Page 1 of 1 *KN*

S

Functional Requirements and Technical Criteria for the 241-SY-101 RAPID Mitigation System

M. F. Erhart

Lockheed Martin Hanford Company
Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-96RL13200

EDT/ECN: 625911

UC: 2070

Org Code: 747300

Charge Code: 108968BA10

B&R Code: EW3120074

Total Pages: 5961

KN

Key Words: SY-101, Mitigation, Transfer, Overground, Pump, PPP, piping, pump pit, drop leg, New Generation Transfer Pump, NGTP, prefabricated pump pit

Abstract: This document provides functional, performance, and design criteria for the RAPID Mitigation System. In addition, critical interface, design assumptions, and analytical requirements are identified.

TRADEMARK DISCLAIMER. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

Printed in the United States of America. To obtain copies of this document, contact: Document Control Services, P.O. Box 950, Mailstop H6-08, Richland WA 99352, Phone (509) 372-2420; Fax (509) 376-4989.

Karen M. Noland 2/26/99
Release Approval Date

Release Stamp

Approved For Public Release

HNF-3885

Rev. 0

FUNCTIONAL REQUIREMENTS AND TECHNICAL
CRITERIA FOR THE 241-SY-101 RAPID
MITIGATION SYSTEM

BY

Steven W. Shaw
Merrick & Co.
February 24, 1999

CONTACT
M. F. Erhart
Lockheed Martin Hanford Company

Table of Contents

1.0	SCOPE.....	1
1.1	OVERVIEW	1
1.2	BASIS AND OBJECTIVES	3
1.2.1	ASSUMPTIONS	3
1.2.2	OBJECTIVES	5
1.3	SAFETY CLASSIFICATIONS.....	5
2.0	TERMS, DEFINITIONS, AND SYMBOLS	8
3.0	APPLICABLE DOCUMENTS AND INFORMATION.....	9
3.1	APPLICABLE HANFORD STANDARD DESIGN CRITERIA AND PRACTICES	9
3.2	APPLICABLE CONSENSUS CODES AND STANDARDS	9
3.3	APPLICABLE DOE ORDERS.....	12
3.4	APPLICABLE GOVERNMENT REGULATIONS.....	12
3.5	DRAWINGS.....	12
3.6	REFERENCES, OTHER DOCUMENTS AND INFORMATION.....	14
4.0	FUNCTIONS AND REQUIREMENTS.....	16
4.1	DEFINITION.....	16
4.2	CHARACTERISTICS.....	17
4.2.1	Waste.....	17
4.2.2	New Generation Transfer Pump.....	17
4.2.3	Prefabricated Pump Pit.....	17
4.2.4	Transfer Line and Drop Leg.....	17
4.2.5	Instrumentation.....	18
4.2.6	Infrastructure.....	18
4.3	TECHNICAL DESIGN REQUIREMENTS, CONSTRAINTS, AND CRITERIA.....	19
4.3.1	System	19
4.3.2	Prefabricated Pump Pit.....	20
4.3.3	Transfer Line	23
4.3.4	Control and Instrumentation	25
4.3.5	Alarms.....	27
4.3.6	Interlocks.....	28
4.3.7	Infrastructure	28
4.4	MATERIALS.....	29
4.5	ARCHITECTURAL/CIVIL ENGINEERING AND SITEWORK.....	30
4.6	MECHANICAL ENGINEERING	30
4.7	ELECTRICAL, INSTRUMENTATION AND CONTROLS	30
4.8	SAFETY	31
4.9	RADIATION AND NUCLEAR CONTROL	31
4.10	HUMAN ENGINEERING.....	31
4.11	LOGISTICS.....	32
4.12	PROJECT INTERFACES.....	32
4.12.1	Waste Tanks.....	32
4.12.2	Water.....	33
4.12.3	Electrical	34
4.13	SECURITY.....	34
4.14	QUALIFICATION	34
5.0	QUALITY ASSURANCE	35
5.1	INSPECTIONS	35

5.2	TEST AND EXAMINATIONS.....	35
6.0	TURNOVER.....	36
7.0	APPENDICES.....	36

APPENDICES

Appendix A	Internal Memo
Appendix B	FGEAB Meeting Minutes
Appendix C	Process Flow Diagram
Appendix D	NGTP Flange Interface Drawings
Appendix E	Internal Memo (Draft)

TABLES

1-1	New Generation Transfer Pump Design Data	2
4-1	Instrumentation/Alarm Indication Location	28
4-2	RAPID System Interface Table	34

FUNCTIONAL REQUIREMENTS AND TECHNICAL CRITERIA FOR THE 241-SY-101 RAPID MITIGATION SYSTEM

1.0 SCOPE

1.1 OVERVIEW

Tank 241-SY-101 (SY-101) has recently exhibited a steady waste surface level growth. A path forward to mitigate the SY-101 surface level growth issue has been developed (Reference A). The project has been directed to install the necessary equipment to transfer 380 - 570 m³ (100,000 - 150,000 gallons) of waste from SY-101 to SY-102 before the waste elevation reaches the region of the tank where the transition from a double to a single shell tank occurs. It is assumed that the SY-101 waste is compatible with that in SY-102.

To accomplish this primary objective will require that the system design, fabrication, equipment installation, and the first waste transfer be completed prior to September 24, 1999. Further transfers may be required over the next five years.

The Respond and Pump in Days (RAPID) Mitigation System is comprised of a number of components and sub-assemblies. Major components/assemblies/upgrades associated with the system include:

- New Generation Transfer Pump (NGTP)
- Prefabricated Pump Pit (PPP) Assembly
- Transfer Line Assembly
- Drop Leg in Receiver Tank
- Necessary Installation Hardware
- Control System
- Facility Upgrades
- Electrical Power System
- Flush and Dilution System

The transfer pump is the general service component around which the remaining equipment comprising the RAPID Mitigation System is arranged. The New Generation Transfer Pump's nominal design values are identified in Table 1-1.

The PPP provides the interface between a number of the key components and subsystems contained within the SY-101 RAPID Mitigation System. The design of the PPP assembly includes piping and control valves necessary to allow flushing of the transfer line, pump bearings, and pump internals. The PPP assembly is the "adapter" that

provides for connection at the encased transfer line and the transfer pump/pipeline flush connections.

The RAPID system design includes a dedicated transfer line (not physically connected to other active or inactive waste transfer lines) from the PPP installation to SY-102. Transfer system leak detectors are installed at all low points. The number of low points shall be minimized to the extent practicable.

A drop leg is required for installation into the receiver tank. The drop leg will discharge waste being transferred from SY-101 below the waste surface of SY-102. The design of the drop leg shall be configured to maximize the horizontal discharge velocity into the tank without significantly increasing the potential for plugging in the leg or nozzle that would preclude further transfers from SY-101.

**TABLE 1-1
NEW GENERATION TRANSFER PUMP DESIGN DATA**

Design Head (Nominal):	450 ft at the discharge flange.	
Design Flow (Nominal):	140 GPM	
Operating Speed	3860 RPM	
Critical Speed (@ duty point):	6175 RPM (160% Operating)	
Fluid Specific Gravity	1.5 max	
(@ design point)		
Fluid Viscosity (@ design point):	30 Centipoise Max	
Fluid Temperature	200 F Max	
Required NPSH	10.6 ft minimum	
Power Required	460 V, 3 phase, 60 Hz to VFD	
Motor Cooling	Process Fluid	
Bearing Lubrication	Process Fluid	
Dilution Water Supply	105 GPM @ 100 psig	
Purge Water Supply	10 GPM @ 90 psig	
Operating Life	10,000 hours over 10 years.	
Weight	Rotating Assembly	161
	Dry Motor Unit	1239
	Dry Column	2390
	Total Dry Weight	3790
	Motor Unit Fluid @ 1.5 SG	44
	Column Assembly Fluid @ 1.5 SG	262
	Total Wet Weight	4096

60 HP, 67 kW, Rated Current 120 Amps, No-Load 50 Amps, Locked Rotor Current 255 Amps.

Screen Size: 0.25 in diameter

The RAPID Mitigation System's control system is comprised of all instrumentation and control functions necessary to accomplish waste transfers between SY-101 and SY-102. Control functions include system configuration of waste, service water, dilution water, and flush water line routing. Instrumentation provides feedback to operations with respect to operating parameters and system status. The control system shall provide the minimum amount of remote/automatic control possible, relying instead upon operator inputs and procedural and/or other administrative controls to ensure proper system operating configuration and control.

Infrastructure upgrades are required to support the deployment and operation of the RAPID Mitigation System. Facility upgrades include the supply of electrical power to the transfer pump's Variable Frequency Drive (VFD), providing heated raw water to meet transfer system requirements for dilution during waste transfer, the provision of instrument and service air supplies for instrumentation and process requirements as required. All efforts will be made to minimize the number of field modifications required by the design.

1.2 BASIS AND OBJECTIVES

1.2.1 ASSUMPTIONS

It is necessary to make a number of assumptions to facilitate a schedule that requires the system design, fabrication, equipment installation, and the first waste transfer be completed prior to September 24, 1999. Further transfers may be required over the next five years. To meet this schedule requirement, the following assumptions have been made:

- 1.2.1.1 The waste transferred from SY-101 will be compatible with the waste in SY-102.
- 1.2.1.2 Transfers will be made as necessary to/from SY-102 to ensure sufficient room is available for transfers from SY-101, and contains sufficient waste to keep the discharge nozzles of the drop leg installed in 102 submersed.
- 1.2.1.3 PE Stamping of design media shall not be required as per the Chief Engineer, Lockheed Martin Hanford Company.
- 1.2.1.4 Radiation fields during waste transfers may be in excess of those normally observed in the Tank Farms. Due to dome load constraints, time and distance may be the primary method of maintaining radiation exposure ALARA.
- 1.2.1.5 The New Generation Transfer Pump and VFD will be utilized and are suitable for this application.

- 1.2.1.6 It is more cost effective, and best meets mission requirements, to replace the transfer pump if it is damaged beyond serviceability by seismic event rather than modify the pump to withstand seismic loads for which it was not designed.
- 1.2.1.7 The primary transfer line is classified as a general service component.
- 1.2.1.8 Heat trace is only required on new transfer line piping outside the PPP.
- 1.2.1.9 It will not be required that the transfer line encasement comply with the requirements of Section III of the ASME Boiler and Pressure Vessel code. The ASME B31.3 Process Piping code with additional inspection requirements will be used to ensure that the encasement integrity is suitable for its safety class function.
- 1.2.1.10 Existing spare conduits between the vicinity of DACS trailer and tank 101-SY are available and sufficient.
- 1.2.1.11 Adequate power is available at substation 242-S and MCC SY272-EDS-MCC-003.
- 1.2.1.12 Leak detection shall not be connected into any site wide alarm system (i.e. CASS, TMACS) but only locally alarm and send a single alarm to the DACS trailer. It is assumed that Operations will respond to any leak detector alarm in 30 minutes or less.
- 1.2.1.13 Power (120 V) is readily available in the farm for I & C.
- 1.2.1.14 Pressure readouts are local to their assumed sensing locations at the transfer pump and dilution water supply, with no readouts in the DACS trailer.
- 1.2.1.15 I & C remains simple and non-interlocking to the transfer pump with the exception of the following:
- An interlock provided from the raw water supply to the transfer pump shutdown circuit (i.e. VFD input). Upon loss of or lessening Water pressure/flow-rate a shutdown signal will be sent to the VFD.
 - A feature to prevent inadvertent water addition to the waste tanks will be designed.
- 1.2.1.16 A water pump skid is required, portable, and powered from an available welding outlet.
- 1.2.1.17 If supplemental water heat is required, diesel generators will be obtained to power the heating units.

- 1.2.1.18 Water booster pump is portable and powered from existing MCC building welding outlet if needed.
- 1.2.1.19 In the service water pit, indication of total raw water flow (totalizer readout) will only be local, and not available in the DACS trailer.
- 1.2.1.20 The magnetic flow meters for the raw water (dilution) supply system will be safety significant components.
- 1.2.1.21 Installation of a mass-flow meter in any of the transfer lines will not be required.
- 1.2.1.22 Seal Loop water level will be detected by a reverse acting leak detection sensor/circuit that will alarm at the PPP and also in the DACS trailer.
- 1.2.1.23 No Safety Class or Safety Significant power is required.
- 1.2.1.24 NFPA 497A Hazardous Classification will be designed to be nonclassified for the pump pit and surrounding areas.
- 1.2.2 OBJECTIVES

The near term desired end state of the waste transfer is to regain sufficient reserve operational head space within SY-101 to allow routine operations to occur without the concern of waste impacting the operation of equipment or reaching unacceptable levels within the tank.

