANK	REMARK	RM#
LEVEL (con't)		water added thru flush connection during system operation	aqueous to truck	administrative controls on flush procedures	S1 (6-26)		
AGITATION	MORE/HIGH	coalescer media plugged, reduces separation capabilities	aqueous to truck	redundant filters prevent solids from entering coalescer	S1 (6-27)		
		low temperature increases waste viscosity, reduces separation capabilities	aqueous to truck	coalescer heat traced to keep waste at high temperature	S1 (6-28)		
		damage to coalescer fibers reduces separation capabilities	aqueous to truck	coalescer designed to handle larger process volume than required	S1 (6-29)		
		high flow through coalescer sustains emulsions	aqueous to truck	flow element at coalescer inlet	S1 (6-30)		
		switching filter banks results in air in liquid causing bubbling, sustains emulsions	emulsions of aqueous formed in organic, aqueous to truck	none	S1 (6-31)	find out if filters filled with liquid when on standby	R23
	AS WELL AS (foaming)	see REMARKS	potential plugging of the coalescer, release of aqueous to the truck	see REMARKS	S1 (6-32)	some examination of the potential of foaming in the coalescer might be needed	R24
REACTION	LESS/LOW	corrosion, rust	leak, release/fire	short operating life prevents long-term corrosion effects administrative controls on procurement with regard to compatibility issues	S1/S2 (6-33)		
	MORE/HIGH	none of concern identified	none of concern identified	N/A	N/A		
SPECIAL	NO (loss of utilities)	loss of power	aqueous discharge valve fails open, coalescer contents drain to drain tank (no effect)	discharge valves fail in safe position	S0		
		loss of computer	potential level interface upset (because of loss of monitoring), possible aqueous to tanker truck	system shuts down on loss of computer	S1 (6-34)	verify that system shuts down on loss of computer	R25

Node Description: COALESCER, INCLUDING INTERFACE CONTROL INSTRUMENTATION AND OTHER INSTRUMENTATION

PROCESS PARAMET	GUIDE WORD	CAUSES	CONSEQUENCES	SAFEGUARD	RANK	REMARK	RM#
LEVEL (con't)	LESS/LOW	line plug	send coalescer contents back to C-103 thru drain tank	see "NO FLOW" node 2	S0		
		skimmer failure	send coalescer contents back to C-103 thru drain tank	see "NO FLOW" node 2	S0		
	MORE/HIGH	No issues of concern	No issues of concern	N/A	N/A	Coalescer operates at full capacity, so high level is meaningless	R22
	PART OF (low interface)	aqueous outlet valve opens wide (loss of interface control)	send organic back to tank	level interface monitored administrative control	S0		
		organic outlet valve closed (loss of interface)	send organic back to tank	level interface monitored	S0		
		leak in lower part of coalescer	release	separation enclosure provides containment leak detection and pumpout capabilities in sump	S1 (6-22)		
	AS WELL AS (high interface)	aqueous outlet valve closes (loss of interface control)	aqueous to truck	interface monitored aqueous discharge valve fails in open position to allow gravity drain to drain tank radiation detection on organic discharge line	S1 (6-23)		
		organic outlet valve opens wide (loss of interface)	aqueous to truck	interface monitored radiation detection on organic discharge line	S1 (6-24)		
		leak in upper part of coalescer	release/fire, aqueous to truck	interface monitored coalescer made of steel, capable of withstanding high pressures pressure testing of coalescer prior to operation	S1/S2 (6-25)		

Node Description: COALESCER, INCLUDING INTERFACE CONTROL INSTRUMENTATION AND OTHER INSTRUMENTATION

PROCESS PARAMET	GUIDE WORD	CAUSES	CONSEQUENCES	SAFEGUARD	RANK	REMARK	RM#
TEMPERATURE (con't)	MORE/HIGH	fire in enclosure (pooled organic)	possible airborne release, equipment damage, possible damage to separations enclosure, potential for larger fire if organic contents of coalescer ignited	no ignition of liquid at < 280 F few or no ignition sources in separations enclosure separations enclosure is made of heavy steel and provides containment of fire	S2 (6-18)		
		fire in enclosure (electical)	no effect on coalescer integrity, process delay	non-sparking, sealed pump motor little fuel for fire available large heat capacity of filled coalescer	S1 (6-19)		
		Hot weather	heat hazard to maintance personnel	administrative controls on work in hot weather	S1 (6-20)		
LEVEL	NO	Large leak/rupture from coalescer	release/fire	see: FIRE IN ENCLOSURE (POOLED ORGANIC), above coalescer capable of withstanding high pressures	S1/S2 (6-21)		
		inlet valve closed	see "NO FLOW" node 2	see "NO FLOW" node 2	---		
		skimmer pump failure	see "NO FLOW" node 2	see "NO FLOW" node 2	---		
		system shut down	none of concern identified	N/A	N/A		
		inlet line ruptured or severed	see "NO FLOW" node 2	see "NO FLOW" node 2	---		
		inlet liquid misrouting	see "NO FLOW" node 2	see "NO FLOW" node 2	S0		
	LESS/LOW	aqueous outlet valve wide open (interface control failure)	send coalescer contents back to C-103 thru drain tank	level interface monitored	S0		
		inlet partially closed	send coalescer contents back to C-103 thru drain tank	flow indicator on inlet line	S0		
		inlet line leak or rupture	send coalescer contents back to C-103 thru drain tank	see "NO FLOW" node 2	S0		
		filter plug	send coalescer contents back to C-103 thru drain tank	see "NO FLOW" node 2	S0		

Project: C-103 Organic Layer Removal and Seperation WHC-SD-WM-PLN-092 Rev.0	Revision: 0	Node: 007 Page: 1
	Date: 07/29/94	Time: 08:08:51
	Session: 1	Team: (see below)
Node Description: VENT SYSTEM INCLUDING VENT LINES TO C-103 PUMP/SKIMMER RISER, SEPARATION ENCLOSURE, TANKER TRAILER, TANKER TRAILER VACUUM BREAKER, HEPA FILTERS, CHARCOAL FILTERS, AND BUTTERFLY VALVES	Leader: MFR	Recorder: MP
	Organization: Risk Management	
	Location: 450 Hills	
Design Intention: PASSIVE VENTILATION OF SYSTEM AND ITS COMPONENTS. FILTERING OF AIRBORNE CONTAMINANTS FROM SYSTEM VENTILATION	P&ID's: #X	Rev #'s: 0
Team Members:		

ode Description: VENT SYSTEM INCLUDING VENT LINES TO C-103 PUMP/SKIMMER RISER, SEPARATION ENCLOSURE, TANKER TRAILER, NKER TRAILER VACUUM BREAKER, HEPA FILTERS, CHARCOAL FILTERS, AND BUTTERFLY VALVES

PROCESS PARAMET	GUIDE WORD	CAUSES	CONSEQUENCES	SAFEGUARD	RANK	REMARK	RM#
FLOW	NO/LOW	butterfly valve on truck line closed or HEPA plugged	deadhead organic discharge line, potential skimmer pump damage	interface control shuts down skimmer pump on +or- 5% deviation	S0	pressure indicator on trailer tank would alert operators to this situation	R26
						HEPAs plug very infrequently	R27
				administrative controls on valve configuration			
		separation enclosure ventilation outlet plugged	no consequences of concern identified	N/A	N/A		
		C-103 HEPA filter(s) plug	eventual deadhead of organic line to truck, potential skimmer pump damage, organic/aqueous interface upset	interface control shuts down skimmer pump on + or - 5% deviation	S1 (7-01)	pressure indicator on trailer tank would alert operators to this situation	R28
		charcoal filters plugged	same as HEPA plug, above	same as HEPA plug, above	S1 (7-02)		
		C-103 Butterfly valve closed	same as HEPA plug, above	same as HEPA plug, above	S1 (7-03)		
		passive ventilation results in low flow	no consequences of concern	anticipated event	S0		
	HIGH	fire in tank or seperation enclosure	high air flow is of no consequence, fires discussed elsewhere	N/A	S0		
		vacuum breaker open during organic line drainback in addition to butterfly valve open	high volume backflow through the HEPAs (probably no effect on HEPAs)	administrative controls on valving configurations	S0		
	AS WELL AS	spray leak in seperation enclosure creates aerosol	release of airborne contaminants, potential HEPA damage	system runs at low pressure(difficult to cause spray release)	S2 (7-04)		
				redundant HEPA filters			
				leak detection in separation enclosure sump			
				seperation enclosure provided containment			
		toxic vapors	personnel injuries	charcoal filters	S1 (7-05)		
				administrative controls on entry to C-103 area (PPE)			

