

DEC 8 1998

Sta. 4

58

## ENGINEERING DATA TRANSMITTAL

Page 1 of 4

1. EDT

625179

2. To: (Receiving Organization) Distribution	3. From: (Originating Organization) Cold Vacuum Drying Facility	4. Related EDT No.: n/a
5. Proj./Prog./Dept./Div.: W-441/Spent Nuclear Fuel	6. Design Authority/ Design Agent/Cog. Engr.: J. J. Irwin	7. Purchase Order No.: n/a
8. Originator Remarks: Initial release issued for configuration control.		9. Equip./Component No.: n/a
		10. System/Bldg./Facility: CVD Facility
11. Receiver Remarks: 11A. Design Baseline Document? <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No		12. Major Assm. Dwg. No.: n/a
		13. Permit/Permit Application No.: n/a
		14. Required Response Date: n/a

15. DATA TRANSMITTED					(F)	(G)	(H)	(I)
(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	Approval Designator	Reason for Transmittal	Originator Disposition	Receiver Disposition
1	SNF-3062		0	Cold Vacuum Drying Facility Vacuum and Purge System Design Description	SQ	1	/	/
2	Memo: J. Brecht to J. J. Irwin/L. P. Hoss	1-4		Comments on CVDF SAR's (From CVDF SAR Team)	N/A	3	6	6

16. KEY			
Approval Designator (F)	Reason for Transmittal (G)		Disposition (H) & (I)
E, S, Q, D or N/A (see WHC-CM-3-5, Sec.12.7)	1. Approval	4. Review	1. Approved
	2. Release	5. Post-Review	2. Approved w/comment
	3. Information	6. Dist. (Receipt Acknow. Required)	3. Disapproved w/comment
			4. Reviewed no/comment
			5. Reviewed w/comment
			6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION (See Approval Designator for required signatures)											
(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN
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18. Signature of EDT Originator J. J. Irwin 11/17/98	19. Authorized Representative Date for Receiving Organization J. J. Irwin 11/17/98	20. Design Authority/ Cognizant Manager C. Haller 11/17/98	21. DOE APPROVAL (if required) Ctrl. No. <input type="checkbox"/> Approved <input type="checkbox"/> Approved w/comments <input type="checkbox"/> Disapproved w/comments
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# SPENT NUCLEAR FUEL PROJECT COLD VACUUM DRYING FACILITY VACUUM AND PURGE SYSTEM DESIGN DESCRIPTION

J. J. Irwin

Numatec Hanford Corporation, Richland, WA 99352  
U.S. Department of Energy Contract DE-AC06-96RL13200

EDT/ECN: 625179  
Org Code: 8C453  
B&R Code: 39EW70400


UC: 721  
Charge Code: LH302  
Total Pages: 59

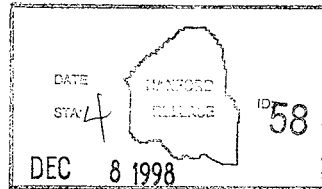
Key Words: Cold Vacuum Drying, System Design Descriptions

**Abstract:** This document provides the System Design Description (SDD) for the Cold Vacuum Drying Facility (CVDF) Vacuum and Purge System (VPS). The SDD was developed in conjunction with HNF-SD-SNF-SAR-002, *Safety Analysis Report for the Cold Vacuum Drying Facility, Phase 2, Supporting Installation of Processing Systems* (Garvin 1998), The HNF-SD-SNF-DRD-002, 1998, *Cold Vacuum Drying Facility Design Requirements*, and the CVDF Design Summary Report. The SDD contains general descriptions of the VPS equipment, the system functions, requirements and interfaces. The SDD provides references for design and fabrication details, operation sequences and maintenance. This SDD has been developed for the SNFP Operations Organization and shall be updated, expanded, and revised in accordance with future design, construction and startup phases of the CVDF until the CVDF final ORR is approved.