The long term desired end state is to have sufficient amounts of the tank material either treated or removed so continued operation of the SY-101 Mixer pump is no longer required. The safety issue will be closed and there will be no open Unreviewed Safety Questions (USQs) against tank SY-101.

1.3 SAFETY CLASSIFICATIONS

The Safety Related Components that have been established for waste transfer-related accidents in the BIO will also apply to this proposed activity as appropriate to remain consistent with the TWRS BIO:

Safety Class SSCs

Transfer System Covers. The safety function of the transfer system covers is (1) to provide a physical barrier to knock down spray and limit release of aerosols to the atmosphere in case of a release during a transfer and (2) to limit release of aerosols generated by splatter inside the pit and limit shine and skyshine dose to the onsite receptor. [The second safety function is safety significant.]

Pressure Switch Interlock(s) or Alarm to Waste Transfer Pumps (Raw Water and Other Water Service Supply Lines). The safety function of the pressure switch interlocks to waste transfer pumps is to prevent backflow of waste into interconnecting systems.

Transfer Leak Detection System. The safety function of the transfer leak detection system is to detect waste accumulation in the pits and the transfer pump auto stop or alarm function.

Primary Tank Leak Detection For Double-Shell Tanks. The safety function of the annulus leak detector in a DST is to detect waste accumulation in the DST annulus.

Waste Transfer Pipe Encasements. The safety function of waste transfer pipe encasements is to ensure that a leak in the primary waste transfer system piping is directed to a waste transfer-associated structure.

Stack Continuous Air Monitor and Interlock to Exhaust Fan on All Actively Ventilated Tanks. The safety function of the stack continuous air monitor and interlock to exhaust fan is to detect radioactivity caused by failure of a high-efficiency particulate air (HEPA) filter and the shut-off of the exhaust fan for all actively ventilated tanks.

Safety Significant SSCs

Raw Water or Service Water System Backflow Preventers. The safety function of backflow preventers is to prevent the backflow of waste into raw water or service water systems.

Tank Level Monitors. The safety function of level monitors is to indicate the waste level in the tank to support material balance calculations during waste transfers.

Service Water Flow Totalizers. The safety function of the service water flow totalizers is to monitor flow of service water.

The transfer-related TSRs listed in HNF-SD-WM-TSR-006 are applicable to this Proposed Activity. These include:

- LCO 3.1.1, *Transfer System Covers*
- LCO 3.1.2, *Service Water Pressure Detection Systems*
- LCO 3.1.3, *Transfer Leak Detection Systems*
- LCO 3.1.4, *Ventilation Stack CAM Interlock Systems*
- LCO 3.2.6, *Primary Tank Leak Detection Systems*

- AC 5.12, *Transfer Controls*
- AC 5.13, *Encasement Seal Loop Controls*
- AC 5.14, *Emergency Preparedness*
- AC 5.17, *Excavation Controls*

HNF-3885
Rev. 0
Feb. 24, 1999

AC 5.19, Process Instrumentation and Measuring and Test Equipment
AC 5.20, Transfer Pump Administrative Lock Controls
AC 5.21, Tank Service Water Intrusion Monitoring Program
AC 5.22, Transfer System Cover Removal Controls

2.0 TERMS, DEFINITIONS, AND SYMBOLS

ABU	Acceptance for Beneficial Use
ACI	American Concrete Institute
AISC	American Institute of Steel Construction
ALARA	As-Low-As-Reasonably-Achievable
ANSI	American National Standard Institute
BIO	Basis for Interim Operation
BPA	Bonneville Power Administration
CAM	Continuous Air Monitor
cc	cubic centimeter
CFR	Code of Federal Regulations
cP	Centipoise
DACS	Data Acquisition and Control System
DST	Double Shell Tank
ECN	Engineering Change Notice
g	gram
GPM	Gallons Per Minute
HEPA	High Efficiency Particulate Air-filter
HMS	Hanford Meteorological Service
HVAC	Heating, Ventilating and Air Conditioning
LANL	Los Alamos National Laboratory
lbf	pounds force
NFPA	National Fire Protection Association
NGTP	New Generation Transfer Pump
PPP	Prefabricated Pump Pit
QAPP	Quality Assurance Program Plan
RAPID	Respond and Pump in Days
SA	Safety Assessment
SG	Specific Gravity
SSC	Systems, Structures, and Components
TBD	To Be Determined
TWRS	Tank Waste Remediation System
USQ	Unreviewed Safety Question
VFD	Variable Frequency Drive

3.0 APPLICABLE DOCUMENTS AND INFORMATION

The following documents form a part of these requirements to the extent specified herein.

3.1 APPLICABLE HANFORD STANDARD DESIGN CRITERIA AND PRACTICES

HNF-PRO-097	Engineering Design and Evaluation
HNF-PRO-704	Hazard and Accident Analysis Process
HNF-PRO-1621	ALARA Decision Making Methods
HNF-PRO-1622	Radiological Design Review Process
HNF-PRO-1819	PHMC Engineering Requirements
HNF-IP-0842	TWRS Administration Manual, Volume IV, "Engineering"

3.2 APPLICABLE CONSENSUS CODES AND STANDARDS

These are the Codes and Standards identified at this time. Others may be identified as the design progresses. The latest issue of codes and standards shall be used.

ACI	American Concrete Institute P.O. Box 19150 Detroit, MI 48219
ACI-301	Specification for Structural Concrete for Buildings
ACI-318	Building Code Requirements for Reinforced Concrete
ACI-349	Code Requirements for Nuclear Safety Related Concrete Structures
AISC	American Institute of Steel Construction 400 North Michigan Avenue Chicago, IL 60611
AISC	Manual of Steel Construction
ANS	American Nuclear Society 555 North Kensington Avenue LaGrange Park, IL 60525

ANS 6.4	Guidelines on the Nuclear Analysis and Design of Concrete Radiation Shielding for Nuclear Power Plants
ANSI	American National Standards Institute 1430 Broadway New York, NY 10018
ANSI B30	Hoisting and Rigging Standards
ANSI N512	Protective Coatings (Paint) for the Nuclear Industry
ASME	American Society of Mechanical Engineers 22 Law Drive Box 2300 Fairfield, NJ 07007
ASME	Boiler and Pressure Vessel Code
ASME B31.1	Power Piping
ASME B31.3	Process Piping
ASME N509	Nuclear Power Plant Air Cleaning Units and Components
ASME N510	Testing of Nuclear Air Cleaning System
ASME NQA-1	Quality Assurance Program Requirements for Nuclear Facilities
ASTM	ASTM 1916 Race Street Philadelphia, PA 19103
ASTM A312	Specification for Seamless and Austenitic Stainless Steel Pipe
AWS	American Welding Society 550 NW LeJeune Road P.O. Box 351040 Miami, FL 33135
AWS D1.1	Structural Welding Code - Steel
AWS D5.2	Standard for Welded Steel, Elevated Tanks, Standpipes, and Reservoirs for Water Storage
BOCA	Building Officials and Code Administrators International, Inc. 4051 West Flossmoor Road Country Club Hills, IL 60477
BOCA	Basic/National Mechanical Code

DOD	U. S. Department of Defense Attention: NPFC Code 1052 Naval Publications and Forms Center 5801 Tabor Avenue Philadelphia, PA 19120-5099
DOD	MIL-STD-1472C, Human Engineering Design Criteria for Military Systems, Equipment, and Facilities
EPRI	Electric Power Research Institute P.O. Box 10412 Palo Alto, CA 94303
EPRI NP-3659	Human Factors Guide for Nuclear Power Plant Control Room
IAPMO	International Association of Plumbing and Mechanical Officers 5032 Alhambra Avenue Los Angeles, CA 90032-3490
IAPMO	UPC, Uniform Plumbing Code
ICBO	International Conference of Building Officials 5360 South Workman Road Mill Road Whittier, CA 90601
ICBO	UBC (Uniform Building Code)
LLNL / UCRL	Lawrence Livermore National Laboratory Livermore, CA 94550
UCRL 15673	Human Factors Design Guidelines for Maintainability of DOE Nuclear Facilities
NFPA	National Fire Protection Association Batterymarch, Park Quincy, MA 02269
NFPA 70	National Electrical Code (NEC)
NFPA 497A	Classification of Class 1 Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas

3.3 APPLICABLE DOE ORDERS

**U.S. Department of Energy
1000 Independence Ave, SW
Washington, DC 20585**

DOE 5480.11	Radiation Protection for Occupational Workers
DOE 5480.21	Unreviewed Safety Questions
DOE 5480.4	Environmental Protection, Safety, and Health Protection Standards
DOE 6430.1A	General Design Criteria
DOE-RL-92-39	Hanford Site Hoisting and Rigging Manual

3.4 APPLICABLE GOVERNMENT REGULATIONS

**Code of Federal Regulations
Superintendent of Documents
Government Printing Office
Washington, DC 20402**

10 CFR 830	Quality Assurance
10 CFR 835	Occupational Radiation Protection
29 CFR 1910	Occupational Health and Safety Standards
29 CFR 1926	Safety and Health Regulations for Construction

**Washington Administrative Code
State of Washington
Olympia, WA**

WAC 173-303	Dangerous Waste Regulations
WAC 296-46	Installing Electric Wires and Equipment

3.5 DRAWINGS

Drawing Number	Sheet	Rev.	Date	Title
H 140100573	1	0	10/2/96	DRAWING LIST & AREA MAP
H 140100586	1	0	3/31/97	DRAWING LIST & AREA MAP
H 140100586	2	0	3/31/97	DRAWING LIST & AREA MAP
H 140100586	1	0	3/31/97	DRAWING LIST & AREA MAP
H 140100586	2	0	3/31/97	DRAWING LIST & AREA MAP

HNF-3885
Rev. 0
Feb. 24, 1999

Drawing Number	Sheet	Rev.	Date	Title
H 140100573	1	0	10/2/96	DRAWING LIST & AREA MAP
H 140100587	1	0	3/31/97	CIVIL SITE PLAN 241-SY TANK FARM
H 020037778	1	6	12/16/92	PIPING PLAN TANKS 101 102 & 103
H 020037778	2	5	12/16/95	PIPING PLAN TANKS 101 102 & 103
H 020037778	3	1	1/7/93	PIPING PLAN 241-SY TANK FARM
H 020037780	1	7	5/20/97	PIPING PLAN VALVE PITS 241-SY-A & B
H 020037781	1	3	2/19/93	PIPING SECTS & DETAILS VALVE PITS 241-SY-A & B
H 020037783	1	5	2/13/96	PIPING PLAN & DETAILS PUMP PIT 241SY-01A, 02A, 03A
H 020037785	1	3	3/19/93	PIPING PLAN & DETAILS ANNULUS PUMP PIT 241-SY-01B,03B
H 140010531	1	0	4/23/98	DOME PENETRATION SCHEDULES (WST/WSTA) TANK 241-SY-101
H 140010531	2	0	4/23/98	DOME PENETRATION SCHEDULES (WST/WSTA) TANK 241-SY-102
H 140010531	3	0	4/23/98	DOME PENETRATION SCHEDULES (WST/WSTA) TANK 241-SY-103
H 140100598	1	0	3/31/97	PIPING AREA PLAN TANK 241-SY-102
H 140100599	1	0	3/31/97	PIPING TANK 241-SY-102 PLAN, SECTIONS & DETAILS
H 140100599	2	0	3/31/97	PIPING TANK 241-SY-102 SECTION & DETAILS
H 140100599	3	0	3/31/97	PIPING TANK 241-SY-102 PLAN, SECTIONS & DETAILS
H 140100599	4	0	3/31/97	PIPING TANK 241-SY-102 PLAN & SECTIONS
H 140100599	5	0	3/31/97	PIPING TANK 241-SY-102 PLAN & SECTIONS
H 020037770	1	9	4/7/98	ENGINEERING FLOW DIAGRAM MISCELLANEOUS
H 020037770	2	4	5/21/98	ENGINEERING FLOW DIAGRAM MISCELLANEOUS
H 020037771	1	2	1/1/77	HYDRAULIC DIAGRAM TK-101,102+103
H 140100701	1	0	3/31/97	ELECTRICAL TANK 241-SY-102 ONE LINE DIAGRAM
H 020037732	1	9	4/14/97	ELECTRICAL SITE PLAN
H 020037732	2	1	12/1/95	ELECTRICAL SITE PLAN
H 020037732	3	0	7/8/93	ELECTRICAL SITE PLAN
H 020037734	1	16	7/16/98	ELECTRICAL INSTMT HOUSE PLANS
H 020037736	1	7	4/7/97	ELECTRICAL DETAILS
H 020037736	2	1	2/2/96	ELECTRICAL DETAILS
H 020038373	1	1	2/1/76	ELECT LEAK DETECTION ALARM S,SX,SY+U TK FARMS
H 020046789	1	7	6/11/97	ELEC/INSTR PLANS EL DET & ELEM DIAGS