Node Description: VENT SYSTEM INCLUDING VENT LINES TO C-103 PUMP/SKIMMER RISER, SEPARATION ENCLOSURE, TANKER TRAILER, TANKER TRAILER VACUUM BREAKER, HEPA FILTERS, CHARCOAL FILTERS, AND BUTTERFLY VALVES

PROCESS PARAMET	GUIDE WORD	CAUSES	CONSEQUENCES	SAFEGUARD	RANK	REMARK	RM#
FLOW (con't)	AS WELL AS	fire in tank truck	release of airborne contaminants	ignition temperature of organic is from 400 to 1200 degres F lack of ignition sources in truck	S2 (7-06)		
		fire in C-103	release of airborne contaminants	ignition temperature of organic is 400 to 1200 degrees F lack of ignition sources in C-103	S3 (7-07)		
		fire releases volatized organics	release of airborne contaminants	HEPAs fire unlikely in C-103	S2 (7-08)		
		misdirection of airflow	no consequences	system is passively ventilated	N/A		
	OTHER THAN	truck overfill	liquid waste in vent lines, potential HEPA damage, potential release	vent lines dump back into C-103 prior to release to atmosphere vent outlet filtered by reduntant HEPAs	S1 (7-09)		
		leak in seperation enclosure	liquid waste in vent lines, potential HEPA damage, potential release	vent lines dump back into C-103 prior to release to atmosphere leak detection in separation enclosure sump vent outlet filtered by redundant HEPAs	S1 (7-10)		
	REVERSE	vacuum line open during organic line drainback in addition to top butterfly valve open	backflow of airspace draws from C-103 contaminates downstream side of HEPAs (resulting in release when normal flow is restored)	vent outlet filtered by redundant HEPAs administrative controls on valve configuring	S0 S1 (7-11)		
PRESSURE	NO (atmospheric pressure)	planned operating status	no consequences	anticipated	N/A	because system is passivly ventilated no low pressure situation can be identified	R29
	LOW	none of concern identified	none of concern identified	N/A	N/A		
	HIGH	see 'NO FLOW'	see 'NO FLOW'	see 'NO FLOW'	---		
	REVERSE	see 'REVERSE FLOW'	see 'REVERSE FLOW'	see 'REVERSE FLOW'	---		

Node Description: VENT SYSTEM INCLUDING VENT LINES TO C-103 PUMP/SKIMMER RISER, SEPARATION ENCLOSURE, TANKER TRAILER, TANKER TRAILER VACUUM BREAKER, HEPA FILTERS, CHARCOAL FILTERS, AND BUTTERFLY VALVES

PROCESS PARAMETER	GUIDE WORD	CAUSES	CONSEQUENCES	SAFEGUARD	RANK	REMARK	RM#
TEMPERATURE	NO/LOW	cold weather	none of concern identified	N/A	S0		
	HIGH	hot weather	none of concern identified	N/A	---		
		external fire	potential HEPA damage, potential release	redundant HEPAs	S2 (7-12)		
REACTION	LOW	corrosion	release of airborne contaminants	lines are stainless steel	S2 (7-13)		
				short operating life minimizes corrosion time			
				redundant HEPAs prevent contaminants from entering the line			
				passive ventilation would provide slow corrosion environment			
SPECIAL	NO (utility failure)	none of concern identified	none of concern identified	N/A	N/A		
	OTHER THAN	failure to open butterfly valves	see 'NO FLOW'	see 'NO FLOW'	---		
		failure to close vacumn breaker	organic flow through vent line - return to truck, increased exposure from vent lines	administrative controls on valve configuring	S1 (7-14)		
		truck rolls forward or backward damaging vent lines	potential release	truck wheels blocked	S2 (7-15)	flex hose could help prevent a possible problem	R30
		worker exposure from HEPAs during D & D	personel hazard	administrative controls on D&D	S1 (7-16)		
		improper welds flange connection, or seals around HEPAs result in airborne release of contaminants	minor release	administrative controls on fabrication and installation (ATPs)	S1 (7-17)		
				redundant HEPAs			

Project: C-103 Organic Layer Removal and Seperation	Node: 008	Page: 1
	Date: 06/28/94	Time: 09:39:11
	Session: 1	Team: (see below)
Node Description: SEPARATION ENCLOSURE STRUCTURE	Leader: MFR	Recorder: MP
	Organization: Risk Management	
	Location: 450 Hills	
	P&ID's:	Rev #'s:
Design Intention: COVERING OF SYSTEM EQUIPMENT, SHIELDING FROM PROCESSING WASTE DIRECT RADIATION, CONTAINMENT OF WASTE IN THE EVENT OF A PROCESS LEAK	#X	0

Team Members:

de Description: SEPARATION ENCLOSURE STRUCTURE

PROCESS PARAMET	GUIDE WORD	CAUSES	CONSEQUENCES	SAFEGUARD	RANK	REMARK	RM#
PRESSURE	NO (at atmospheric pressure)	no issues of concern identified	no issues of concern identified	enclosure at atmospheric pressure	N/A	passive breathing enclosure	R31
	LESS/LOW	no issues of concern identified	no issues of concern identified	process systems self-contained	N/A		
	MORE/HIGH	no issues of concern identified	no issues of concern identified	process systems self-contained	N/A		
	REVERSE (vacuum)	no issues of concern identified	no issues of concern identified	process systems self-contained	N/A		
TEMPERATURE	NO	cold weather	no issues of concern identified:	enclosure structure heavy steel and not susceptible to cold weather	N/A		
	MORE/HIGH	hot weather	no issues of concern identified	enclosure structure heavy steel and not susceptible to cold weather	N/A		
LEVEL	NO	no issues of concern	no issues of concern	N/A	N/A		
	LESS/LOW	incidental system leaks	small release to enviroment	enclosure structure provides containment leak detection pumpable sump	S1 (8-01)		
	MORE/HIGH	rupture of pipe or other equipment resulting in major leak that overcomes sump pump capability	large release/fire	large liquid leaks would drain back to C-103 via aqueous return line encasement to the center pump pit leak detection interlocked to skimmer pump to shutdown operation upon leak detection separation enclosure provides containment leak detection in sump liquids would be pumped out to C-103 at max. of 3 gpm	S1/S2 (8-02)		
		flushing of interior of enclosure	no issues of concern identified	N/A	N/A	spraying of enclosure is a planned event	R32
AGITATION	AS WELL AS	no issues of concern identified	no issues of concern identified	N/A	N/A		
REACTION	NO	no issues of concern identified	no issues of concern identified		N/A		

Node Description: SEPARATION ENCLOSURE STRUCTURE

PROCESS PARAMET	GUIDE WORD	CAUSES	CONSEQUENCES	SAFEGUARD	RANK	REMARK	RM#
REACTION (con't)	LESS/LOW	corrosion	degradation of structure, possible release	short mission time of project	S1 (8-03)		
				thick enclosure walls			
				completely sealed welds			
	MORE/HIGH	no issues of concern	no issues of concern	N/A	N/A		
SPECIAL	NO (Utility Failure)	loss of leak detection	loss of indication of leak, no effect without leak	see remarks	---	on loss of electricity will leak detection fail safe? (i.e., leak detected and skimmer pump shuts off)	R33
	OTHER THAN (startup, shutdown, maintance)	separations enclosure weight exceeds tank dome weight limitations	dome damage, C-103 breach	enclosure will be located just off the tank dome	S3 (8-04)		
		separation enclosure dropped while being lifted with crane	potential dome damage, C-103 breach	critical lift procedures will be followed	S3 (8-05)		
			potential personnel injury				
		organic and aqueous line connected incorrectly	C-103 waste enters separations enclosure where aqueous is intened to exit. Rapid overflow of drain tank.	startup testing	S1 (8-06)		
				Operations test procedures			
				Operational readiness review			
				separations enclosure provides containment			
				leak detection in sump			
			process delay				
		heavy equipment on tank dome area	dome damage, C-103 breach	administrative controls prevent heavy equipment from resting on dome	S3 (8-07)		
		insuffiencient flushing of separations enclosure piping during D&D	leak of waste to enviroment	admin controls	S1 (8-08)		
				prejob planning			
			exposure of personnel				

A T T A C H M E N T

HAZOP CHECKLIST

ADJACENT FACILITIES HAZARDS CHECKLIST

What hazards do adjacent facilities (e.g., units, highways, railroads, underground pipelines) pose to personnel or equipment in the unit from:

1. toxic, corrosive, or flammable sprays, fumes, mists, or vapors?
   None.
2. overpressure from explosions?
   None.
3. thermal radiation from fires (including flares)?
   Nothing close enough to threaten system.
4. contamination?
   Entire C-farm area somewhat contaminated. An anticipated hazard.
5. noise?
   N/A
6. contamination of utilities (e.g., potable water, breathing air, sewers)?
   N/A
7. impacts (e.g., airplane crashes, derailments, turbine blade fragments)
   Nearby air compressor building contains air receiver tank that could damage system in the event of an explosion.
8. flooding (e.g., ruptured storage tank, plugged sewer)
   No flood sources of concern.