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Release Approval 11/30/98  
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Subject: COMMENTS ON COLD VACUUM DRYING FACILITY SYSTEM DESIGN DESCRIPTION

SNF-3062 (EDT 625179)	CVDF Vacuum and Purge System Design Description
SNF-3063 (EDT 625180)	CVDF Residual Gas Monitoring System Design description
SNF-3067 (EDT 625181)	CVDF General Service Helium System Design Description
SNF-3068 (EDT 625182)	CVDF Safety Class Helium System Design Description
SNF-3075 (EDT 625183)	CVDF Safety Electrical System Design Description
SNF-3077 (EDT 625184)	CVDF Fire Protection System Design Description
SNF-3081 (EDT 625185)	CVDF Heating, Venting, and Air Conditioning System Design Description
SNF-3082 (EDT 625186)	CVDF Process Water Conditioning System Design Description
SNF-3083 (EDT 625187)	CVDF Conditioned Water Shipping System Design Description
SNF-3084 (EDT 625188)	CVDF Contaminated Water Sampling and Analysis System Design Description
SNF-3085 (EDT 625189)	CVDF Tempered Water and Tempered Water Cooling System Design Description
SNF-3086 (EDT 625190)	CVDF Chilled Water System Design Description
SNF-3087 (EDT 625191)	CVDF Vacuum and Purge System Chilled Water System Design Description
SNF-XXXX (EDT XXXXXX)	CVDF Structural Systems Description
SNF-XXXX (EDT XXXXXX)	CVDF Crane Description
SNF-XXXX (EDT XXXXXX)	CVDF De-Ionized Water System
SNF-XXXX (EDT XXXXXX)	CVDF Potable Water System
SNF-XXXX (EDT XXXXXX)	CVDF Condensate Collection Description
SNF-XXXX (EDT XXXXXX)	CVDF Effluent System
SNF-XXXX (EDT XXXXXX)	CVDF Compressed and Instrument Air System

Twenty SDDs were transmitted to the SAR Safety organization for review and approval. Specific sections of two SDDs (SNF-3062, Vacuum and Purge System and SNF-3068, Safety Class Helium System) were reviewed for their ability to provide the system information required for preparing the CVDF FSAR. Section 3.0, "System Function," of the SDDs was of most interest to the SAR Safety organization for preparing the final SAR. It is noted that many comments previously submitted have been incorporated. It is also noted that some information is neither identified in the SDDs nor in any other design baseline document.

## COMMENTS

### SNF-3061 and SNF-3068

Section 3.0 (SNF-3061 and SNF-3068) was reviewed and it was noted that even though the SAR and SEL were referenced in this section, the information as noted in the revision number of these documents (as referenced in Section 9.3) was not documented accurately in the SDD. This section of the SDDs appears not to have been changed since the February 11, 1998 revision we reviewed. Between then and the latest SAR and the SEL as referenced in the SDDs, the systems have changed and this change is not reflected in the SDDs. All required safety class and/or safety significant equipment is not identified in the SDDs.

### SNF-3062 AND SNF-3068

The Section 3.2 "SAFETY FUNCTIONS," is a combination of several things. It appears to try to identify information from the SAR accident analysis but falls short of providing complete and accurate information. It also appears to identify some other safety functions (from the DRD?). Since the term "safety function" is used as a very specific term in SARs, suggest that this section is kept pure and talks to just the "safety functions" identified in the SAR, Chapter 4.0. If the system is not a safety class or safety significant SSC then this section can state that in accordance with HNF-SD-SNF-SAR-002, there are no safety functions for this system. Perhaps all these other safety functions that are identified in the SDD but not in the SAR can be placed in a sub section listed, for example, "Non-SAR Safety Functions." (found a close example in the way Sections 3.2 and 3.3 in SNF-3075 were prepared).

Specific safety functions for each system (if required) is identified in Section 4.0 of the SAR. (The following descriptions also include the requirements of DOE-STD-3009-94.)

Section 4.3.5.1, "Safety Function," (of the SAR) states the safety function of the VPS (also applies to SNF-3068 but SAR Section 4.3.2):

1. Provides the safety-class function of isolation of the MCO from the VPS upon SCIC system actuation of the VPS isolation valves during the thermal runaway reaction.
2. Initiates the safety-class process instrument signals to the SCIC system to initiate SCIC activation that is credited for the thermal runaway reaction.
3. Performs the above functions to prevent or mitigate the safety-significant consequences of the gaseous release, internal hydrogen explosion and the external hydrogen explosion.
4. Provides additional "water isolation" of the MCO from potential water ingress sources during and after the proof-of-dryness demonstration (use of redundant safety-class valves).
5. Safety-class pressure instruments are also utilized during the pressure hold tests.

Section 4.3.5.2, "System Description," provides a description of each safety-class component. For the VPS this includes valves, connectors, flexible piping, hard piping, instruments, pressure transmitters, pressure indicators, and a differential pressure indicator/transmitter.

Section 4.3.5.3, "Functional Requirements," identifies the requirements that are specifically needed to fulfill the safety functions of the VPS safety-class components.