Drawing Number	Sheet	Rev.	Date	Title
H 020046789	2	1	9/30/92	ELEC/INSTR PLANS EL DET & ELEM DIAGRAMS
H 140100572	1	0	3/8/96	ELECTRICAL CATHODIC PROTECTION PLAN (EN)
H 140100720	1	0	3/31/97	ELECTRICAL TANK 241-SY-102 CATHODIC PROTECTION PLAN
H 140100721	1	0	3/31/97	ELECTRICAL TANK 241-SY-102 CATHODIC PROTECTION DETAILS
H 140100571	1	0	3/8/96	ELECTRICAL CATHODIC PROTECTION SCHEMATIC (EN)
H 140100500	1	0	3/26/96	SY TANK FARM UNDERGROUND CONDUIT LAYOUT AND DETAILS
H 140100500	2	0	3/26/96	SY TANK FARM UNDERGROUND CONDUIT LAYOUT AND DETAILS
H 140100501	1	0	3/26/96	TANK SY-101 UNDERGROUND CONDUIT LAYOUT AND DETAILS
H 140100501	2	0	3/26/96	TANK SY-101 UNDERGROUND CONDUIT LAYOUT AND DETAILS
H 140100502	1	0	3/26/96	TANK SY-102 UNDERGROUND CONDUIT LAYOUT AND DETAILS
H 140100602	1	0	3/31/97	JUMPER ARRANGEMENT PUMP PIT 241-SY-02A
H 140100602	2	0	3/31/97	JUMPER ARRANGEMENT PUMP PIT 241-SY-02A NOZ LOCATIONS
H 140100603	1	0	3/31/97	JUMPER ARRANGEMENT VALVE PIT 241-SY-A
H 140100604	1	0	3/31/97	JUMPER ARRANGEMENT VALVE PIT 241-SY-B
H 140100606	1	0	3/31/97	PIPING VALVE PIT 241-SY-A MODIFICATIONS
H 140100607	1	0	3/31/97	PIPING VALVE PIT 241-SY-B MODIFICATIONS

3.6

REFERENCES, OTHER DOCUMENTS AND INFORMATION

- A. Raymond, R. E., 1999, "Tank 241-SY-101 Surface Level Rise Remediation Project," HNF-3824, Rev. 0, Lockheed Martin Hanford Company, Richland, WA Feb.
- B. Estey, S. D., 1999, "Anticipated Dynamic Viscosity and Solids Concentration of Slurries Produced During the Dilution and Transfer of Tank 241-SY-101 Wastes to Tank 241-SY-102," (Internal Memo number 74B50-99-017, to W. J. Powell, Feb. 11), Lockheed Martin Hanford Company, Richland, WA (See Appendix A).

- C. Lindner, Toghiani and Barfield, 1998, "Thermodynamic Simulation of Hanford Tank 241-SY-101 Dissolution – Part 2: Supernate Transfer Followed by In-Tank Dillution.", Mississippi State University, Mississippi
- D. Herting, D.L., et al, 1995, "Tank Characterization Report for Double-Shell Tank 241-SY-101," WHC-SD-WM-ER-409, Rev. 0, Westinghouse Hanford Company, Richland, WA, July
- E. LMHC, 1999, "Tank Waste Remediation System Basis for Interim Operation, (BIO)", HNF-SD-WM-BIO-001, Revision 1-A, Lockheed Martin Hanford Company, Richland, Washington
- F. Sullivan, L. Harold, 1996, WHC-SD-WM-SAD-033, Rev 2, "A Safety Assessment for Proposed Pump Mixing Operations to Mitigate Episodic Gas Releases in Tank 241-SY-101: Hanford Site, Richland, WA." Westinghouse Hanford Company, Richland, WA July.
- G. Flammable Gas Equipment Advisory Board Meeting Minutes, January 19, 1999. (See Appendix B).
- H. Hauck, F. M, 1994, WHC-S-0238, "Specification For Prototype Tank Farm Transfer Pumps with Submersible Motor," Westinghouse Hanford Company, Richland, WA August
- I. Westinghouse, 1997, S.O. V001, "Model 2A-513-A1 Lead Unit Final Design Report Addendum," Westinghouse Electric Corporation, Electro-Mechanical Division, Cheswick, PA April
- J. Carter, S. B., 1988, SD-RE-DGS-002, Rev. 3, "Jumper Design Standard," Westinghouse Hanford Company, Richland, WA Oct.
- K. Conner, J. M., 1999, "Estimated Properties of Tank 241-SY-101 Waste Affecting Dilution and Transfer," (Internal Memo, DRAFT, to W. J. Powell, Feb. 26), Lockheed Martin Hanford Company, Richland, WA. (See Appendix E).

4.0 FUNCTIONS AND REQUIREMENTS

4.1 DEFINITION

The RAPID system is envisioned as a simple, dedicated transfer system that is used to transfer waste from SY-101 to SY-102. The system design will use an existing, available 42-inch riser for installation of the NGTP. This will be accomplished via the installation of a prefabricated pump pit around the riser that will provide the typical shielding, confinement, and drain functions provided by existing cast in place concrete pits.

To perform the waste transfer the waste is to be diluted at a nominal ratio of 1:1 with warm raw water injected at the NGTP suction. Similarly, post transfer flushing of the NGTP and the transfer line is accomplished using warm water. To ensure an adequate supply of water at the required flow rates and pressures (see Process Flow Diagram, Appendix C), the RAPID system design requires a water skid. Water is supplied from the tank farm water system to the water skid. The skid contains a number of pumps, and a water holding tank that ensures an adequate supply of transfer line flush water is available to flush the pump and transfer lines in the event of a disruption of the tank farm water supply.

Control of the RAPID system is to be accomplished without the use of remote/automatically operated equipment to the maximum extent practicable. This operational philosophy will enhance system reliability by reducing the number of components that could fail and require cessation of a transfer. Similarly, operator-training requirements are minimized.

The design for the RAPID system must provide for the repair or replacement of assemblies or components that have failed either during, or between transfer pumping operations. Design provisions may include temporary shielding remotely installed and/or remote operations,

A requirement for routine maintenance of radioactively contaminated equipment and equipment in radiation zones is highly undesirable. The design of the RAPID mitigation system shall provide for a 5 year operating life, and shall not require planned replacement of any components during that life. Assume that repair of a transfer pump that has failed in operation is not feasible. This does not preclude the performance of routine, or post transfer operations of very low, or no dose consequence that would extend the life of the RAPID system's hardware. Provision shall be made within the RAPID system design for replacement of ex-tank components that have failed in-service (e.g. control valves, valve operators, sensing elements, gauges).

4.2 CHARACTERISTICS

4.2.1 Waste

4.2.1.1 The NGTP shall be capable of pumping fluids with specific gravities (SG) ranging between 1.0 and 1.7, with viscosity values ranging between 0.55-600 centipoise (cP) at 50 per second shear rate (Reference B).

4.2.1.2 The solids intrinsic to the tank waste have a density of 2.0-2.2 g/cc (Reference C). The bulk densities of the convective waste at tank temperatures range from 1.54 to 1.75 g/cc (Reference D. See also for chemical composition of the SY-101 waste.).

4.2.1.3 Waste temperatures within SY-101 range between 47.2 °C (117° F) and 54.5 °C (130 °F) (maximum per the Authorization Basis, Reference E), with a mean value of 50 °C (122 °F).

4.2.1.4 Temperatures of the diluted waste should be between 43.3 and 54.4°C (110 and 130° F) during transfers.

4.2.2 New Generation Transfer Pump

4.2.2.1 As a minimum, the pump provided must be capable of transferring 380 - 570 m³ (100,000-150,000 gallons) of waste (see paragraph 4.3.1.6) with its associated dilution water (nominal combined volume of waste and diluent is 760-1140 m³) out of SY-101, to SY-102. The transfer must be completed in less than 20 days.

4.2.2.2 The PPP design shall locate the transfer pump's suction bell 0.92 to 4.6 m (3 to 15 ft) above the bottom of SY-101.

4.2.3 Prefabricated Pump Pit

The design of the PPP shall provide a drain and seal loop back to the waste tank capable of draining 20 gallons a minute back to tank without plugging, or capable of being unplugged. The seal loop fluid shall be environmentally and waste compatible.

4.2.4 Transfer Line and Drop Leg

4.2.4.1 The minimum diluted waste transfer line velocities shall not be less than 1.8 m/sec (6 ft/sec).

- 4.2.4.2 The primary piping's minimum bend radius (at centerline) outside the PPP shall not be less than 5 pipe diameters.
- 4.2.4.3 The drop leg design shall discharge at an elevation approximately 4 m (160 in) above the bottom of the SY-102 tank.
- 4.2.5 Instrumentation
 - 4.2.5.1 Instrumentation shall be selected ensuring that measured properties are within 30-70% of the instrument span during normal system operation.
 - 4.2.5.2 All instrumentation shall be designed to accommodate simple in-situ operability or functional testing.
 - 4.2.5.3 The design shall include provision for isolation of sensing lines where applicable.
- 4.2.6 Infrastructure
 - 4.2.6.1 Electrical
 - 4.2.6.1.1 A minimum of 160 amps, of 480 V, 3 phase power shall be supplied to the transfer pumps VFD enclosure, located outside the farm in the MCC building, 241-SY-272.
 - 4.2.6.1.2 20 Amps of 120 V, single phase control power supplied to the RAPID Mitigation systems control console. The design for provision of power/monitoring of the leak detectors installed in Riser 007 of SY-101, and the drop leg location of SY-102 shall be completed as part of the control system design.
 - 4.2.6.2 Water
 - 4.2.6.2.1 Infrastructure upgrades shall provide a water supply sufficient to support a 380 - 570 m³ (100,000 - 150,000 gallon) batch transfer of waste from SY-101, and for post transfer line and pump flushing at the conclusion of pumping.
 - 4.2.6.2.2 The design of the dilution/flush water system shall ensure that in the event of a component failure or an operational discrepancy, no more than 7570 liters (2000 gallons) of water could be added to either SY-101 or -102.

- 4.2.6.2.3 Requirements for flush and dilution water flow rates are identified in the RAPID system Process Flow Diagram (see Appendix C).
- 4.2.6.2.4 Water supplied by the water system for waste dilution shall be at 120 ± 10 °F.
- 4.3 TECHNICAL DESIGN REQUIREMENTS, CONSTRAINTS, AND CRITERIA
 - 4.3.1 System
 - 4.3.1.1 Deployment of the RAPID mitigation system should not preclude operation, or replacement of the mixer pump installed in SY-101's central pump pit, or the transfer pump installed in SY-102.
 - 4.3.1.2 The design of the RAPID mitigation system shall allow for the installation of its hardware with minimum dose consequence.
 - 4.3.1.3 Design of the RAPID must be completed on a schedule that will allow deployment of the system in time to complete an initial transfer from SY-101 by September 24, 1999.
 - 4.3.1.4 The RAPID system is intended for use on a batch transfer basis, with the dedicated transfer line and pump flushed following the completion of a waste transfer.
 - 4.3.1.5 The use of automatic/remote controls shall be minimized to the maximum extent practicable both to minimize training requirements, and to minimize the number of components/interface requirements that could compromise the system's operating reliability.
 - 4.3.1.6 The control valves and associated process piping provided as part of the pump-PPP assembly shall provide for the following system operating configurations:
 - 4.3.1.6.1 In-line dilution: Piping, and control valves shall:
 - 4.3.1.6.1.1 allow 100% dilution water supply to the pump suction at start-up.
 - 4.3.1.6.1.2 ensure instantaneous SY-101 waste transfer flow rates (in seconds) do not exceed 3 times dilution water flow rates.
 - 4.3.1.6.1.3 provide an adjustable lower interlock/alarm limit on dilution water flow.
 - 4.3.1.6.2 Internal Flush: This configuration of piping and control valves shall provide for an internal flush of the transfer pump using heated, raw water controlled within the transfer pump/PPP interface.