EXTERNAL FORCE HAZARDS CHECKLIST

What external forces could affect the site? Consider:

1. high winds (e.g., hurricanes, typhoons, tornadoes).
   Enclosure is very heavy and immune to high winds. Control trailer could sustain damage. External HEPAs could be plugged.
2. earth movement (e.g., earthquakes, landslides, sink holes, settling, freeze/thaw heaving, coastal/levee erosion).
   Earthquakes could damage system though release would be local. Probability and consequence unknown.
3. snow/ice (e.g., heavy accumulation, falling icicles, avalanches, hail, ice glaze).
   Covered in HAZOP tables.
4. utility failures from outside sources.
   Covered in HAZOP tables.
5. releases from adjacent plants.
   Potential release hazards from 242-A Evaporator nearby in the event of a major accident.
6. sabotage/terrorism/war.
   Considered a greater threat in themselves than their effects on system.
7. airborne particulates (e.g., pollen, seeds, volcanic dust, dust storm).
   Potential plugging of external HEPAs.
8. natural fires (e.g., forest fires, grass fires, volcanism).
   Considered in HAZOP tables.
9. extreme temperatures (causing, for example, brittle fracture of steel).
   No effect.
10. flooding (e.g., hurricane surge, seiche, broken dam or levee, high waves, intense precipitation, spring thaw).
    No significant flooding sources identified.

11. lightning.
    Could damage system. Some study may be needed.
12. drought (causing, for example, low water levels or poor grounding).
    No effect.
13. meteorite.
    Considered an incredible event.
14. fog.
    No effect.

LOSS OF CONTAINMENT (LOC) HAZARDS CHECKLIST

1. "Open-end" route to atmosphere due to genuine process relief or dumping requirements.
   NONE

2. "Open-end" route to atmosphere due to maloperation of equipment in service.
   ONLY IF FLUSH CONNECTION VALVE STUCK OPEN

3. "Open-end" route to atmosphere due to operator error.
   SAMPLING ERROR CONTAMINATES PERSONNEL

4. Containment failure under design operating conditions due to equipment being inadequately designed for the proposed duty (material, pressure, temperature specification).
   INSTALLATION OF WRONG SEALS, INCOMPATIBLE WITH ORGANIC

5. Containment failure due to defects arising during manufacture of equipment.
   TRUCK TANK LINE WELDS

6. Containment failure due to damage or deterioration of equipment during transit or during storage.
   DAMAGE TO PUMPS (SKIMMER AND SUMP) BUT BOTH STILL ENCLOSED

7. Containment failure due to defects arising during construction.
   SHOULD BE FOUND DURING OTPs

8. Normal wear and tear causing deterioration of equipment and eventual LOC (e.g., pump or agitator seals, valve packings, flange gaskets, etc.).
   ALL CONTAINMENT IS DOUBLE-CONTAINED

9. Internal and/or external corrosion (including stress corrosion cracking) not detected before it causes LOC.
   SHOULD BE MINIMIZED BY TESTING AND SHORT OPERATING LIFE

10. Erosion or thinning not detected before causing LOC.
    SHOULD BE MINIMIZED BY SHORT OPERATING LIFE, LOW PRESSURE AND FLOW IN SYSTEM, AND SMALL, MINIMAL PARTICULATES

11. Metal fatigue or vibration not detected before causing LOC.
    SHOULD BE MINIMIZED BY SHORT OPERATING LIFE

12. Previous periods of gross maloperation not detected which causes LOC.
N/A

13. Hydrogen embrittlement not detected before it causes LOC.
N/A

14. Pipe or equipment stress caused by steady or cycling high temperature service.
SYSTEM TEMPERATURES RELATIVELY LOW

15. Routine maintenance or minor modifications not carried out correctly which leads to LOC.
NO ROUTINE MAINTENANCE EXPECTED

16. LOC caused by impact damage, i.e., by cranes, vehicles, forklifts, etc.
CRANE, DRYWELL VAN. SHOULD BE MINIMIZED BY RUGGED STRUCTURE OF SEPARATION ENCLOSURE

17. Accumulation and ignition of flammable mixtures from small process leaks leading to confined explosion and equipment damage.
FLASH POINT OF ORGANIC IS VERY HIGH

18. Equipment damage due to settlement of structural supports due to geological, climatic, or corrosion factors.
SHOULD BE MINIMIZED BY SHORT OPERATING LIFE. NO STRUCTURAL SUPPORTS.

19. Damage to tank trucks, railcars, containers, etc. during transport of material on or off-site.
SHORT TRAVELLING DISTANCE (2 MILES) WITH EXTENSIVE CONTROL OVER TRAVEL ROUTE (ON SITE). TANK BUILT TO DOT 51 REQUIREMENTS.

20. Overpressuring of equipment due to connected pressure sources breaking through into low pressure equipment (e.g., pressure or level controller failure, isolation valve left open, etc.).
ALL EQUIPMENT RELATIVELY LOW PRESSURE

21. Overpressuring of equipment due to pressurized backflow into low pressure equipment (e.g., due to compressor failure).
ALL EQUIPMENT RELATIVELY LOW PRESSURE

22. Overpressuring of equipment due to a liquid pressure source pumping blocked in gas spaces.
DISCUSSED IN HAZOP NODES

23. Overpressuring of equipment due to hydraulic overpressuring due to a blocked-in condition downstream.
DISCUSSED IN HAZOP NODES

24. Equipment failure caused by excessive surge or hammer due to sudden valve closure in liquid transfer lines.
RELATIVELY LOW SYSTEM PRESSURE AND FLOW

25. Equipment failure due to rising process temperature caused by loss of coolant flow.
NO COOLING SYSTEMS. RELATIVELY LOW SYSTEM TEMPERATURES

26. Equipment failure due to rising process temperature caused by elevated coolant temperature.
NO COOLING SYSTEMS. RELATIVELY LOW SYSTEM TEMPERATURES

27. Equipment failure due to rising process temperature caused by fouling of coolers, condensers, or exchangers.
NO COOLING SYSTEMS. RELATIVELY LOW SYSTEM TEMPERATURES

28. Equipment failure due to high metal temperatures caused by flow rate or higher temperature of the hotter stream. Or, exchanger failure due to high metal temperature caused by higher temperature or lower flow of the colder stream.
N/A

29. Equipment failure due to excessive heat input caused by heater control failure.
DISCUSSED IN COALESCER NODE.

30. Equipment failure due to excessive heat input caused by flow of hot extraneous material.
N/A

31. Equipment failure due to reactor runaway causing excessive heat generation.
N/A

32. Equipment failure due to catalytic impurities causing excessive heat generation.
N/A

33. Equipment failure due to exothermic heat generation from mixing of incompatible chemicals.
CHARACTERIZATION SHOWS NO INCOMPATIBILITIES

34. Equipment failure due to exothermic heat generation from decomposition of thermally unstable or explosive materials, iron sulfide, etc.
NONE

35. Internal explosions caused by presence of air in equipment.
NONE

36. Internal explosions caused by loss of critical inert diluents, blankets, or solids conveying materials.
NONE

37. Internal explosions caused by loss of explosion suppressants.
NONE

38. Internal explosions caused by flammable excursions in oxidation processes.
N/A

39. Equipment failure due to expansions upon change of state (freezing).
DISCUSSED IN NODES

40. Equipment failure due to thermal expansion of blocked in liquids.
NO BLOCKED IN LIQUIDS

41. Equipment failure due to entrance of extraneous phases (e.g., compressor failure due to liquid carry-through, condensate hammers).
NO EXTRANEOUS PHASES