Section 4.3.5.4, "System Evaluation," this section provides performance criteria imposed on the components so they can meet the functional requirements and thereby satisfy their safety function. Performance criteria characterize the specific operational responses and capabilities necessary to meet functional requirements. An evaluation is performed to see if the capabilities of the components meet the performance criteria.

The same comment above can be made for the other SDDs.

The SDDs need to be consistent with the SAR, i.e., the systems in Section 3.2 of the SDDs need to be identical to that Chapter 4.0 (corresponding subsection) of the SAR. The SDDs also need to provide some detailed description of the SSCs to be used in Section 4.3.5.2 of the SAR. In addition, the SDDs need to identify how the systems (or components) can meet the requirements identified in Section 4.3.5.3 of the SAR so that they can perform their "safety function" as identified in Section 4.3.5.1 of the SAR. If we don't have this information, we will not be able to conclude in the SAR that we have the appropriate SSCs that will make the CVDF a safe facility to operate. We cannot risk having DOE think otherwise. This is what the SAR is all about, do we have adequate controls, and have we provided proof (a robust argument)?

### SNF-3062, Section 2.1.3

Change sentence to read: "... The water vapor removed **from** the MCO is ..."  
(change "form" to "from.")

### SNF-3062, Section 3.2.4

Identify all performance category items for the VPS and provide a reference. The second sentence in the paragraph, "All process water conditioning ..." has nothing to do with the VPS system. Change this to the VPS. Provide a reference to the study or section of the SDD that evaluates the VPS SSCs and their ability to perform their safety function. (The SDD will not be able to provide a reference because no evaluation has been performed and/or documented yet. The evaluation is the responsibility of the SDD in Section 3.0 for not just NPH, but for the SAR design basis accidents. See previous comments on Section 3.0 of the SDD above.)

### SNF-3062, Section 8.1

The title of the section is "Potential System and Component Failure," however the contents do not comply with what appears to be the identified content matter of this section. First, the vacuum and purge system that this SDD was prepared for is not identified in the radioactive liquid release accident. Also, the SAR does not do a systematic review of the VPS failure. The SAR assumes systems are non-existent (or do not provide mitigation) so that an unmitigated dose can be calculated and then appropriate SSCs are identified to bring the dose to below guidelines for onsite and offsite doses. The SAR identifies that these SSCs must meet certain criteria and how the SSCs are built to meet the criteria to ensure that they can perform their intended safety function. But, the SAR does not identify system or component failure analysis. None of the other SDDs have a section on "System Design Analysis." Either delete this section from SNF-3062 or revise Section 8.1 to reference a correct failure analysis study.

### SNF-3075

Section in this SDD does not always follow the same format as most of the other SDDs (SNF-3062, SNF-3063, etc.) Should the format be consistent, if not, why?

Description in Section 1.0, "Introduction," is more detailed than in Section 2.1 "General Description." Should this be the reverse, if not, why?

It is an interesting way of dividing Safety Function (Section 3.2) and Nonsafety Function (Section 3.3). Section 3.2 should reference the SAR (as long as the information is correctly summarized

from the SAR). Section 3.3 could address all the other non-SAR items that the SDD may have to address.

#### SNF-3081

There is more system description (Section 1.1.2) and sometimes the exact description (Sections 1.1.3 and 1.1.5) in Section 1.0 as in Section 2.1 of the SDD. A summary system description should be in Section 1.0 with the more detailed description in Section 2.0.

Section 3.1.2 (and following sections) should specifically list by consistent nomenclature the system components that are safety class or safety significant as identified in the SAR. Identify these here since they need to be evaluated in this section (see comment on Section 3.0 for SNF-3062).

#### Crane SDD

There is very little description here, as a matter of fact you can find more description on the crane in the SAR than in the SDD. Add enough description so that this SDD is a stand-alone document.

#### GLOBAL COMMENTS FOR ALL SDDS

1. In general, Section 2.1 of all the SDDs has less descriptive information than the SAR (i.e., SCHe – SAR Section 2.5.4.2, VPS – SAR Section 2.5.3, etc.). SNF-3081 is better.
2. In general, Section 3.2.4 of all the SDDs has the same problem as noted in the comment above on SNF-3062. Provide a reference to the study or section of the SDD that evaluates the system SSCs and their ability to perform their safety function. (The SDD will not be able to provide a reference because no evaluation has been performed and/or documented yet. The evaluation is the responsibility of the SDD in Section 3.0 for not just NPH, but for the SAR design basis accidents. See previous comments on Section 3.0 of SNF-3062 above.)
3. Section 4.12.2 - As it currently reads it is not a true statement. Change the paragraph to read:

#### 4.12.2 Decontamination and Decommissioning

A conceptual decontamination and decommissioning plan for the CVDF, as identified in the guidelines of DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*, is scheduled for the final SAR.