- 4.3.1.6.3 Transfer Line Flush: This configuration shall provide for a decontamination flush of the transfer lines using heated raw water to lower radiation fields in regions surrounding the transfer line after a batch transfer of waste has been completed. The transfer pump, including pump flush and dilution lines are isolated from the flush water to allow for more effective flush of the transfer lines and a more accurate accounting of the total water addition to SY-102.
- 4.3.1.6.4 Transfer line Preheat: This configuration will allow the transfer line to be preheated before transfer of the waste using heated water.
- 4.3.1.7 The design of the transfer pump and associated discharge "leg" shall ensure that the pump will not be subject to air binding during normal operation when pumping fluid media. Provisions for and the methods of clearing an "air bound" pump shall be explicitly identified in design media.
- 4.3.1.8 The design shall enable an adjustable upper limit on transfer pump speed.
- 4.3.1.9 Ensure adequate redundancy in design and spares so that the system can accommodate without damage to the operators, tank farm, or project goals, equipment failures that may occur.
- 4.3.1.10 A D & D Plan shall be prepared as part of the RAPID system design.
- 4.3.1.11 Temperature extremes are identified in the BIO. Design operating temperatures for the RAPID system are (-)7 to 38 °C (20 - 100 °F).
- 4.3.1.12 All environmental load conditions are identified in HNF-PRO-097.
- 4.3.2 Prefabricated Pump Pit

The PPP provides for the following:

- Installation of the transfer pump into Tank 241-SY-101's Riser 007,
- incorporates shielding to reduce radiation dose fields in operator accessed regions around the riser,
- fulfills a confinement function (sized in accordance with the authorization basis requirements for minimum and maximum pit size) in the case of a spray leak at the mechanical connection of the transfer pump to the transfer and flush lines,
- contains control valves necessary to accomplish remote decontamination and flushing of waste transfer lines and pump internals,
- and accommodates the electrical feed throughs necessary to supply power and allow monitoring and control of transfer components installed in the riser,

- provides a drain back to the tank

4.3.2.1 Pump Mounting

4.3.2.1.1 The PPP shall be isolated from the SY-101 tank dome space. The NFPA Hazardous (classified) locations within the PPP is classified as "non-classified" in accordance with the Safety Assessment (Reference F), and in accordance with the guidance of the Flammable Gas Equipment Advisory Board (see meeting minutes in Appendix B). Below the PPP, the pump design must meet the requirements for a Class 1, Div 1, Group B environment.

4.3.2.1.2 The PPP shall provide for mounting of the transfer pump in a 106.68-cm (42") diameter tank riser. A survey shall be performed to determine the riser's as-built dimensions that shall be incorporated into an as-built drawing. A sketch of the transfer pump's mounting flange is included in Appendix D.

4.3.2.1.3 The PPP's maximum diameter below the mating flange shall not exceed 101.6 cm (40").

4.3.2.1.4 The overall length of the PPP shall not extend below the junction of the primary and secondary tank walls.

4.3.2.1.5 The design of the PPP shall not amplify the pump resonant frequencies.

4.3.2.1.6 The design shall allow for the removal/replacement of a failed transfer pump without removal of the PPP.

4.3.2.1.7 The design of the PPP assembly must provide for the mechanical/electrical feed throughs. Design of the feed throughs shall not preclude replacement of a failed transfer pump while the PPP assembly is installed in the waste tank.

4.3.2.1.8 The PPP assembly includes piping and control valves necessary to allow flushing of the transfer line, pump bearings, and pump internals.

4.3.2.1.9 Piping and valves shall be configured to allow manual control of dilution water supply to the transfer pump.

4.3.2.1.10 Connections to the transfer pump shall be made via remote connection or methods with short radiation exposure durations during field installation and removal.

4.3.2.1.11 The piping design within the PPP shall preclude the accumulation of solids after a pump shutdown.

- 4.3.2.2 Seal Loop/Drain
 - 4.3.2.2.1 During routine operations, the seal loop shall provide a water seal, isolating the internal environs of the PPP from the waste tank's dome space. Nominal tank dome space operating pressure is 1-4 inWC vacuum (maximum 6 inWC).
 - 4.3.2.2.2 A method for freeze protection, remote monitoring and filling of the seal loop shall be provided.
 - 4.3.2.2.3 The drain design shall allow a depth accumulation of at least 1.27-cm (1/2") of liquid in the bottom of the pre-fabricated pump pit prior to draining to tank to allow sufficient accumulation of liquid for activation of the leak detectors. The design shall allow for complete drainage from the PPP after a leak detector alarm per the requirements of WAC 173-303-640.
 - 4.3.2.2.4 The design of the PPP assembly shall incorporate a Safety Class leak detector.
 - 4.3.2.2.5 Those portions of the PPP that function as a secondary containment barrier to the primary piping must comply with the WAC 173-303-640 (4) "Containment and detection of releases" requirements.
- 4.3.2.3 Decontamination Spray Ring
 - 4.3.2.3.1 A high-pressure spray ring (maximum capacity 20,684 kPa (3000 psi) and supply line shall be provided as part of the PPP design.
 - 4.3.2.3.2 The ring shall have nozzles mounted that provide 360° of coverage directed at the pump centerline.
 - 4.3.2.3.3 The spray ring shall be mounted on the exterior bottom surface of the PPP.
 - 4.3.2.3.4 Spray nozzle design and orientation shall be selected to minimize the formation of aerosols and provide maximum cleaning.
 - 4.3.2.3.5 Spray ring piping shall terminate outside of the PPP.
- 4.3.2.4 Transfer System (PPP) Cover
 - 4.3.2.4.1 The design of the PPP shall isolate equipment contained within the interior of the PPP from the tank dome space environment.
 - 4.3.2.4.2 The design of the PPP shall ensure that new spurious air-ingress paths into the tank dome space are not created. This seal(s) must withstand

the (-)6 inWC differential pressure, the maximum vacuum generated by the existing primary ventilation system.

- 4.3.2.4.3 The design shall ensure that a confinement boundary that prevents the migration of radioactive contamination and prevents communication between the PPP and the environs is established.
- 4.3.2.4.4 The transfer system (PPP) cover must allow for replacement of the transfer pump without removing the PPP. The safety class function of the cover is to provide a tortuous path boundary between the waste tank dome space and the environs in the event of a waste line spray leak.
- 4.3.2.4.5 The transfer system cover shall also provide a non-sparking access port for vapor space monitoring of flammable gas concentrations within the closed PPP assembly.
- 4.3.2.4.6 The design of the PPP and transfer system cover shall preclude the buildup of flammable gasses.
- 4.3.2.5 Transmitted Loads
 - 4.3.2.5.1 Loads transferred to the riser/tank dome via the PPP assembly, at any time during the PPP's installation in the tank, including installation, pump operation and transfer, shall not damage the tank or riser (see Section 4.5 below). The design and installation procedures shall ensure that drop loads that could occur during installation in the riser are covered by the BIO.
 - 4.3.2.5.2 The transfer pump installation, support load frame, and the existing tank structures (riser and tank dome) shall not be damaged or exceed allowable stresses when subjected to the maximum loads and any cyclic loads that occur from operation of the transfer pump or the mixer pump. Cyclic loads shall address the effect of the mixer pump operation on the transfer pump and the normal cyclic loading caused by operation of the transfer pump. The transfer pump shall not be damaged or exceed allowable stresses when subjected to cyclic loads caused by operation of the mixer pump.
- 4.3.3 Transfer Line
 - 4.3.3.1 Primary Piping
 - 4.3.3.1.1 The primary transfer piping is rated as general service, and provides no safety function.
 - 4.3.3.1.2 The inner pipe shall be designed and fabricated in accordance with the provisions of ASME B31.3 (use latest version). In no instance may the

rated working pressure of the newly installed piping be less than that prescribed by the M-25 Piping Code as modified by B-101-C3 (230 psig).

- 4.3.3.1.3 Connections of the inner pipe to pump and drop leg connections may be made via mechanical methods.
- 4.3.3.1.4 For welded connections, welders and welding procedures shall be qualified in accordance with ASME B&PV Code, Section IX.
- 4.3.3.2 Encasement Piping
 - 4.3.3.2.1 The transfer line encasement is a Safety Class component.
 - 4.3.3.2.2 The encasement piping shall be designed and fabricated in accordance with the provisions of ASME B31.3, with additional inspection requirements as identified in ASME B & PVC, Section V, and quality assurance requirements per ASME NQA-1. In no instance may the rated working pressure of the newly installed piping be less than that prescribed by the M-26 Piping Code as modified by B-101-C3 (60 psig).
 - 4.3.3.2.3 A manner for objectively verifying the integrity of the barrier formed by the encasement piping while connected to the transfer pump and drop leg after installation in the field shall be provided by the design (pressure test).
- 4.3.3.3 Transfer Line Assembly
 - 4.3.3.3.1 Spacers or shims used to locate the primary piping shall not impede the gravity flow of liquid within the encasement piping to leak detection elements.
 - 4.3.3.3.2 Jumper design (if applicable) and fabrication shall be compatible with existing design (Reference J) criteria.
- 4.3.3.4 Leak Detectors
 - 4.3.3.4.1 RAPID system leak detectors shall be provided at all low points. The number of low points shall be minimized to the extent practicable.
 - 4.3.3.4.2 A leak detector system that complies with WAC 173.303 requirements shall be provided for the transfer line and/or transfer associated structure(s).
- 4.3.3.5 Heat Trace
 - 4.3.3.5.1 The transfer line piping shall be provided with thermostatically controlled heat trace.

- 4.3.3.6 Drop Leg
 - 4.3.3.6.1 Drop leg discharge to the tank shall be accomplished so as to maximize the horizontal component of the stream velocity to facilitate mixing of the discharge stream with the contents of SY-102.
 - 4.3.3.6.2 Drop leg discharge configuration shall be designed to:
 - 4.3.6.6.2.1 minimize the restriction to transfer system flow rates,
 - 4.3.6.6.2.2 prevent the accumulation of solids,
 - 4.3.6.6.2.3 minimize the potential for plugging.
- 4.3.4 Control and Instrumentation
 - 4.3.4.1 Control
 - 4.3.4.1.1 Operator Interface: The transfer pump controls shall be limited to an on-off key switch at the DACS transfer pump panel and an emergency trip at the Farm control panel.
 - 4.3.4.1.2 Transfer Pump Status: Operating lights shall be provided that indicate the status (ON/OFF) of the transfer pump at both transfer pump control locations.
 - 4.3.4.1.3 Engineering Interface: The design of the RAPID System shall allow for engineering directed alteration of the transfer pump's variable frequency drive settings.
 - 4.3.4.1.4 Water Skid Flush/Dilution Pump(s) Status: Operating lights shall be provided as part of the water skid that indicate the status (ON/OFF) for each of the water skid pumps.
 - 4.3.4.1.5 The Rapid system's piping configuration is to be administratively controlled. All valve operation performed to reconfigure the system is to be performed manually to the maximum extent practicable.
 - 4.3.4.2 Instrumentation
 - 4.3.4.2.1 A transfer system control panel (remote) will be installed in DACS Trailer.
 - 4.3.4.2.2 The transfer system will not interface with the DACS.
 - 4.3.4.2.3 The use of installed spares shall be considered as part of the design.

- 4.3.4.2.4 Transfer Line Pressure: Transfer line pressure shall be monitored and displayed.
- 4.3.4.2.5 Transfer Line Flow: Flows of diluted waste and transfer line flush water shall be monitored and displayed.
- 4.3.4.2.6 Transfer Line Temperature: Transfer line waste temperatures shall be displayed.
- 4.3.4.2.7 Dilution Line Flow: Dilution line flow rates shall be displayed.
- 4.3.4.2.8 Water Skid Tank Temperature: Water temperatures in the skid water tank shall be displayed.
- 4.3.4.2.9 Service Water Totalizer: The raw water supply shall be equipped with a safety significant flow totalizer that will indicate total water supplied to the RAPID System.
- 4.3.4.2.10 Transfer System Leak Detection: Intrinsically safe leak detectors shall be installed in any low points. Leak detectors shall be set to alarm at 1.27 cm (1/2") liquid level. Both visual and audible indication of alarm shall be provided.
- 4.3.4.2.11 Water Skid Flush/Dilution Pump Pressure: The discharge pressure of the water skid flush/dilution water pump(s) shall be displayed.
- 4.3.4.2.12 Water Skid Flush/Dilution Pump Flow: The flow rate from the water skid flush/dilution water pump(s) shall be displayed.
- 4.3.4.2.13 Water Skid Water Flow Totalizer: The water skid discharge piping shall be equipped with a flow totalizer that will indicate total water supplied discharged from the flush/dilution water pumps.
- 4.3.4.2.14 Sensing elements shall readout both locally and remotely. Minimum requirements are defined in Table 4-1. Columns in the table are defined below:
- PPP: An indicator panel at the PPP, within view of the operator controlling dilution line valve settings. Location of the panel will consider ALARA principles.
 - Remote: An indicator panel within the Data Acquisition and Control System (DACS) trailer near the transfer pump-operating console.
 - Local: Local displays shall be located at or near the sensing element installation location.
 - Skid: An indicator panel located on the portable water skid.