42. Underpressuring of equipment caused by direct connection of an ejector or to equipment running under vacuum.
DISCUSSED IN NODES

43. Underpressuring of equipment caused by equipment malfunction (e.g., loss of liquid seal due to a failure of a level controller causing vacuum to be applied upstream).
DISCUSSED IN NODES

44. Underpressuring of equipment caused by pumping out of tanks or vessels.
ALL VESSELS PASSIVELY VENTILATED

45. Underpressuring of equipment caused by emptying or draining elevated blocked-in equipment under gravity.
ONLY IN TRUCK LIQUID LINE. VACUUM BREAKER PRESENT

46. Underpressuring of equipment caused by condensation or condensable vapors (e.g., vessel blocked-in after steaming).
N/A

47. Underpressuring of equipment caused by cooling of non-condensable vapors (e.g., storage tank failure during heavy rainfall in summer).
N/A

48. Underpressuring of equipment due to solubility effects (e.g., dissolution of gases in liquids).
N/A

49. High metal temperature causing loss of strength due to fire under equipment.
DISCUSSED IN HAZOP NODES

50. High metal temperature causing loss of strength due to flame impingement.
DISCUSSED IN HAZOP NODES

51. High metal temperature causing loss of strength due to overheating of electric heaters.
ELECTRIC HEATERS ARE LOW POWER

52. High metal temperature causing loss of strength due to inadequate flow of fluid via heated equipment (e.g., furnace tube failure on loss of hot oil flow.)
N/A

53. Low metal temperature causing cold embrittlement and overstressing due to overcooling by refrigeration units.
N/A

54. Low metal temperature causing cold embrittlement and overstressing due to incomplete vaporization and/or inadequate heating of refrigerated material before transfer into equipment.
N/A

55. Low metal temperature causing cold embrittlement and overstressing due to loss of system pressure on unit handling liquids of low boiling point.
N/A

56. Low ambient temperatures causing equipment failure during start-up or initial pressurization.
DISCUSSED IN HAZOP NODES

57. Variations in stream compositions causing accelerated corrosion, chemical attack of seals or gaskets, stress corrosion cracking, embrittlement, etc.
DISCUSSED IN HAZOP NODES

58. Abnormal impurities in raw materials or wrong raw materials causing accelerated corrosion, chemical attack of seals or gaskets, stress corrosion cracking, embrittlement, etc.
DISCUSSED IN HAZOP NODES

59. By-products of abnormal chemical reactions causing accelerated corrosion, chemical attack of seals or gaskets, stress corrosion cracking, embrittlement, etc.
N/A

60. Oxygen, chlorides, or other impurities remaining in equipment at start-up due to inadequate evacuation or decontamination which cause accelerated corrosion, chemical attack of seals or gaskets, stress corrosion cracking, embrittlement, etc.
N/A

61. Impurities entering the process from atmosphere, service connections, tube leaks, etc. causing accelerated corrosion, chemical attack of seals or gaskets, stress corrosion cracking, embrittlement, etc.
N/A

APPENDIX 2
HAZARDS TABLE

EVNT	FREQ	P	O	F	FACTORS
1-01	REL 2	1	1	1	Flushes not anticipated to be necessary during operation Administrative controls on flush procedures, High-high level alarm/interlock on drain tank, Separations enclosure provides shielding and containment, Sump leak detection and pumpout
1-02	REL 1	1	1	1	HEPAs plug very infrequently (esp. w/low flow), Vacuum in tank probably insufficient to collapse HEPA, Redundant HEPAs in vent system would prevent airborne contaminants from reaching atmosphere, If vapors did escape, they would be low in volume (passive ventilation).
1-03	REL 1	1	1	1	Waste is warm out of coalescer, Enclosure kept warm by process, All lines gravity drain, Separations enclosure provides shielding and containment, Sump leak detection and pumpout
1-04	REL 1	1	1	1	Tank is structurally very strong (1" thick steel walls), Enclosure kept warm by process, Separations enclosure provides shielding and containment, Sump leak detection and pumpout
1-05	AIRBN 1	1	1	1	Control on heat trace electrical current Heat trace breaks at high temperature setpoint Enclosure vented through redundant HEPAs downstream in vent system, Separations enclosure provides shielding and containment, Sump leak detection and pumpout If vapors did escape, they would be low in volume (passive ventilation)

1-06	REL	1	1	1	1	Testing prior to operation Tank is structurally very strong (1" thick steel walls), Separations enclosure provides shielding and containment, Sump leak detection and pumpout
1-07	REL	1	1	1	1	Non-maintenance pump selected, Short operating life reduces chance of pump failure, High-high level alarm/interlock on drain tank, Separations enclosure provides shielding and containment, Sump leak detection
1-08	REL	1	1	1	1	Administrative controls on valve positioning, Short operating life reduces chance of valve failure, High-high level alarm/interlock on drain tank, Separations enclosure provides shielding and containment, Sump leak detection and pumpout
1-09	REL	1	1	1	1	Short operating life reduces chance of line plug, High-high level alarm/interlock on drain tank, Separations enclosure provides shielding and containment, Sump leak detection and pumpout
1-10	REL	1	1	1	1	Flushes not anticipated to be necessary during operation Administrative controls on flush procedures, High-high level alarm/interlock on drain tank, Separations enclosure provides shielding and containment, Sump leak detection and pumpout
1-11	REL	1	1	1	1	Tank is structurally very strong (1" thick steel walls), Short operating life prevents long term corrosion, Separations enclosure provides shielding and containment, Sump leak detection and pumpout
1-12						Call Larry DellaRocco

1-13	EXP 4	1	1	1	Anticipated event, Administrative controls over D&D, Personal Protective Equipment, Training
1-14	EXP 4	1	1	1	Anticipated event, Administrative controls over repairs, Personal Protective Equipment, Training
1-15	REL 3	1	1	1	Normal sump pump operation prevents aqueous build-up, Tank flushed before D&D, Administrative controls over D&D, Personal Protective Equipment, Training
1-16	REL 1	1	1	1	Tank is structurally very strong (1" thick steel walls) and corrosion resistant, Short operating life prevents long term corrosion, Separations enclosure provides shielding and containment, Sump leak detection and pumpout

EVNT	FREQ	P	O	F	FACTORS
2-01	REL 3 FIRE 2 SPRAY 3	1 1 1	1 1 1	1 3 2	External impact necessary to rupture lines (double encased), Administrative controls over heavy equipment near separation enclosure, Low personnel activity at C-103, Organic difficult to ignite
2-02	REL 3 FIRE 2 SPRAY 3				
2-03	EXP 3	1	1	1	Requires pump overspeed failure, Emulsion formation uncertain, Radiation detection on organic discharge line, Concrete shielding around truck tank,
2-04	EXP 3	1	1	2	Automatic interface control in coalescer, Radiation detection on organic discharge line, Concrete shielding around truck tank,
2-05	EXP 3	1	1	2	Automatic interface control in coalescer, Radiation detection on organic discharge line, Concrete shielding around truck tank,
2-06	REL 3 FIRE 2	1 1	1 1	1 3	External impact necessary to rupture lines (double encased), Administrative controls over heavy equipment near separation enclosure, Low personnel activity at C-103, Organic difficult to ignite, Lack of ignition source in surrounding area
2-07	REL 2 FIRE 1 SPRAY 1	1 1 1	1 1 1	1 3 2	Double encased lines, Gravity drain to C-103, Leak detection on pipe encasement drainback to C-103, Organic difficult to ignite, No ignition sources in or near lines, A small leak would provide little organic to burn in case of a fire,
2-08	REL 2 FIRE 1 SPRAY 2	1 1 1	1 1 1	2 4 2	Would require a misrouting to the flush connection, Isolation valve on flush connection would have to be opened, Quick-connect valve would prevent release, Organic difficult to ignite, No ignition sources near enclosure