HNF-SD-SNF-SAR-002 (Rev 4/4a) states that this is scheduled for the FSAR. It is not in the Phase 2 SAR that is referenced in the SDDs.

**COLD VACUUM DRYING FACILITY  
VACUUM AND PURGE SYSTEM  
DESIGN DESCRIPTION**

**SYSTEM 07-1**

Numatec Hanford Corporation  
Richland, Washington

COGEMA Engineering Corporation  
Richland, Washington

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## CONTENTS

1.0 INTRODUCTION	1-1
1.1 SUMMARY DESCRIPTION OF EQUIPMENT	1-1
1.2 ROLE OF SYSTEM IN PROCESS	1-1
1.3 TECHNICAL RESPONSIBILITY OF SYSTEM DESIGN DESCRIPTION	1-1
2.0 SYSTEM DEFINITION	2-1
2.1 GENERAL DESCRIPTION	2-1
2.1.1 Bulk Water Removal from the Multi-Canister Overpack	2-1
2.1.2 Helium Gas Purge of the Multi-Canister Overpack Atmosphere	2-1
2.1.3 Vacuum Pump-Down of the Multi-Canister Overpack Atmosphere	2-1
2.1.4 Multi-Canister Overpack Acceptance Testing	2-1
2.2 SYSTEM BOUNDARIES	2-2
2.3 SYSTEM INTERFACES	2-2
2.3.1 Electrical System	2-2
2.3.2 Monitoring and Control System and Safety-Class Instrumentation and Control System	2-2
2.3.3 Facility Deionized Water Supply	2-2
2.3.4 Facility Instrument Air	2-3
2.3.5 Process Equipment Skid and Process Hood Support Stand	2-3
2.3.6 Vacuum and Purge System Chilled Water System	2-3
2.3.7 Facility Helium Supply	2-3
2.3.8 Facility Heating, Ventilation, and Air Conditioning System	2-3
2.3.9 Safety-Class Helium System	2-3
2.3.10 Process Water Conditioning System	2-4
2.3.11 Tempered Water System	2-4
2.3.12 Tempered Water Cooling System	2-4
3.0 SYSTEM FUNCTION	3-1
3.1 SYSTEM CLASSIFICATION	3-1
3.1.1 Safety-Class Piping and Equipment	3-1
3.1.2 General Services Piping and Equipment	3-1
3.2 CVDF SAR SAFETY FUNCTIONS	3-1
3.3 Non-SAR SAFETY FUNCTIONS	3-2
3.3.1 Radiation Protection	3-2
3.3.2 Natural Phenomena Hazard Mitigation (Seismic)	3-3
3.3.3 Worker Safety Hazards Protection	3-3
3.4 ENVIRONMENTAL FUNCTIONS	3-3
4.0 SYSTEM REQUIREMENTS	4-1
4.1 OPERATIONAL AND FUNCTIONAL REQUIREMENTS AND BASIS FOR REQUIREMENTS	4-1
4.1.1 Water Removal from Multi-Canister Overpack	4-1
4.1.2 Evacuation of Multi-Canister Overpack Drain Line	4-1
4.1.3 Helium Pressure for Water Transfer	4-2
4.1.4 Isolation Valve Sealing	4-2
4.1.5 Flushing of Multi-Canister Overpack Plug Valve and Line	4-2