**TABLE 4-1
INSTRUMENTATION/ALARM INDICATION LOCATION**

	PPP	Remote	Local	Skid
INSTRUMENT READOUT				
Transfer Line Pressure	X			
Transfer Line Flow	X	X		
Transfer Line Temperature	X	X		
Dilution Line Flow	X	X		
Transfer Pump Operation (ON/OFF)	X	X		
Emergency Trip Transfer Pump	X			
Service Water Flow Totalizer			X	
Water Skid Tank Temperature				X
Water Skid Flush/Dilution Pump Pressure				X
Water Skid Flush/Dilution Pump Flow				X
Water Skid Water Flow Totalizer				X
Water Skid Pump Run Indication				X
ALARMS				
Leak Detection	X	X	X	
Low Dilution Line Temperature	X	X		
Low Seal Loop Level	X	X		
Flush Water Isolation Pressure	X	X		X
Water Skid Tank High Level				X
Water Skid Tank Low Level				X

4.3.5 Alarms

- 4.3.5.1 Leak Detection: The RAPID System shall be provided with both visual and audible indication (both local and remote locations) that a leak has been detected in any of the RAPID system dedicated leak detectors.
- 4.3.5.2 Low Dilution Line Temperature: Indicates in-line dilution of waste may be having a detrimental effect on waste temperature during transfer, and may result in plugging of the transfer line. Requires operator evaluation.
- 4.3.5.3 Low Seal Loop Level: Indicates liquid level low in the PPP seal loop.
- 4.3.5.4 Flush (Transfer Line and Pump Cavity) Water Isolation Pressure: A pressure switch shall be provided that will trigger both audible and visual indication of a loss of pressure boundary integrity at the waste/raw water interface.
- 4.3.5.5 Water Skid Tank High Level: A level alarm shall be provided that gives visual and audible indication of a high water level in the water skid flush/dilution water holding tank.

- 4.3.5.6 Water Skid Tank Low Level: A level alarm shall be provided that gives visual and audible indication of a low water level in the water skid flush/dilution water holding tank.

- 4.3.6 Interlocks
 - 4.3.6.1 Dilution Water Supply: An interlock shall be provided that stops transfer pump operations on high or low dilution water flow rates.
 - 4.3.6.2 Transfer Line: A feature to prevent an inadvertent water addition to the waste tanks shall be designed.

- 4.3.7 Infrastructure
 - 4.3.7.1 Water
 - 4.3.7.1.1 Cross contamination control is required to prevent the contamination of the service water supply source from waste in the transfer pump piping/transfer lines.
 - 4.3.7.1.2 The design of the dilution/flush water supply system shall incorporate safety class features that will prevent the contamination of the water supply by tank waste.
 - 4.3.7.1.3 Heated water shall be supplied to the PPP for use as dilution water by the transfer line.
 - 4.3.7.1.4 A skid mounted totalizer and flow meter (GPM) shall be included in the raw water system infrastructure upgrades.
 - 4.3.7.1.5 Water supply piping shall be designed and constructed in accordance with the provisions of ANSI B31.3.
 - 4.3.7.1.6 Provision shall be made for a flush of the transfer line in the event of a loss of heated raw water.
 - 4.3.7.2 Electrical
 - 4.3.7.2.1 Electrical power shall be routed to the PPP in accordance with National Electrical Code requirements.
 - 4.3.7.2.2 Any power or control wiring that is not permanently installed in underground Trendways or buried conduit shall have receptacles, plugs, and connectors to allow removal after use without tools of any kind. (e.g.- if a power cord is run temporarily on the ground, the above ground portion

should have welding type connectors at each end, so the cord can be easily disconnected and removed when not in service.)

4.3.8 Installation Hardware

The PPP and drop leg assemblies shall be provided with lifting attachment points. These attachment points shall be used during installation of the assembly into position. Lifting attachment points shall be designed such that the assembly can be adjusted to hang plumb within ± 2.54 cm (1") over its length during installation in the tank with a crane. Below-the-hook lifting hardware, if required, shall be designed and provided with the PPP assembly. Design shall be in accordance with ANSI B30.20, and DOE-RL-92-36, *Hanford Site Hoisting and Rigging Manual*.

4.4 MATERIALS

- 4.4.1 Selection of materials shall consider operations, maintenance, and decontamination and decommissioning in addition to ensuring compatibility with interfacing components and environments.
- 4.4.2 All piping within the PPP shall be 304L Series Stainless Steel (ASTM A312) to minimize corrosion and facilitate decontamination.
- 4.4.3 Each major component fabrication specification or drawing shall specify the appropriate standard to be used for material procurement.
- 4.4.4 The use of hazardous materials (e.g., lead) shall be minimized and specifically identified in design media. The use of organic based lubricants in components or assemblies of the RAPID System that must be placed in the waste tanks shall be avoided. If lubricants must be used, special consideration shall be given to ensure that the lubricant will not leak into the tank.
- 4.4.5 The drop leg assembly shall be fabricated from 300L series stainless steel to facilitate decontamination during removal, and minimize its potential for corrosion in the tank.
- 4.4.6 Welding of the drop leg shall be in accordance with AWS D1.1 or other recognized equivalent.
- 4.4.7 To the maximum extent practical the design shall use existing parts.

4.5 ARCHITECTURAL/CIVIL ENGINEERING AND SITEWORK

The allowable tank riser loading precludes direct mounting of the PPP and transfer pump. A load frame and associated foundation designed to transmit PPP associated loads to the tank overburden must be provided while allowing direct connection between the PPP and riser flange to ensure waste tank ventilation confinement is maintained.

The applied loads (dead weight, pressure, vibration, seismic, wind, etc.) and load combinations for each component and structure shall be defined in a structural design criteria (SDC) document, reviewed and approved by the Design Review Committee. The natural phenomena loadings shall be a function of the safety classes of the SSCs and evaluated in accordance with HNF-PRO-097 and DOE-6430.1A.

The SDC shall also provide codes and standards used to evaluate and qualify the SSCs of the waste transfer system. The application of those codes and the fulfillment of their requirements shall be documented in a design compliance matrix prepared as part of the design.

4.6 MECHANICAL ENGINEERING

The RAPID Mitigation System could include a significant number of mechanical components, including pumps, piping, valves, and hydraulic/pneumatic accumulators. Consensus codes and standards applicable to the system design shall be appropriately applied during design. The application of those codes and the fulfillment of their requirements shall be documented in a design compliance matrix prepared as part of the design.

4.7 ELECTRICAL, INSTRUMENTATION AND CONTROLS

The RAPID Mitigation System will include a significant number of instrumentation and electrical components. Consensus codes and standards applicable to the system design shall be appropriately applied during design. The application of those codes and the fulfillment of their requirements shall be documented in a design compliance matrix prepared as part of the design.

4.8 SAFETY

The Authorization Basis for this design is split between the Los Alamos National Laboratory's (LANL) Safety Assessment (SA)(Reference F), and the Tank Waste Retrieval Systems (TWRS) Basis for Interim Operation (BIO) (Reference E). Efforts are currently underway to resolve differences between the two.

The LANL SA presently prescribes the NFPA hazardous classification environment in and around SY-101. The tank's annulus and above grade zones are presently nonclassified per the NFPA guidelines. The dome space within 3 feet of the waste is classified as Class 1, Div 1, Group B. The remainder is Class 1, Div 2, Group B. Within the waste is nonclassified.

4.9 RADIATION AND NUCLEAR CONTROL

The RAPID System design shall be performed in accordance with the requirements of 10 CFR 835 and HSRM-1, *Hanford Site Radiological Control Manual*, and DOE 6430.1A, ensuring that operator and maintenance dose consequence associated with the RAPID Systems Installation/Operation/Maintenance and Decommissioning remains As Low As Reasonably Achievable (ALARA). The following procedures HNF-PRO-1621, "ALARA Decision-Making Methods" and HNF-PRO-1622, "Radiological Design Review Process" will be used to guide the optimization and subsequent application of radiological source term reduction techniques.

The RAPID System design shall limit radiation field dose rates per the design objectives stated in 10CFR835.1002 paragraph (b).

4.10 HUMAN ENGINEERING

- 4.10.1 Process variable displays shall be located within view of individuals operating system control elements.
- 4.10.2 Minimize the need for operator action in the event of unexpected conditions (transients).
- 4.10.3 Simplify system design to rely primarily on direct operator control rather than on automatic control.
- 4.10.4 Control system design should minimize the level of training required for safe operation.

- 4.10.5 Control system design should minimize the amount of coordination required between operators in locations distant from one another.
- 4.10.6 Layout of displays, labeling of components, and control orientation should be readable and adhere to the guidelines of MIL-STD-1472C, "Human Engineering Design Criteria for Military Systems, Equipment, and Facilities", EPRI NP-3659, "Human Factors Guide for Nuclear Power Plant Control Room," to the extent practical. The requirements of HNF-IP-0842, Volume IV, Section 4.14, "Tank Farm Operations Equipment Labeling and Master Equipment List Control" shall be met.
- 4.10.7 The design of the RAPID system should follow the guidance of UCRL-15673, "Human Factors Design Guidelines for Maintainability of DOE Nuclear Facilities."
- 4.10.8 Personnel Training and Staffing requirements are identified in HNF-3824, "Tank 241-SY-101 Surface Level Rise Remediation Project Plan."

4.11 LOGISTICS

Construction and operation of the RAPID Mitigation System are not expected to result in the generation of any waste not already addressed within existing guidelines, procedures, and permits. Waste generated during decommissioning shall be addressed in the D & D plan.

4.12 PROJECT INTERFACES

RAPID system interface requirements are summarily identified in Table 4-2.

4.12.1 Waste Tanks

The top of SY-101 Riser 007 106.68 cm (42") diameter flange face is at an elevation of 204.9 m (672.24 ft), approximately 5.08 cm (2 inches) above the ground. The flange includes 6-2.22cm (7/8") diameter holes on a 118.11 cm (46 1/2 ") diameter bolt circle.

The top of SY-102 Riser 007 106.68 cm (42") diameter flange face is at an elevation of 204.8 m (672.01 ft), approximately 5.08 cm (2 inches) above the ground. The flange includes 6-2.22cm (7/8") diameter holes on a 118.11 cm (46 1/2 ") diameter bolt circle.

4.12.2 Water

All water for the 200 Area is supplied from the Hanford Site export water system. Export water is defined as water pumped from the Hanford Site reservoir to reservoirs located in the 200 East and 200 West Areas. Water is distributed throughout the area by two separate systems, the raw water system and the sanitary water system. Raw water is untreated and is used principally for cooling, flushing, and dilution systems. Sanitary water is treated (filtered, purified, etc.) and is used for drinking and sanitary facilities.

All water supply piping that has the potential for contacting other water or radioactively contaminated liquids is protected with backflow preventers. In addition, to monitor raw water usage in TWRS facilities, flow totalizers have been installed.

**TABLE 4-2
RAPID SYSTEM INTERFACE TABLE**

	Transfer Pump	PPP	Primary Piping	Encasement Piping	Dilution Water	Flush Water	Power Supply	Leak Detectors	Drop Leg	SY-101 Riser	SY-101 Dome Space	SY-102	D & D
Transfer Pump	X	X	X		X	X	X				X		
PPP	X	X	X	X	X	X	X	X		X	X		
Primary Piping	X	X	X	X		X			X			X	
Encasement Piping		X	X	X				X	X			X	X
Dilution Water	X	X			X	X						X	
Flush Water	X	X	X		X	X			X			X	
Power Supply	X	X					X	X					
Leak Detectors		X		X			X	X				X	
Drop Leg			X	X		X			X			X	
SY-101 Riser		X								X	X		
SY-101 Dome Space	X	X								X	X		
SY-102			X	X	X	X	X	X				X	
D & D				X									X

4.12.3 Electrical

Substation 242-S supplies power to Motor Control Center SY272-EDS-MCC-003 at 480 V, 3 phase. This MCC provides power to the existing SY-101 Mixer Pump through a variable frequency drive located in the MCC Building. A new compartment in SY272-EDS-MCC-003 will be utilized to provide power through a new 125 HP, 480 V, VFD to the SY-101 New Generation Transfer Pump. The pump is a 60 HP unit that due to its overspeed capabilities and operational parameters requires the larger drive noted above. The drive will be located in the MCC Building. The circuit to the motor will include an isolation disconnect at the output of the drive and one within sight of the PPP. The circuit will utilize existing wireways (conduits and trench) where possible. Some additional wireways will be required to complete the circuit to the pump.