2-09	REL 1	1	1	1	Administrative controls on valve config, Separations enclosure provides containment and shielding, Drain tank hi-level interlock/alarm, Sump leak detection and pumpout, Enclosure drains to C-103 via pipe annulus
2-10	REL 1 SPRAY 1	1 1	1 1	1 2	Requires pump overspeed failure, Skimmer pump hydraulic overpressure shutdown interlock, Separations enclosure provides containment and shielding, Sump leak detection and pumpout, Transfer lines double contained and gravity drain to C-103, Enclosure ventilated by redundant HEPAs to contain spray release,
2-11	REL 2 SPRAY 1	1 1	1 1	1 2	Waste from C-103 is thermally warm, Lines gravity drain to prevent liquid collection, Double encased transfer lines.
2-12	REL 2 SPRAY 1	1 1	1 1	1 2	Lines gravity drain to prevent liquid collection, Leak detection on pipe encasement drainback to C-103, Double encased transfer lines, Leak because of thermal shock would be small
2-13	EXP 2	1	1	2	Moving waste volume would keep temperature roughly constant, Level interface monitoring, Radiation detection on organic discharge, Concrete shielding around trailer tank
2-14	REL 2 FIRE 2 SPRAY 2	1 1 1	1 1 1	1 3 2	Lines would probably not be breached by external fire, Transfer lines double encased, Organic difficult to ignite, Lack of ignition sources within transfer lines, Minimal combustibles in area around enclosure, Separation enclosure provides containment shielding and fire protection
2-15	EXP 3	1	1	1	Emulsion creation uncertain, Radiation detection on organic discharge, Concrete shielding around trailer tank
2-16	EXP 3	1	1	1	Emulsion creation uncertain, Radiation detection on organic discharge, Concrete shielding around trailer tank

2-17	EXP 2	1	1	1	Redundant filters available, Emulsion creation uncertain, Radiation detection on organic discharge, Concrete shielding around trailer tank
2-18	EXP 3	1	1	1	Administrative controls on valving config, Emulsion creation uncertain, Radiation detection on organic discharge, Concrete shielding around trailer tank
2-19	REL 2 FIRE 1 SPRAY 2	1 1 1	1 1 1	1 3 2	Administrative controls on compatibility during procurement, Short operating life minimizes corrosion effects, Double encased lines, Lack of ignition sources around enclosure
2-20	REL 3	1	1	1	"Critical lift" administrative controls in effect
2-21	EXP 4	1	1	1	Anticipated event, Administrative controls over D&D, Personal Protective Equipment, Training
2-22	EXP 4	1	1	1	Repairs not expected in short operating life, Administrative controls over repairs, Personal Protective Equipment, Training

EVNT	FREQ	P	O	F	FACTORS
3-01	REL 3 FIRE 2 SPRAY 3	1 1 1	1 1 1	1 2 2	External impact necessary to rupture lines (double encased), Administrative controls over heavy equipment near separation enclosure, Low personnel activity at C-103, Organic difficult to ignite, Lack of ignition source in surrounding area
3-02	REL 2 FIRE 1 SPRAY 2	1 1 1	1 1 1	2 4 2	Isolation valve on flush connection would have to be opened, Quick-connect valve would prevent release, Organic difficult to ignite, No ignition sources near enclosure
3-03	EXP 3	1	1	1	Administrative controls over flush procedures, Flush operations not anticipated to be necessary
3-04	EXP 2	1	1	2	Level interface monitoring and control, Radiation detection on organic discharge, Concrete shielding around tank
3-05	REL 2 FIRE 1	1 1	1 1	1 3	Flushes not anticipated during operation, Administrative controls on flush procedure, Leak detection on tank trailer Bermed area around truck provides containment
3-06	REL 3 FIRE 2	1 1	1 1	1 3	External impact necessary to rupture lines (double encased), Administrative controls over heavy equipment near separation enclosure, Low personnel activity at C-103, Organic difficult to ignite, Lack of ignition source in surrounding area
3-07	REL 1 FIRE 1	1 1	1 1	1 3	Truck intentionally oversized to accomodate larger volume than organic waste volume, Tank designed to handle pressure (3/8 in steel) Leak detection on tank trailer, Bermed area around truck provides containment
3-08	IND 2	1	1	3	Administrative controls on hot weather work, Little personnel activity with enclosure
3-09	REL 2 FIRE 1 SPRAY 2	1 1 1	1 1 1	2 4 2	Flushes not anticipated during operation, Self-sealing quick connect valve prevents release, Administrative controls on valve configurations (isolation valve), Organic difficult to ignite

3-10	EXP 3	1	1	1	Would require damage to the line which is not anticipated, Administrative controls over repairs, Personal Protective Equipment, Training
3-11	REL 2 FIRE 1 SPRAY 2	1 1 1	1 1 1	1 3 2	Parking pad level, Wheels braked and blocked during operation, Organic difficult to ignite, Lack of spark sources around trailer

EVNT	FREQ	P	O	F	FACTORS
4-01	REL 1 FIRE 1	1 1	1 1	1 3	Tank overfill pressure insufficient to rupture tank
4-02	REL 2 FIRE 2	1 1	1 1	1 3	Leakage through sample valves would require overfill which is unlikely, Lack of ignition sources in area, Bermed area would contain release, Leak detection on trailer,
4-03	REL 2 FIRE 1	1 1	1 1	2 4	Administrative controls over heavy equipment usage near separations equip, Structural integrtity of tank, Testing of tank prior to operation, Lack of ignition sources in area, Bermed area would contain release, Leak detection on trailer,
4-04	REL 1 FIRE 1	1 1	1 1	1 3	Waste characterization, Level indication on trailer tank, Leak detection on trailer, Bermed area provides containment, Lack of ignition sources in area,
4-05	REL 2 FIRE 1	1 1	1 1	1 3	Flushes not anticipated during operation, Administrative controls on valve configurations (isolation valve), Leak detection on trailer, Bermed area provides containment, Lack of ignition sources in area, Organic difficult to ignite
4-06	EXP 2	1	1	2	Level interface monitoring, Radiation detection on organic discharge, Concrete shielding around tank
4-07	REL 1 FIRE 1	1 1	1 1	1 3	Level interface monitoring, Radiation detection on organic discharge, Level indication on trailer tank, Bermed area would contain release, Leak detection on trailer, Organic difficult to ignite, Lack of ignition sources in area,
4-08	EXP 2	1	1	2	Level interface monitoring, Radiation detection on organic discharge, Concrete shielding around tank
4-09	EXP 2	1	1	2	Requires skimmer upset, Level interface monitoring, Radiation detection on organic discharge, Concrete shielding around tank

4-10	EXP 1	1	1	1	Flow rate low, Liquid released below liquid level, Volume of tank requires large amount of foam to foul HEPAs, Redundant HEPAs in vent system,
4-11	REL 1 FIRE 1	1 1	1 1	1 3	Tank is structurally strong (heavy steel), Short operating life prevents long term corrosion, Bermed area would contain release, Leak detection on trailer, Organic difficult to ignite, Lack of ignition sources in area,
4-12	REL 1 FIRE 1	1 1	1 1	1 3	Tank manufactured for this mission, no previous use, Administrative controls on manufacture and inspection, No chemicals available in sufficient quantity or incompatibility to threaten tank, Tank is structurally strong (heavy steel), Short operating life prevents long term corrosion, Bermed area would contain release, Leak detection on trailer, Organic difficult to ignite, Lack of ignition sources in area,
4-13	REL 2 FIRE 1 SPRAY 2	1 1 1	1 1 1	1 3 2	Parking pad level, Wheels braked and blocked during operation, Organic difficult to ignite, Lack of spark sources around trailer
4-14	REL 2 FIRE 2	1 1	1 1	1 3	Administrative controls on removal, Process shut down during removal so no waste in transfer line, Structural integrity of tank and anchoring supports,
4-15	REL 3	1	1	1	Flexible splash guard on connect nozzle to prevent spillage, Flush performed prior to disconnect, Anticipated event, Administrative controls over sampling, Personal Protective Equipment, Training
4-16	REL 4	1	1	1	Anticipated event, Administrative controls over sampling, Personal Protective Equipment, Training Waste volumes involved in sampling minor,