4.13 SECURITY

NOT APPLICABLE.

4.14 QUALIFICATION

Qualification of the RAPID Mitigation System design shall be accomplished through a combination of formal design verification and verification/acceptance testing.

5.0 QUALITY ASSURANCE

The "quality" management system for this activity is designed to achieve project control and meet our customer's quality requirements as specified in 10 CFR 830.120, "Quality Assurance." Additional customer quality requirements are derived from the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1994). These quality requirements are transmitted to this activity through FDH-MP-0599, the *FDH Quality Assurance Program Description*, which identifies the guidance criteria to be used by all Project Hanford Management Contractors.

The interpretive authority for the customer's quality requirements is the QA Center of Expertise (COE). The QA COE has described the plan to achieve the customer's quality requirements in WHD-SP-1131, *Quality Assurance Program and Implementation Plan*.

This activity's quality assurance policies and requirements is described in HNF-IP-0842, Volume XI, Sec. 1.1, TWRS Quality Assurance Program Plan (QAPP) document. This QAPP includes an "Implementation Matrix" which identifies (1) the ten major elements of the requirements from DOE Order 5700.6C and 10 CFR 830.120, (2) the sub-elements for each major element as specified in the Fluor Daniel Hanford Quality Assurance Program Description (HNF-MP-599), and (3) the associated implementation documents cited in the matrix constitute the TWRS approach for achieving the requirements delineated in the FDH QAPP.

5.1 INSPECTIONS

5.1.1 Cleanliness requirements for the fabrication and installation of RAPID system assemblies shall be specified by their design. Cleanliness inspections shall be performed at the completion of fabrication, and again at the end of any acceptance testing performed prior to installation in the field. Dirt, oil residue, liquids, metal chips, or other forms of contamination shall be removed using approved cleaning methods.

5.1.2 Requirements for the permanent marking of RAPID System components and assemblies shall be specified in design media. As a minimum, marking requirements shall provide a tie between hardware and design drawings.

5.2 TEST AND EXAMINATIONS

5.2.1 The transfer line primary and encasement piping shall be pressure tested in accordance with ASME B31.3.

- 5.2.2 Performance testing shall be specified for the pump and operational components within the PPP. Sufficient data shall be obtained to assure satisfactory operation after installation in SY-101.
- 5.2.3 A run-in test shall be specified. The pump shall be placed in a test fixture and operated at pump design flow rates and pressures for a minimum of 24 hours prior to acceptance by Lockheed Martin Hanford Company or installation in SY-101.
- 5.2.4 Additional testing to be specified shall include verification of the interface between the RAPID control console and the transfer pump PPP assembly and its associated control valves provided for the various operating configurations identified in paragraph 4.3.1.6. The performance of the dilution system shall be demonstrated via testing.
- 5.2.5 Verification testing shall be specified for all essential components to ensure their ability to fulfill the form, fit, and function required by the RAPID system design.

6.0 TURNOVER

Requirements for documentation required for turnover of the RAPID system will be described as part of an Acceptance for Beneficial Use listing, included as part of HNF-4044, "Engineering Task Plan for Waste Transfer from Tank 241-SY-101 to 241-SY-102."

7.0 APPENDICES

- Appendix A Internal Memo
- Appendix B FGEAB Meeting Minutes
- Appendix C Process Flow Diagram
- Appendix D NGTP Flange Interface Drawings
- Appendix E Internal Memo (Draft)

HNF-3885
Rev. 0
Feb. 24, 1999

APPENDIX A
INTERNAL MEMO
(FOR INFORMATION ONLY)

A-O

KN

INTEROFFICE MEMO

LOCKHEED MARTIN

From: Process Control 74B50-99-017
Phone: 373-2461 R2-11
Date: February 11, 1999
Subject: ANTICIPATED DYNAMIC VISCOSITY AND SOLIDS
CONCENTRATION OF SLURRIES PRODUCED DURING THE
DILUTION AND TRANSFER OF TANK 241-SY-101 WASTES TO TANK
241-SY-102

To: W. J. Powell S5-13

cc: Distribution

- References:
- (1) Document, "In Situ Rheology and gas Volume in Hanford double-Shell Waste Tanks, PNNL-11296, dated September 1996.
 - (2) Document, and Physical Properties of Tank 241-SY-101 Waste, PNL-10198, dated October 1994.

This memo is issued to constitute a referenceable basis for specifying the Respond and Pump in Days (RAPID) waste transfer system for tank 241-SY-101. Specifically, the questions answered in this memo are as follows:

- (1) What is the significance of the specified water dilution ratios for tank 241-SY-101 waste?
- (2) What are the volume percent precipitated solids in the resulting slurries?
- (3) What are the ranges of dynamic viscosity for these slurries?
- (4) What dilution is required to produce a slurry viscosity of 30 cP?

(1) The volumetric dilution range specified for the RAPID system varies from 2 parts waste to 1 part water to 1 part waste to 2 parts water. The mean dilution ratio is specified as 1 part waste to 1 part water. The low dilution limit is specified due to concerns about the build-up of high salt concentrations in tank 241-SY-102. Some of the 200 West area single-shell tank saltwell wastes possess high concentrations of phosphate. Interim stabilization activities accumulate these wastes in tank 241-SY-102. By limiting the nitrate/nitrite salt concentrations in tank 241-SY-102, the probability of phosphate precipitation will be minimized. The high dilution limit is specified from a desire to limit the impact of tank 241-SY-101 transfer activities on operational double-shell tank volume.

(2) The volume percent precipitated solids contained in the in-situ convective regions of tank 241-SY-101 are stated as 5% to 25% with a mean of 15%. This corresponds to the solids concentration at 120°F. During the actual transfer of waste from tank 241-SY-101 to tank 241-SY-102, the waste will be in the piping system for only a few seconds. It is prudent to assume that no dissolution of precipitated solids occurs during slurry transfer. Therefore, the solids concentrations in the transferred waste are diluted proportional to the dilution volume of water.

Assuming that tank 241-SY-101 waste with 25 volume (vol) % solids is diluted with water at the low dilution limit, the maximum expected solids concentration in the transfer line is:

$$[2(25 \text{ vol } \%) + 1(0 \text{ vol } \%)] \div (2 + 1) = 17 \text{ vol } \%$$

Likewise, the mean slurry solids concentration derived the mean value of tank 241-SY-101 convective waste solids concentration and the mean water dilution yields:

$$[1(15 \text{ vol } \%) + 1(0 \text{ vol } \%)] \div (1 + 1) = 7.5 \text{ vol } \%$$

The resulting slurry solids concentration in the transfer line is expected to range from about 2 vol% to 17 vol% with 7.5 vol% as the mean.

(3) The question of the viscosity of slurries is highly complex and essentially indeterminate. The viscosity and viscosity behavior of many liquids, such as water, is well defined. However, when suspended solids are included in a liquid (i.e., a slurry), no universally known method exists to specify the viscosity of a slurry, even if other physical properties of the slurry are well known. For example, whereas most liquids can be considered Newtonian fluids, most slurries cannot. The only way the viscosity of an actual slurry in a specific application can be positively determined is to measure it in that application. Such a measurement cannot be made in the application of the transfer from tank 241-SY-101.

The best known means of estimating a slurry viscosity from other known slurry parameters is via an "Einstein" type relationship. This relationship can at best be considered as only a rough rule-of-thumb. In a simplified form, this relationship expresses the slurry viscosity as a linear function of the carrier liquid viscosity and an exponential function of the solids loading or slurry density. Some terms are useful to define:

- c = carrier or liquid phase of a slurry
- d = dispersed or solid phase of a slurry
- m = bulk property of a slurry
- α = phase volume fraction in a slurry (dimensionless)
- ρ = phase density of a slurry (units of mass per volume)
- μ = dynamic viscosity (units of mass per length per time)

The following relationships apply:

$$\begin{aligned}\alpha_c + \alpha_d &= 1 \\ \rho_m &= \alpha_c \rho_c + \alpha_d \rho_d \\ \rho_\infty &= \rho_m \text{ at infinite dilution, where } \rho_m = \rho_c\end{aligned}$$

α_d must be distinguished from the volume fraction of settled solids. Settled solids always contain void volumes occupied by the liquid phase so that the volume fraction of settled solids will be greater than the volume fraction of dispersed solids, AKA true solids.

The desired quantity is the slurry viscosity μ_m . A simplified "Einstein" relationship can then be defined as:

$$\mu_m = \mu_c \exp\left[k\left(\frac{\rho_m - \rho_\infty}{\rho_\infty}\right)\right] \quad \text{where "k" is an empirical constant}$$

Therefore, the slurry viscosity becomes a function of the carrier liquid viscosity and the difference in density between the slurry and its carrier liquid.

To determine the constant in the "Einstein" relation, the value of μ_m must be known for at least one set of μ_c , ρ_c , and ρ_m values. ρ_m is a value nailed down fairly well for the waste in question. The range of ρ_m values for tank 241-SY-101 convective wastes at 120°F is stated as 1.45 to 1.75 gm/cc with a mean of 1.60 gm/cc. For tank 241-SY-101 wastes, the value of ρ_c at any non-infinite dilution is not known with much precision. The only thing that can be positively stated for tank 241-SY-101 waste is that at infinite dilution, $\rho_m = \rho_c = 1.0$ gm/cc.

References (1) and (2) document viscosity analyses performed on tank 241-SY-101 wastes. Reference (1) reported results from ball rheometer testing in tank 241-SY-101 and Reference (2) investigated material from core 22 taken during Window C. Both references report Non-Newtonian, shear-thinning (thixotropic) behavior of the tank wastes.

Analyses documented in Reference (2) looked at parameters of ρ_m , settled solids density, settled solids volume fraction, filtered solids weight fraction, and viscosity at a 400 sec⁻¹ shear rate at a 0, 10, 20, 35, and 50 vol % 2M NaOH dilution and 50, 70, and 90°C. The results indicate that little difference could be noted between ρ_m and the settled solids density at any dilution or temperature. Differences in viscosity, volume percent settled solids, and weight percent filtered solids showed much more variation at differing dilutions and temperatures. In this application, 2M NaOH can be considered equivalent to water.

Reference (2) reported a dynamic viscosity of 40 cP at a 400 sec⁻¹ shear rate for undiluted waste at 50 °C. Reference (1) reported the following ball rheometer viscosity behavior with an uncertainty factor of 2 (Section 4.1.2):

Shear rate (sec ⁻¹)	1	10	100	400
Viscosity (cP)	~600	~150	~80	~40

The viscosity results from both references for undiluted wastes at tank temperature and a 400 sec⁻¹ shear rate show good agreement. When shear rate is expressed as the pipe flow velocity divided by the pipe inner radius, a 6 ft/sec flow velocity corresponds to a shear rate of about 50 sec⁻¹ in a 3" ID pipe. At this shear rate, Reference (1) indicates an in situ waste viscosity of about 100 cP

A summary of selected data for tank 241-SY-101 waste at 50 °C from Reference (2) is reproduced below:

Dilution ▶ Property ▼	0 vol%	10 vol%	20 vol%	35 vol%	50 vol%
Apparent Viscosity at 400 sec ⁻¹ (cP)	39.4	35.8	12.3	6.8	2.9
Vol% settled solids	100	100	96	89	34
Wt% filtered solids	83	60	68	40	25
Settled solids density	1.72	1.68	1.59	1.51	1.42
Slurry density	1.72	1.68	1.60	1.48	1.34

The value of 50 vol% dilution corresponds to the minimum dilution specified for the RAPID transfer system. Based on the shear viscosity behavior reported in Reference (2), the viscosity at 50 sec⁻¹ shear rate would appear to be 2.4 times larger than the value at 400 sec⁻¹. The viscosity of water at 50°C is 0.55 cP.

For a 50 sec⁻¹ shear rate, the following table of tank 241-SY-101 waste viscosities could be derived from data in References (1) and (2):

Dilution ▶ Property ▼	0 vol%	10 vol%	20 vol%	35 vol%	50 vol%
Apparent Viscosity at 50 sec ⁻¹ (cP)	100	85	30	16	7.0

This suggests a slurry viscosity expression in the form of:

$$\mu_m = 0.55cP * \exp[k(\frac{\rho_m - 1.0 \text{ gm/cc}}{1.0 \text{ gm/cc}})] \quad \text{where}$$

$$100cP = 0.55cP * \exp[k(\frac{1.6 \text{ gm/cc} - 1.0 \text{ gm/cc}}{1.0 \text{ gm/cc}})]$$

since $\mu_m = 100 \text{ cP}$ when $\rho_m = 1.6 \text{ gm/cc}$. This yields $k = 8.67$.

Therefore, at 50°C , ($\sim 120^\circ\text{F}$) and a shear rate of 50 sec^{-1} , the expression for the slurry viscosity produced by the RAPID transfer system becomes:

$$\mu_m = 0.55cP * \exp[8.67 * (\frac{\rho_m - 1.0 \text{ gm/cc}}{1.0 \text{ gm/cc}})]$$

This expression yields the following results:

Slurry Viscosity Behavior at 120°F and 50 sec^{-1} Shear Rate

Slurry Density (gm/cc)	Mean Viscosity (cP)	Maximum Viscosity (cP)
1.6 (corresponding to no dilution)	100	200
1.4 (corresponding to minimum specified dilution of 1 part water to 2 parts waste)	18	36
1.3 (corresponding to mean dilution of 1 part water to 1 part waste)	7.4	15
1.2 (corresponding to maximum dilution of 2 parts water to 1 part waste)	3.1	6.2
1.0 (corresponding to infinite dilution)	0.55	0.55

(4) From the above table, at the specified RAPID transfer system operating temperature of 120°F, the minimum specified dilution of 1 part by volume water to 2 parts by volume waste yields a slurry with an estimated viscosity of less than 30 cP. Only in the extreme of low dilution at the high viscosity bound does it exceed 30 cP. At the mean 1:1 dilution, the expected slurry viscosity is about 7.5 cP with an expected maximum of 15 cP.

A handwritten signature in cursive script, appearing to read "S. D. Estey", followed by the word "for" in a similar script.

S. D. Estey, Engineer
Process Control

sde/mjg

HNF-3885
Rev. 0
Feb. 24, 1999

APPENDIX B
FLAMMABLE GAS EQUIPMENT ADVISORY
BOARD MEETING MINUTES

(FOR INFORMATION ONLY)

MEETING MINUTES

SUBJECT: FLAMMABLE GAS EQUIPMENT ADVISORY BOARD (FGEAB) MEETING

TO: DISTRIBUTION		BUILDING 2750E/A-229		
FROM: CC Scaief III		CHAIRMAN RL Schlosser		
DEPARTMENT-OPERATION- COMPONENT	AREA	SHIFT	DATE OF MEETING	NUMBER ATTENDING
TWRS-Equipment Engineering	200E	Day	January 19, 1999	7

Members or Alternates/Attendees (*)

JR Kriskovich CC Scaief III* RL Schlosser* DB Smet* RA Wahlquist
RA Huckfeldt* RE Larson

Other Attendees

TR Benegas JM Grigsby CE Hanson

Meeting Minutes

The meeting began at 2:00 p.m. and the subject was sealing of a new pump pit associated with pumping of SY-101 waste. The question of the drain seal integrity was discussed to determine the pit classification. If the pit were considered dome space it would be subject to the ignition controls associated with the same. The Board members present agreed that if the pit had a mechanical seal or a seal pot that would seal against the largest historically observed pressurization, it would be adequate to consider the pit non intrusive. It was felt that a 50% safety margin for a seal was sufficient. This would mean a seal with about 9 or 10 inches water head. The Board members also stated that some venting of the pit would be required to ensure no buildup of flammable gases.

Carl Hanson also discussed arranging a formal design review board that would include appropriate members of the FGEAB. Rich Schlosser indicated that he would provide a suggested review board membership based on the design and requirements. This portion of the meeting ended at about 3:00 p.m.

Todd Brown arrived to discuss the use of a caustic addition hose made of EPDM (Ethylene Propylene Rubber). The material has a high resistivity and the inside of the hose would be exposed to the dome space at the start of addition (after the riser valve was opened). The Board indicated that there might be some potential for charge generation due to dragging of the hose on the ground. This charge could conceivably be discharged on the inside of the hose by the conductive caustic. Wetting the outside of the hose could mitigate the charging. Dave Smet suggested that the hose was being enclosed in static dissipative sleeving (for containment of caustic leak). If this were true, then wetting would not be required. Todd agreed to find out about the sleeving.

The Board also discussed a request by Jeff Ranschau (not present) for a general ruling on the use of DC battery powered flashlights. Chuck Scaief agreed to add them to a report with some bounds on voltage and power based on the ignition curves for resistive circuits. The meeting adjourned at 3:30 p.m.

APPENDIX C
PROCESS FLOW DIAGRAM
(FOR INFORMATION ONLY)

LEGEND	
---	WASTE TRANSFER LINE
---	WATER SUPPLY LINE

GENERAL NOTES: (UNLESS OTHERWISE SPECIFIED)
 SEE SHEET 2 THIS DRAWING FOR TABLES REFERRING
 1. IDENTIFIERS ON DIAGRAM

PRELIMINARY
 NOT FOR FABRICATION.
 FOR COMMENT ONLY.
 DATE: 2/28/98

HN-3885
 Rev. 0
 C-1

U.S. DEPARTMENT OF ENERGY LOUISIANA STATE UNIVERSITY RAPID MITIGATION SYSTEM PROCESS FLOW DIAGRAM	
DATE: 2/28/98	PROJECT: H-14-103640.0
DESIGNED BY: [blank]	CHECKED BY: [blank]
DRAWN BY: [blank]	DATE: [blank]
SCALE: 1"=1'	PLANT SCALE: 1"=1'

REF. NUMBER	TITLE	DATE	BY	CHKD.	APP'D.
1	OVERGROUND TRANSFER LINE TO TANK 241-SY-102	2/28/98	[blank]	[blank]	[blank]
2	WASTE TRANSFER LINE	2/28/98	[blank]	[blank]	[blank]
3	WATER SUPPLY LINE	2/28/98	[blank]	[blank]	[blank]
4	TRANSFER FROM TANK 241-SY-102 TO TANK 241-SY-101	2/28/98	[blank]	[blank]	[blank]
5	TRANSFER FROM TANK 241-SY-101 TO TANK 241-SY-102	2/28/98	[blank]	[blank]	[blank]
6	TRANSFER FROM TANK 241-SY-101 TO NCTP	2/28/98	[blank]	[blank]	[blank]
7	TRANSFER FROM NCTP TO TANK 241-SY-101	2/28/98	[blank]	[blank]	[blank]
8	TRANSFER FROM TANK 241-SY-101 TO WASTE TRANSFER LINE	2/28/98	[blank]	[blank]	[blank]
9	TRANSFER FROM TANK 241-SY-101 TO TANK 241-SY-102	2/28/98	[blank]	[blank]	[blank]
10	TRANSFER FROM TANK 241-SY-101 TO TANK 241-SY-102	2/28/98	[blank]	[blank]	[blank]
11	TRANSFER FROM TANK 241-SY-101 TO TANK 241-SY-102	2/28/98	[blank]	[blank]	[blank]

RAPID Process Flow Mode

Normal Waste Transfer
Transfer Line Flush
Transfer Pump Outlet Line Flush
Transfer Pump Internal Flush

Explanation of Table Symbols:

(N/A) is not applicable, as this section of process piping is valued out from the piping sections in active use - or - this parameter has no meaning for the flow mode in question.

(-) process piping is in active use but the parameter value is not of specific concern to the process. However, specification of parameter value/final limits requires prudent engineering judgement.

(R.F.) symbol used for waste transfer operations expressing the required transfer flow rate as a variable to be optimized depending upon determination of the process piping diameter. Waste transfer flow control is specifically stated as a flow velocity requirement as opposed to a flow rate requirement. Specifying the transfer flow rate as a variable allows the convenient expression of the allowable waste and dilution water flow rates.

For process line flushes, the primary objective is to simply displace process waste fluid from the lines and replace it with fresh water. Prudent engineering suggests that additional requirements be stated to maximize the efficiency of the flush within the limits of the RAPID Infrastructure (i.e., a volumetric flush water flow rate of 70 gpm). The specified process line flush volume is equal to the larger of either:

- two times the volume of the process line being flushed
- two minutes of flow at the specified line flow velocity

The process line flush flow rate is specified as 4 ft/sec to 6 ft/sec. This velocity is estimated to meet critical velocity requirements for the process lines.

The transfer pump internal flush requirement is stated as flow rate of approximately 10 gpm. The transfer pump internal flush volume and temperature limits are then defined by the limits on water addition to tank 241-SY-10 (i.e., a volume not to exceed the capacity of the water sump tank that is within the water addition temperature limits of 110°F to 130°F).

Permissible Process Limits for Transfer Pump Outlet Line Flush

Flow Parameter	Water Skid Inlet (1)	Water Skid Outlet (2)	Water Supply Line (3)	Transfer Pump Inlet (4)	Transfer Pump Outlet (5)	Transfer Pump Inlet (6)	Transfer Pump Outlet (7)	Transfer Pump Inlet (8)	Transfer Pump Outlet (9)
Flow Rate	-	< 70 gpm	< 70 gpm	N/A	N/A	< 70 gpm	< 70 gpm	< 70 gpm	N/A
Flow Volume	2 line volumes or 2 minutes of flow, whichever ever is greater	2 line volumes or 2 minutes of flow, whichever ever is greater	2 line volumes or 2 minutes of flow, whichever ever is greater	N/A	N/A	2 line volumes or 2 minutes of flow, whichever ever is greater	2 line volumes or 2 minutes of flow, whichever ever is greater	2 line volumes or 2 minutes of flow, whichever ever is greater	N/A
Flow Velocity (ft/sec)	-	-	-	N/A	N/A	-	-	-	N/A
Temperature (°F)	-	110 to 130	110 to 130	N/A	N/A	110 to 130	110 to 130	110 to 130	N/A
Viscosity (cP)	-	0.50 to 0.62	0.50 to 0.62	N/A	N/A	0.50 to 0.62	0.50 to 0.62	0.50 to 0.62	N/A
Density (g/cm ³)	-	< 1.0	< 1.0	N/A	N/A	< 1.0	< 1.0	< 1.0	N/A
Volume % Solids	< 0.01	< 0.01	< 0.01	N/A	N/A	< 0.01	< 0.01	< 0.01	N/A
Mass % Solids	100	100	100	N/A	N/A	100	100	100	N/A
Mass % Completely Insoluble Solids	0	0	0	N/A	N/A	0	0	0	N/A

HNF-3885
Rev. 0
C-2

Permissible Process Limits for Transfer Line Flush

Flow Parameter	Water Skid Inlet (1)	Water Skid Outlet (2)	Water Supply Line (3)	Transfer Pump Inlet (4)	Transfer Pump Outlet (5)	Transfer Pump Inlet (6)	Transfer Pump Outlet (7)	Transfer Pump Inlet (8)	Transfer Pump Outlet (9)
Flow Rate	-	< 70 gpm	< 70 gpm	N/A	N/A	< 70 gpm	< 70 gpm	< 70 gpm	< 70 gpm
Flow Volume	2 line volumes or 2 minutes of flow, whichever ever is greater	2 line volumes or 2 minutes of flow, whichever ever is greater	2 line volumes or 2 minutes of flow, whichever ever is greater	N/A	N/A	2 line volumes or 2 minutes of flow, whichever ever is greater	2 line volumes or 2 minutes of flow, whichever ever is greater	2 line volumes or 2 minutes of flow, whichever ever is greater	2 line volumes or 2 minutes of flow, whichever ever is greater
Flow Velocity (ft/sec)	-	-	-	N/A	N/A	-	-	-	-
Temperature (°F)	-	110 to 130	110 to 130	N/A	N/A	110 to 130	110 to 130	110 to 130	110 to 130
Viscosity (cP)	-	0.50 to 0.62	0.50 to 0.62	N/A	N/A	0.50 to 0.62	0.50 to 0.62	0.50 to 0.62	0.50 to 0.62
Density (g/cm ³)	-	< 1.0	< 1.0	N/A	N/A	< 1.0	< 1.0	< 1.0	< 1.0
Volume % Solids	< 0.01	< 0.01	< 0.01	N/A	N/A	< 0.01	< 0.01	< 0.01	< 0.01
Mass % Solids	100	100	100	N/A	N/A	100	100	100	100
Mass % Completely Insoluble Solids	0	0	0	N/A	N/A	0	0	0	0