4-17	AIRBN 2	1	1	1	Administrative controls on installation, Passive ventilation would release minor amount of vapors,
4-18	REL 1 FIRE 1	1 1	1 1	2 4	Structural integrity of tank and trailer, Tank anchored to trailer, Packaging safety analysis, inspection, Bermed area provides containment Low personnel activity around C-103, Organic difficult to ignite, Lack of ignition sources in area,
4-19	REL 1 FIRE 1	1 1	1 1	2 4	Structural integrity of axle and trailer, Multiple, redundant axles, Tank anchored to trailer, Packaging safety analysis, inspection, Bermed area provides containment, Low personnel activity around C-103, Organic difficult to ignite, Lack of ignition sources in area,
4-20	REL 2 FIRE 1	1 1	1 1	2 4	Structural integrity of anchors and tank, Short distance between shielding and tank prevent high energy falls, Bermed area would contain release, Organic difficult to ignite, Lack of ignition sources in area,
4-21	IND 2	1	1	4	Structural integrity of tank, Low personnel activity around C-103, Administrative controls on heavy equipment around separations equipment
4-22	REL 1 FIRE 1	1 1	1 1	2 4	Multiple, redundant tires, Tank anchored to trailer, Packaging safety analysis, inspection, Bermed area provides containment, Low personnel activity around C-103, Organic difficult to ignite, Lack of ignition sources in area,
4-23	REL 1 FIRE 1	1 1	1 1	2 4	Only an accident in the event of a sizeable leak of organic, Leak detection on trailer, Organic difficult to ignite, Lack of ignition sources in area,
4-24	REL 1 FIRE 2	1 1	1 1	2 4	Weld failure extremely unlikely Packaging safety analysis, testing, inspection, Bermed area provides containment, Low personnel activity around C-103, Organic difficult to ignite, Lack of ignition sources in area,

EVNT	FREQ	P	O	F	FACTORS
5-01	REL 1	1	1	1	Administrative controls on valve config, High-high level alarm/interlock on drain tank, Separations enclosure provides shielding and containment, Sump leak detection
5-02	EXP 1	1	1	1	Administrative controls on valve config, Automatic coalescer level interface control and monitoring, Radiation detection on organic discharge line, Concrete shielding around tank
5-03	REL 1	1	1	1	Administrative controls on valve config, High-high level alarm/interlock on drain tank, Separations enclosure provides shielding and containment, Sump leak detection
5-04	REL 3	1	1	1	External impact necessary to rupture lines (double encased), Administrative controls over heavy equipment near separation enclosure, Low personnel activity at C-103,
5-05	REL 1	1	1	1	Pipe plug extremely infrequent event, High-high level alarm/interlock on drain tank, Separations enclosure provides shielding and containment, Sump leak detection
5-06	REL 1	1	1	1	Pump selected to be maintenance free, Short operating life minimzes chances of pump failure, High-high level alarm/interlock on drain tank, Separations enclosure provides shielding and containment, Sump leak detection
5-07	REL 1	1	1	1	Pipe plug extremely infrequent event, High-high level alarm/interlock on drain tank, Separations enclosure provides shielding and containment, Sump leak detection

5-08	REL 2 SPRAY 2	1 1	1 1	1 2	Pipe leak an infrequent event, Aqueous return line double encased, Lines gravity drain to C-103, Leak detection on pipe encasement drainback to C-103, If leak does occur, volume released would be relatively small
5-09	EXP 1	1	1	1	Maximum sump pump flow rate is 3 gpm, Aqueous return positioned far from skimmer (32 ft), Emulsions would probably not pass through skimmer pump intact, Radiation detection on organic discharge line, Concrete shielding around tank
5-10	REL 1	1	1	1	Operational Test Procedures (OTPs) High-high level alarm/interlock on drain tank, Separations enclosure provides shielding and containment, Sump leak detection
5-11	REL 1 SPRAY 1	1 1	1 1	1 2	Lines gravity drain to prevent liquid collection, Double encased transfer lines,
5-12	REL 2 SPRAY 2	1 1	1 1	1 2	Lines gravity drain to prevent liquid collection, Double encased transfer lines, Leak detection on pipe encasement drainback to C-103, Leak because of thermal shock would be small
5-13	REL 2 SPRAY 2	1 1	1 1	1 2	Lines gravity drain to prevent liquid collection, Double encased transfer lines,
5-14	REL 1 SPRAY 1	1 1	1 1	1 2	Insufficient heat sources to produce water hammer
5-15	EXP 1	1	1	1	Maximum sump pump flow rate is 3 gpm, Aqueous return positioned far from skimmer (32 ft), Emulsions would probably not pass through skimmer pump intact, Radiation detection on organic discharge line, Concrete shielding around tank

5-16	REL 1 SPRAY 1	1 1	1 1	1 2	Lines gravity drain to prevent liquid collection, Double encased transfer lines, Leak detection on pipe encasement drainback to C-103, Short mission time minimizes corrosion, Leakage from corrosion-caused breach would be small
5-17	REL 1 SPRAY 1	1 1	1 1	1 2	Seals are within separation enclosure, Separations enclosure provides shielding and containment, Sump leak detection, Administrative control prevents imcompatibility situation (material compatibility list)
5-18	EXP 4	1	1	1	Anticipated event, Administrative controls over D&D, Personal Protective Equipment, Training
5-19	REL 4	1	1	1	Anticipated event, Administrative controls over D&D, Personal Protective Equipment, Training
5-20	EXP 4	1	1	1	Repairs not anticipated to occur, Administrative controls over repairs, Personal Protective Equipment, Training
5-21	IND 3	1	1	3	Lack of dangerous equipment or energy sources in system, Prejob planning, Training, Correct tools and equipment, Administrative controls on operations

EVNT	FREQ	P	O	F	FACTORS
6-01	REL 2 FIRE 1 SPRAY 2	1 1 1	1 1 1	2 4 2	Administrative controls on flush procedures, Flushes not anticipated during operation, Isolation valve on flush connection would have to be opened, Quick-connect valve would prevent release, Organic difficult to ignite, No ignition sources near enclosure
6-02	EXP 2	1	1	2	Automatic level interface monitoring and control, Radiation detection on organic discharge, Concrete shielding around truck tank,
6-03	REL 1 FIRE 1	1 1	1 1	1 3	Structural strength of coalescer (steel), Pre-operation testing of coalescer, Separation enclosure provides containment and shielding, Sump with leak detection and pumpout, Enclosure drains to C-103 through transfer line encasement, Organic difficult to ignite (no ignition at less than 280 F), Lack of ignition sources in enclosure (non-sparking sealed pump motor), Enclosure vented through multiple HEPAs in passive vent system to contain airborne contaminants,
6-04	EXP 2	1	1	1	Administrative controls on valve config, Inlet flow indicator, Emulsion formation unlikely, Automatic level interface monitoring and control, Radiation detection on organic discharge, Concrete shielding around truck tank,
6-05	REL 1 FIRE 1 SPRAY 1	1 1 1	1 1 1	1 3 2	Skimmer pump hydraulic overpressure shut down interlock, Separation enclosure provides containment and shielding, Sump with leak detection and pumpout, Enclosure drains to C-103 through transfer line encasement, Organic difficult to ignite (no ignition at less than 280 F), Lack of ignition sources in enclosure (non-sparking sealed pump motor), Enclosure vented through multiple HEPAs in passive vent system to contain airborne contaminants,

6-06	REL 1 FIRE 1 SPRAY 1	1 1 1	1 1 1	1 3 2	Skimmer pump overspeed unlikely failure mode, Skimmer pump hydraulic overpressure shut down interlock, Separation enclosure provides containment and shielding, Sump with leak detection and pumpout, Enclosure drains to C-103 through transfer line encasement, Organic difficult to ignite (no ignition at less than 280 F), Lack of ignition sources in enclosure (non-sparking sealed pump motor), Enclosure vented through multiple HEPAs in passive vent system to contain airborne contaminants,
6-07	EXP 2	1	1	1	Rough filters remove solids from waste, Automatic level interface monitoring and control, Radiation detection on organic discharge, Concrete shielding around truck tank,
6-08	REL 1	1	1	1	High-high level alarm/interlock on drain tank, Separation enclosure provides containment and shielding, Sump with leak detection and pumpout, Enclosure drains to C-103 through transfer line encasement, Skimmer pump hydraulic overpressure shut down interlock,
6-09	REL 1	1	1	1	Administrative controls on flush procedures, Flushes not anticipated during operation, High-high level alarm/interlock on drain tank, Separation enclosure provides containment and shielding, Sump with leak detection and pumpout, Enclosure drains to C-103 through transfer line encasement,
6-10	EXP 1	1	1	1	Administrative controls on flush procedures, Flushes not anticipated during operation, Automatic level interface monitoring and control, Radiation detection on organic discharge, Concrete shielding around truck tank,

6-11	REL 1	1	1	1	Drain tank pump activates automatically on high level, High-high level alarm/interlock on drain tank, Separation enclosure provides containment and shielding, Sump with leak detection and pumpout, Enclosure drains to C-103 through transfer line encasement,
6-12	REL 1 FIRE 1	1 1	1 1	1 3	Structural integrity of coalescer vessel, Coalescer heated with heat trace, Coalescer generally filled with liquid during operation, Separation enclosure provides containment and shielding, Sump with leak detection and pumpout, Enclosure drains to C-103 through transfer line encasement, Organic difficult to ignite (no ignition at less than 280 F), Lack of ignition sources in enclosure (non-sparking sealed pump motor), Enclosure vented through multiple HEPAs in passive vent system to contain airborne contaminants,
6-13	SPRAY 1	1	1	2	Structural integrity of coalescer vessel, Coalescer heated with heat trace, Coalescer generally filled with liquid during operation, Separation enclosure provides containment and shielding, Sump with leak detection and pumpout, Enclosure drains to C-103 through transfer line encasement, Enclosure passively ventilated through redundant HEPA filters, Passive ventilation would prevent large release of airborne contaminants,

6-14	REL 1 FIRE 1 SPRAY 1	1 1 1	1 1 1	1 3 2	Gaskets kept warm by waste and by heat of enclosure, Separation enclosure provides containment and shielding, Sump with leak detection and pumpout, Enclosure drains to C-103 through transfer line encasement, Organic difficult to ignite (no ignition at less than 280 F), Lack of ignition sources in enclosure (non-sparking sealed pump motor), Enclosure vented through multiple HEPAs in passive vent system to contain airborne contaminants,
6-15	REL 1 FIRE 1 SPRAY 1	1 1 1	1 1 1	1 3 2	Gaskets kept warm by waste and by heat of enclosure, Separation enclosure provides containment and shielding, Sump with leak detection and pumpout, Enclosure drains to C-103 through transfer line encasement, Enclosure passively ventilated through redundant HEPA filters, Lack of ignition sources in enclosure,
6-16	EXP 2	1	1	1	Heat trace failure is infrequent, Waste already warm from C-103, Coalescer temp monitored in control trailer, Radiation detection on organic discharge, Concrete shielding around truck tank,
6-17	EXP 2	1	1	1	Heat trace failure is infrequent, Waste already warm from C-103, Coalescer temp monitored in control trailer, Automatic level interface monitoring and control, Radiation detection on organic discharge, Concrete shielding around truck tank,
6-18	FIRE 1	1	1	3	Would require a leak of organic, Sump with leak detection and pumpout, Separations enclosure is heavy steel and would provide containment of fire, Organic difficult to ignite (no ignition at less than 280 F), Lack of ignition sources in enclosure (non-sparking sealed pump motor), Enclosure vented through multiple HEPAs in passive vent system to contain airborne contaminants,

6-19	FIRE 2	1	1	1	Electrical fires unlikely (few potential sources and infrequent failure mode), Separations enclosure is heavy steel and would provide containment of fire, Enclosure vented through multiple HEPAs in passive vent system to contain airborne contaminants, Electrical fire would release little or no contamination, Probably no effect on coalescer or organic in system,
6-20	IND 2	1	1	3	Administrative controls on work in hot weather, Little maintenance activity in enclosure anticipated,
6-21	REL 1 FIRE 1	1 1	1 1	1 3	Structural strength of coalescer (steel), Pre-operation testing of coalescer, Separation enclosure provides containment and shielding, Sump with leak detection and pumpout, Enclosure drains to C-103 through transfer line encasement, Organic difficult to ignite (no ignition at less than 280 F), Lack of ignition sources in enclosure (non-sparking sealed pump motor), Enclosure vented through multiple HEPAs in passive vent system to contain airborne contaminants,
6-22	REL 1 SPRAY 1	1 1	1 1	1 2	Structural strength of coalescer (steel), Pre-operation testing of coalescer, Separation enclosure provides containment and shielding, Sump with leak detection and pumpout, Enclosure drains to C-103 through transfer line encasement,
6-23	EXP 1	1	1	2	Aqueous discharge valve fails in open mode to allow gravity drain to drain tank, Automatic level interface monitoring and control, Radiation detection on organic discharge, Concrete shielding around truck tank,
6-24	EXP 1	1	1	1	Automatic level interface monitoring and control, Radiation detection on organic discharge, Concrete shielding around truck tank,

6-25	REL 1 FIRE 1 SPRAY 1	1 1 1	1 1 1	1 3 2	Structural strength of coalescer (steel), Pre-operation testing of coalescer, Separation enclosure provides containment and shielding, Sump with leak detection and pumpout, Enclosure drains to C-103 through transfer line encasement, Organic difficult to ignite (no ignition at less than 280 F), Lack of ignition sources in enclosure (non-sparking sealed pump motor), Enclosure vented through multiple HEPAs in passive vent system to contain airborne contaminants,
6-26	EXP 1	1	1	1	Administrative controls on flush procedures, Flushes not anticipated during operation, Automatic level interface monitoring and control, Radiation detection on organic discharge, Concrete shielding around truck tank,
6-27	EXP 2	1	1	1	Rough filters prevent solids from entering coalescer, Coalescer designed to handle greater than operational flow, Radiation detection on organic discharge, Concrete shielding around truck tank,
6-28	EXP 2	1	1	1	Coalescer heat traced, Waste from C-103 is warm, Radiation detection on organic discharge, Concrete shielding around truck tank,
6-29	EXP 1	1	1	1	Pre-installation inspection of coalescer, Significant damage to coalescer during operation unlikely, Coalescer designed to handle greater than operational flow, Radiation detection on organic discharge, Concrete shielding around truck tank,
6-30	EXP 2	1	1	1	Variable speed control on skimmer pump, Flow element at coalescer inlet, Emulsion formation uncertain, Radiation detection on organic discharge, Concrete shielding around truck tank,
6-31	EXP 3	1	1	1	Emulsion formation unlikely, Emulsion from filter switch would send little aqueous to truck, Radiation detection on organic discharge, Concrete shielding around truck tank,

6-32	EXP 1	1	1	1	Foaming highly unlikely because coalescer completely filled with liquid, Causes of foaming difficult to identify, Radiation detection on organic discharge, Concrete shielding around truck tank,
6-33	REL 1 FIRE 1 SPRAY 1	1 1 1	1 1 1	1 3 2	Administrative controls on procurement with regard to compatibility issues, Short operating life prevents long-term corrosion effects, Structural strength of coalescer (steel), Separation enclosure provides containment and shielding, Sump with leak detection and pumpout, Enclosure drains to C-103 through transfer line encasement, Organic difficult to ignite (no ignition at less than 280 F), Lack of ignition sources in enclosure (non-sparking sealed pump motor), Enclosure vented through multiple HEPAs in passive vent system to contain airborne contaminants,
6-34					Call Larry DellaRocco
6-35	EXP 4	1	1	1	Anticipated event, Administrative controls over D&D, Personal Protective Equipment, Training
6-36	EXP 3	1	1	1	Repairs not anticipated to occur, Administrative controls over repairs, Personal Protective Equipment, Training
6-37	REL 3	1	1	1	Coalescer vessel flushed prior to D&D, Administrative controls over D&D, Personal Protective Equipment, Training

6-38	REL 1 FIRE 1 SPRAY 1	1 1 1	1 1 1	1 3 2	Administrative controls on procurement with regard to compatibility issues, Short operating life prevents long-term corrosion effects, Separation enclosure provides containment and shielding, Sump with leak detection and pumpout, Enclosure drains to C-103 through transfer line encasement, Organic difficult to ignite (no ignition at less than 280 F), Lack of ignition sources in enclosure (non-sparking sealed pump motor), Enclosure vented through multiple HEPAs in passive vent system to contain airborne contaminants,

EVNT	FREQ	P	O	F	FACTORS
7-01	EXP 1	1	1	1	HEPAs plug very infrequently (esp. in passive ventilation), Plugged HEPA would probably not be able to deadhead skimmer pump, Automatic coalescer level interface control and monitoring, Pressure indictor on trailer tank
7-02	EXP 1	1	1	1	Filters plug infrequently (esp. in passive ventilation), Plugged filter would probably not be able to deadhead skimmer pump, Automatic coalescer level interface control and monitoring, Radiation detection on organic discharge Pressure indictor on trailer tank
7-03	EXP 1	1	1	1	Administrative controls on valve config, Automatic coalescer level interface control and monitoring, Radiation detection on organic discharge Pressure indictor on trailer tank
7-04	SPRAY 1	1	1	2	Redundant HEPA filters in vent system, Separations enclosure provides shielding and containment, Sump leak detection and pumpout, Little aerosol would escape vent system because of passive ventilation
7-05	AIRBN 3	1	1	3	Vent system equipped with charcoal filters, Administrative controls on entry to C-103 area (PPE required),