Permissible Process Limits for Transfer Pump Internal Flush

Flow Parameter	Water Skid Inlet (1)	Water Skid Outlet (2)	Water Supply Line (3)	Transfer Pump Inlet (4)	Transfer Pump Outlet (5)	Transfer Pump Inlet (6)	Transfer Pump Outlet (7)	Transfer Pump Inlet (8)	Transfer Pump Outlet (9)
Flow Rate	-	< 70 gpm	< 70 gpm	N/A	N/A	< 70 gpm	< 70 gpm	< 70 gpm	< 70 gpm
Flow Volume	2 line volumes or 2 minutes of flow, whichever ever is greater	2 line volumes or 2 minutes of flow, whichever ever is greater	2 line volumes or 2 minutes of flow, whichever ever is greater	N/A	N/A	2 line volumes or 2 minutes of flow, whichever ever is greater	2 line volumes or 2 minutes of flow, whichever ever is greater	2 line volumes or 2 minutes of flow, whichever ever is greater	2 line volumes or 2 minutes of flow, whichever ever is greater
Flow Velocity (ft/sec)	-	-	-	N/A	N/A	-	-	-	-
Temperature (°F)	-	110 to 130	110 to 130	N/A	N/A	110 to 130	110 to 130	110 to 130	110 to 130
Viscosity (cP)	-	0.50 to 0.62	0.50 to 0.62	N/A	N/A	0.50 to 0.62	0.50 to 0.62	0.50 to 0.62	0.50 to 0.62
Density (g/cm ³)	-	< 1.0	< 1.0	N/A	N/A	< 1.0	< 1.0	< 1.0	< 1.0
Volume % Solids	< 0.01	< 0.01	< 0.01	N/A	N/A	< 0.01	< 0.01	< 0.01	< 0.01
Mass % Solids	100	100	100	N/A	N/A	100	100	100	100
Mass % Completely Insoluble Solids	0	0	0	N/A	N/A	0	0	0	0

Permissible Process Limits for Normal Waste Transfer

Flow Parameter	Water Skid Inlet (1)	Water Skid Outlet (2)	Water Supply Line (3)	Transfer Pump Inlet (4)	Transfer Pump Outlet (5)	Transfer Pump Inlet (6)	Transfer Pump Outlet (7)	Transfer Pump Inlet (8)	Transfer Pump Outlet (9)
Flow Rate	-	< 70 gpm	< 70 gpm	N/A	N/A	< 70 gpm	< 70 gpm	< 70 gpm	< 70 gpm
Flow Volume	2 line volumes or 2 minutes of flow, whichever ever is greater	2 line volumes or 2 minutes of flow, whichever ever is greater	2 line volumes or 2 minutes of flow, whichever ever is greater	N/A	N/A	2 line volumes or 2 minutes of flow, whichever ever is greater	2 line volumes or 2 minutes of flow, whichever ever is greater	2 line volumes or 2 minutes of flow, whichever ever is greater	2 line volumes or 2 minutes of flow, whichever ever is greater
Flow Velocity (ft/sec)	-	-	-	N/A	N/A	-	-	-	-
Temperature (°F)	-	110 to 130	110 to 130	N/A	N/A	110 to 130	110 to 130	110 to 130	110 to 130
Viscosity (cP)	-	0.50 to 0.62	0.50 to 0.62	N/A	N/A	0.50 to 0.62	0.50 to 0.62	0.50 to 0.62	0.50 to 0.62
Density (g/cm ³)	-	< 1.0	< 1.0	N/A	N/A	< 1.0	< 1.0	< 1.0	< 1.0
Volume % Solids	< 0.01	< 0.01	< 0.01	N/A	N/A	< 0.01	< 0.01	< 0.01	< 0.01
Mass % Solids	100	100	100	N/A	N/A	100	100	100	100
Mass % Completely Insoluble Solids	0	0	0	N/A	N/A	0	0	0	0
Mass % Nitrate	0	0	0	N/A	N/A	0	0	0	0
Mass % Nitrite	0	0	0	N/A	N/A	0	0	0	0
Mass % Hydrosulfide	0	0	0	N/A	N/A	0	0	0	0
Mass % Carbonate	0	0	0	N/A	N/A	0	0	0	0
Mass % Aluminum	0	0	0	N/A	N/A	0	0	0	0
Mass % Chloride + Sulfate + Nitrate + Nitrite + Hydrosulfide + Carbonate	0	0	0	N/A	N/A	0	0	0	0
Mass % TOC	0	0	0	N/A	N/A	0	0	0	0
Mass % Other	0	0	0	N/A	N/A	0	0	0	0
Mass % Constituents	0	0	0	N/A	N/A	0	0	0	0
Mass % Completely Insoluble Solids	0	0	0	N/A	N/A	0	0	0	0

FOR GENERAL NOTES AND PARTS LIST
SEE SHEET 1.

U.S. DEPARTMENT OF ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY
LOCATED: MARTIN LUTHER KING, JR. CENTER
PROCESS FLOW DIAGRAM
HNF-14-103640
REV. 0
C-2
2. PLOT SCALE: 1"=1'

HNF-3885
Rev. 0
Feb. 24, 1999

APPENDIX D

NGTP FLANGE INTERFACE DRAWINGS

(FOR INFORMATION ONLY)

D-0
K_N

REVISION
3

SECTION X-X
SEE SHEET 2

SECTION W-W
SEE SHEET 2

SECTION Z-Z
SEE SHEET 2

SECTION Y-Y
SEE SHEET 2

DETAIL -S-
SEE NOTE 14

-VIEW T-T-
SEE SHEET 2

Figure 15-5

E.M. 6673, Rev. 3

15-10

HNF-3885
Rev. 0
D-3

W

Westinghouse Electric Corporation
ELECTRO-MECHANICAL DIV. - CHESBROOK, PA. U.S.A.
DRAWING NO. 04808
SCALE 1:1
SHEET 3 OF 3

4D97536

BAFFLE PLATE TO PIPE WELDING.
LOCATION OF TACK WELDS AT
WELDER'S OPTION.

1 X Ø.75±.03 ITEM 6
Ø.120±.015 (6)

HNF-3885
Rev. 0
Feb. 24, 1999

APPENDIX E
INTERNAL MEMO
(DRAFT)

(FOR INFORMATION ONLY)

INTEROFFICE MEMO

LOCKHEED MARTIN

From: Process Control 74B50-99-021
Phone: 373-2711 R2-11
Date: February 26, 1999
Subject: ESTIMATED PROPERTIES OF TANK 241-SY-101 WASTE AFFECTING
DILUTION AND TRANSFER

To: W. J. Powell S5-13

cc: W. B. Barton	R2-12	K. M. Hodgson	R2-11
R. E. Bauer	S7-73	G. D. Johnson	S7-73
J. W. Brothers	K9-20	N. W. Kirch	R2-11 <i>per telecon</i>
C. Defigh-Price	R2-12	J. C. Person	T6-07 <i>w/NWK</i>
M. F. Erhart	R1-56	R. E. Raymond	R2-38
S. D. Estey	R2-11	D. A. Reynolds	R2-11
J. M. Grigsby	S7-73	S. W. Shaw	G1-54
C. E. Hanson	S7-12	JMC File/LB	

- References:
- (1) Letter, F. H. Steen, WMH, to K. M. Hall, LMHC, "Compatibility Analysis Results for Tank 241-SY-101 Core Composites," WMH-9951091, dated February 24, 1999.
 - (2) Interoffice Memorandum, "Anticipated Dynamic Viscosity and Solids Concentration of Slurries Produced During the Dilution and Transfer of Tank 241-SY-101 Wastes to Tank 241-SY-102," 74B50-99-017, dated February 11, 1999.
 - (3) Letter of Instruction for Composition Studies on Samples Supporting Tank 241-SY-101 Level Growth Mitigation/Remediation," 74B50-99-011, dated February 8, 1999.
 - (4) Interoffice Memorandum, "Prediction of Dilution and Temperature Effects on Waste from Tank 241-SY-101," 74B50-98-061, dated December 15, 1998.

The purpose of this memo is to document estimates of tank 241-SY-101 (SY-101) waste properties relevant to the upcoming transfer. The information is needed to support process design documentation. Data on dynamic viscosity and overall solids concentration were provided previously (Reference 2). References are provided where possible. For some properties, the estimates are based on the opinion of tank waste chemistry experts.

W. J. Powell
Page 2
February 26, 1999

74B50-99-021

Insoluble Solids

The overall solids loading in the SY-101 convective layer was previously estimated as 5 to 25 volume percent. The slurry concentration in the transfer line was estimated to vary from 2 to 17 volume percent with 7.5 as the mean (Reference 2).

The insoluble solids concentration of SY-101 the convective layer is estimated to be 3 weight percent or less. This is consistent with laboratory data and expert opinion. The concentration would be slightly lower on a volumetric basis because of the higher density of solids. The lab data (Reference 1) indicate insoluble metals (Ca, Cr, Fe, Mn, Ni, Si, and U) are present at around 0.5 weight percent. This corresponds to approximately 1 to 1.5 weight percent as metal oxides in the waste. The remainder of the solids is at least partially soluble, depending on temperature and concentration.

Dissolution - Effect of Dilution Ratio

The effect of the water dilution ratio on solids dissolution has been studied using the OLI Environmental Simulation Program (ESP). The simulations indicate that dissolution of soluble salts is 87 percent complete at a dilution of 35 parts water to 100 parts waste and 98 percent complete at 50 parts water to 100 parts waste (Reference 4). Further dilution actually results in a slight increase in solids because of pH-induced precipitation of aluminum hydroxide. The data are shown graphically in Figure 1.

These data support the preliminary conclusion that a dilution of 35 parts water to 100 parts waste is adequate, but a ratio of at least 50 parts water to 100 parts waste is desired. The target dilution range is from 50 to 150 parts water to 100 parts waste. Experimental results using actual waste samples are expected in April (Reference 3).

Dissolution - Effect of Dilution Water Temperature

The effect of dilution water temperature on solubility is also modeled in Reference 4. Increasing the temperature of the dilution water does not have as great an effect as increasing the dilution ratio. At a dilution ratio of 30 parts water to 100 parts waste, approximately 25% more soluble solids are present using 85 °F dilution water than 130 °F water. Additional data are provided in Figure 2. The target temperature range for dilution water has been specified as 110-130 °F to allow operational flexibility. Any dilutions using water in this temperature range will result in lower overall solids concentrations.

A specific question was proposed regarding the net effect of diluting SY-101 waste with water at the nominal 1:1 ratio and allowing the mixture to equilibrate and cool to 65 °F (which could happen in the discharge drop leg in tank 241-SY-102 (SY-102) if a siphon break occurred before line flushing). Although not modeled, it is anticipated that the final solids concentration would be lower than the initial, just-mixed concentration. That is, dissolution with the diluent is expected to have a stronger effect than the reduction in temperature. Figure 1 indicates that a 1:1 dilution is about 3 times more dilution water than is necessary to dissolve all NaNO_3 at the temperature of SY-101 (120 °F). Even

W. J. Powell
Page 3
February 26, 1999

74B50-99-021

upon cooling to 65 °F, much more NaNO_3 will be dissolved in the diluted waste than in the original SY-101 waste.

Dissolution/Precipitation Kinetics

The overall kinetics of dissolution will be measured in the dilution and mixing study specified in Reference 3. The consensus of tank waste chemistry experts is that dissolution of the nitrate, nitrite, carbonate, and phosphate solids should be fairly rapid (minutes). This may not have much effect on transfer properties, as the transit time to SY-102 will be less than one minute. Dissolution of oxalate is expected to take longer (hours).

Some precipitation of aluminum hydroxide is expected to occur because of the reduced pH of the diluted waste. This is known to be a slow process (days) and will not affect the pipeline behavior of the waste during the transfer. Although not expected to be a problem in the pipeline because of dilution, the precipitation of phosphates might occur within minutes and precipitation of oxalate and fluoro-phosphates within hours. The phosphate concentration in SY-101 waste is fairly low (0.5 weight percent from Reference 1). Precipitation of phosphates or fluoro-phosphate double salts may occur upon mixing with high phosphate saltwell liquors in SY-102. However, this is neither a pumping nor a pipeline transfer issue.

If you have any questions regarding the information provided, please call me at the above number.

J. M. Conner, Engineer
Process Control

jmc/mjg

W. J. Powell
Page 4
February 26, 1999

74B50-99-021

Data from Reference 4

Figure 1. 100,000 Gallon Transfer from SY-101

Figure 2. Effect of Dilution Water Temperature
100,000 Gallon Transfer from SY-101
100 Parts Waste to 30 Parts Water