7-06	FIRE 1	1	1	4	Ignition temp of organic is 400 - 1200 F, Lack of ignition sources in trailer tank
7-07	FIRE 2	1	1	2	Ignition temp of organic is 400 - 1200 F, Lack of ignition sources in C-103
7-08	FIRE 2	1	1	1	Ignition temp of organic is 400 - 1200 F, Lack of ignition sources in C-103, HEPA filters would filter volatized organics
7-09	REL 1	1	1	1	Level indication on trailer tank, Overfill of tank would require other failures (discussed earlier), Vent lines gravity drain to C-103 prior to atmospheric release thru filters
7-10	AIRBN 1	1	1	1	Separations enclosure provides shielding and containment, Sump leak detection and pumpout, Redundant HEPA filters in vent system, Vent lines gravity drain to C-103 prior to atmospheric release thru filters,
7-11	AIRBN 2	1	1	1	Administrative controls on valve config, Vent outlet filtered by redundant HEPAs which are not contaminated on the outside, Passive ventilation prevents large quantities of airborne contamination from being released
7-12	FIRE 2	1	1	3	System filtered by redundant HEPAs (some protected by separation enclosure), Insufficient combustibles in area around C-103 (fire very unlikely),
7-13	AIRBN 1	1	1	1	Vent lines stainless steel, Short operating life minimizes corrosion, Redundant HEPAs prevent contaminants from entering line, Passive ventilation would create slow corrosion environment
7-14	EXP 4	1	1	1	Administrative controls on valve config, Exposure would be increased little, Low personnel activity around C-103,
7-15	AIRBN 2	1	1	1	Redundant HEPAs keeps contamination in vent lines low, Parking pad level, Wheels braked and blocked during operation
7-16	EXP 4	1	1	1	Anticipated event, Administrative controls over D&D, Personal Protective Equipment, Training

7-17	AIRBN 2	1	1	1	Administrative controls on fabrication and installation (ATPs), Redundant HEPAs, Passive ventilation would prevent large releases of contamination

EVNT	FREQ	P	O	F	FACTORS
8-01	REL 1	1	1	1	Separations enclosure provides containment and shielding, Pumpable sump with leak detection, Enclosure drains to C-103 through pipe encasements
8-02	REL 1 FIRE 2	1 1	1 1	1 3	Separations enclosure provides containment and shielding, Sump has leak detection, Enclosure drains to C-103 through pipe encasements, Organic difficult to ignite, Lack of ignition sources in enclosure, Enclosure ventilated by multiple HEPA filters
8-03	REL 1	1	1	1	Separation enclosure made of heavy steel, All welds completely sealed, Short mission time minimizes corrosion exposure, Only a hazard in the event of an internal leak
8-04	AIRBN 1	1	1	2	Separations enclosure will not be located on dome area
8-05	AIRBN 1	1	1	2	"Critical lift" administrative controls followed during emplacement or removal, Separations enclosure will not be located on dome area
8-06	REL 1	1	1	1	Startup testing, Operation test procedures (OTPs), Operational Readiness Review, Separation enclosure provides containment and shielding, Sump equipped with leak detection, Enclosure drains to C-103 through pipe encasements
8-07	AIRBN 2	1	1	2	Administrative controls prevent heavy equipment from resting on dome
8-08	REL 4 EXP 4	1 1	1 1	1 1	Anticipated event, Administrative controls over D&D, Personal Protective Equipment, Training

ATTACHMENT
F-1

RESTART SCHEDULE

EARLY START	EARLY FINISH	
		Regulatory Permitting
1MAR95	20JUN95	C-103 RCRA PERMIT(PART-A)
		Detailed Design
1MAR95	18JUL95	ENGINEERING MOBILIZATION
19JUL95	10OCT95	COMPLETE ENGR DESIGN
		Procurement/Fabrication
19JUL95	13FEB96	PROCURE & FAB-PIP'G/INSTR'M'T'S/ELECT COMPONENT
		Readiness Reviews
17JAN96	9APR96	WHC-READINESS REVIEW
10APR96	2JUL96	DOE/RL READINESS REVIEW
		Installation
13MAR96	4JUN96	INSTL'N-SHOP FAB'D COMPONENTS
26JUN96	16JUL96	C-103 - INSTALL PUMP
		Operational Testing
13MAR96	9APR96	O T P - TESTING-SKIMMER/COALESCER/PUMP
5JUN96	25JUN96	FIELD OPERATIONAL TESTING - C-103
		Pump 103-C Organic
17JUL96	10SEP96	Pump 103-C Organic
1MAY95	1MAY95	ASSUMPTIONS

FY95 | FY96 | FY97

OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

ASSUMPTIONS
Restart - Continue w/Strategy as Planned
Assume Design is 50% Complete & Tank & Trailer
Design Will Take 2 to 3 months
Procurement 4 Months - Will Overlap Shop Fab
Procurement Includes Purchase of Coalescer, Tank and Transporter
WHC Readiness Review - Start After Design Compl
Operational Testing After Field Components Instl
Pumping = 30 Days + 10 Days for Poss. Repump

Plot Date 29AUG94
Data Date 30SEP94
Project Start 3JAN94
Project Finish 10SEP96

(c) Primavera Systems, Inc

Activity Bar/Early Dates
Critical Activity
Progress Bar
Milestone/Flag Activity

WHC7

Sheet 1 of 1

WHC ORGANIC - ESTIMATED COMPLETION
103-C PUMPING SCHEDULE
C103 ORGANIC REMOVAL

Scheduler - J Wedge - 372-3798

Date	Revision	Checked	Approved

F-1-1

ATTACHMENT
G-1

ATTACHMENT G-1: PROCURED EQUIPMENT AND LOCATION

The equipment below has been purchased, accepted and is ready for use on the 241-C-103 Organic Removal Program. Equipment is listed under Carl E. Hanson, Manager, Special Projects, 376-4810. All purchased equipment will be located at the 2101-M Storage complex. The control trailer will be sited on the 2101-M Equipment Storage Yard. All smaller items will be identified and stored within the trailer. Larger items such as the hydraulic power unit will be housed within the 2101-M storage building.

EQUIPMENT NAME/IDENTIFICATION	EQUIPMENT LOCATION
IN-TANK:	
Modified Skim-Pack Skimmer #650-H w/ 10.5" weir	Control Trailer
Waukesha Pump Model 18, modified for 12" riser	Control Trailer
Ross Hydraulic Motor Model MG-030710-AAAA	Control Trailer
Monroe-Rucker Hydraulic Power Unit 3 HP, 1800 RPM, 6 GPM	MO-2101M, 200 East
ABOVE GROUND:	
Torangeau Norwest Ball Valves 6 1/2", 6 1" Three way, Multi-Port, Kynar Seats/Seals	Control Trailer
Control Trailer, #9137	MO-2101M, 200 East
Lo-Boy Trailer 60 Ton, 13.5' Wide ** TENTATIVE PERMISSION GRANTED FOR **TEMPORARY USE** ONLY.	1171 Building
SA-9 Radiation Monitors and check source	272-AW, Contact: Lee Livesley
SA-9 Components Including: • IB-4A Interface Box • Special Cable IB-4A to EC-2-11 (200')	Control Trailer

- Connecting cables
  SA-9 to IB-4A
- Electronic control monitors
  EC-2-11 w/ remote check source
  capability
- Single channel panel mount chassis
  for EC-2-11

Source Sample Holders

Control Trailer

ATTACHMENT
H-1

1. Removal Treatment and Disposal of Floating Organic Layer in Tank 241-C-103, **WHC-SD-WM-ES-293, REV. 0.**

2. Probablistic Risk Assessment of Tank C-103 Organic Removal Separation

3. Probablistic Risk Assessment of Tank C-103 Organic Removal In-Tank Pumping System

4. Probablistic Risk Assessment of Tank C-103 Organic Transfer and Storage

5. Solids Removal Investigation

6. Draft - Organic Decontamination By Ion Exchange

7. Technical Basis for Tank 241-C-103 Organic Removal July 15, 1994

8. Test Report: Osmonics Liquid Coalescer Applications to Tank C-103 Simulants

9. Flammability Hazard Requirements matrix

10. Miscellaneous file of SAIC letter reports, correspondence, etc.

11. Final Report- **WHC-SD-WM-ES-320, REV.0,** Organic Decontamination by Ion Exchange