## CONTENTS (Continued)

4.1.6	Multi-Canister Overpack Gas Removal	4-2
4.1.7	Helium Purge of Multi-Canister Overpack Atmosphere	4-3
4.1.8	Vacuum Capability of Vacuum System	4-3
4.1.9	Process Valves Operation	4-3
4.1.10	Helium Leak Check of Top Shield Plugs	4-3
4.1.11	Prevention of Back-Flow to the Multi-Canister Overpack	4-4
4.1.12	Multi-Canister Overpack Offgas Radioactivity and Water Control	4-4
4.1.13	Condenser Water Control	4-4
4.1.14	Prevention of Bulk Water Freezing	4-5
4.1.15	Vacuum System Performance	4-5
4.1.16	Vacuum and Purge System Helium Gas Supply Control	4-5
4.1.17	Hydrogen and Water Vapor Monitoring of Residual Gas	4-5
4.1.18	Specific Design Requirements for Safety-Class Equipment	4-5
4.2	STRUCTURAL REQUIREMENTS	4-6
4.3	MECHANICAL REQUIREMENTS	4-6
4.3.1	Piping and Vessel Leak Test	4-6
4.3.2	Process Vessels and Tanks	4-6
4.3.3	Process Piping and Valves	4-6
4.3.4	Process Pumps and Compressors	4-7
4.3.5	Process Heat Exchangers	4-7
4.3.6	All Safety-Class Electrical Installations	4-7
4.4	MATERIALS REQUIREMENTS	4-7
4.4.1	American Society for Testing and Materials (ASTM)	4-7
4.5	INSTRUMENTATION AND CONTROLS	4-8
4.5.1	Electronic Transmitters	4-8
4.5.2	Local Control Stations	4-8
4.5.3	Instrumentation Units	4-8
4.5.4	Instrumentation and Control Equipment	4-9
4.5.5	Emergency "Off" Buttons Implementation	4-9
4.5.6	Safety Significant and General Service Instrumentation and Control Design and Fabrication	4-9
4.6	RELIABILITY REQUIREMENTS	4-9
4.7	ENVIRONMENTAL REQUIREMENTS	4-9
4.8	INTERFACING SYSTEMS REQUIREMENTS	4-9
4.8.1	Wiring to the Monitoring and Control System	4-9
4.8.2	Electrical Wiring to the Cold Vacuum Drying Facility	4-10
4.8.3	Instrument Air for Vacuum and Purge System	4-10
4.8.4	Cold Vacuum Drying Facility Helium Supply	4-10
4.8.5	Safety Class Helium Supply to the Multi-Canister Overpack	4-10
4.8.6	Chilled Water Supply	4-10
4.8.7	Tempered Water Cooling Water Supply	4-10
4.8.8	Deionized Water Supply	4-10
4.8.9	Process Water Conditioning System Support	4-11
4.8.10	Heating, Ventilation, and Air Conditioning Support	4-11
4.8.11	Multi-Canister Overpack Piping Connections	4-11
4.8.12	Process Equipment Skid and Process Hood Support Stand	4-11
4.9	OPERABILITY	4-11

## CONTENTS (Continued)

4.10	TESTABILITY AND PERIODIC TESTING	4-11
4.11	OPERATOR ACTIONS AND HUMAN FACTORS	4-11
4.12	SPECIAL CONSIDERATIONS	4-12
4.12.1	As Low As Reasonably Achievable	4-12
4.12.2	Decontamination and Decommissioning	4-12
4.12.3	Criticality	4-12
4.12.4	Fire Protection	4-13
4.12.5	Hydrogen Control	4-13
4.12.6	Safety Class Electrical	4-13
4.13	QUALITY ASSURANCE	4-13
4.14	REQUIRED CODES AND STANDARDS	4-13
4.14.1	Code of Federal Regulations (CFR)	4-13
4.14.2	American Society of Mechanical Engineers (ASME)	4-14
4.14.3	American Society of Nondestructive Testing	4-14
4.14.4	American Welding Society (AWS)	4-14
4.14.5	National Equipment Manufacturers Association (NEMA)	4-15
4.14.6	National Fire Protection Association (NFPA)	4-15
5.0	SYSTEM DESCRIPTION	5-1
5.1	GENERAL SUMMARY	5-1
5.2	PIPING AND INSTRUMENTATION DIAGRAM	5-1
5.3	SYSTEM ARRANGEMENT/CONFIGURATION	5-1
5.3.1	Vacuum Line in Process Hood	5-1
5.3.2	Vacuum Line and Associated Hardware on the Process Equipment Skid	5-2
5.3.3	Vacuum and Purge System Condenser Operation	5-2
5.3.4	Vacuum and Purge System Condenser Tank and Exit Line	5-3
5.3.5	Helium Additions and Vacuum Pumps	5-3
5.3.6	Process Control Skid Vacuum Connection to the Multi-Canister Overpack	5-4
5.4	EXPLANATION OF HOW SYSTEM MEETS DESIGN REQUIREMENTS	5-4
5.4.1	Water Removal from Multi-Canister Overpack	5-4
5.4.2	Evacuation of Multi-Canister Overpack Drain Line	5-5
5.4.3	Helium Pressure for Water Transfer	5-5
5.4.4	Isolation Valve Sealing	5-5
5.4.5	Flushing of Multi-Canister Overpack Plug Valve and Line	5-6
5.4.6	Multi-Canister Overpack Gas Removal	5-6
5.4.7	Helium Purge of Multi-Canister Overpack Atmosphere	5-6
5.4.8	Vacuum Capability of Vacuum System	5-6
5.4.9	Process Valves Operation	5-7
5.4.10	Helium Leak Check of Top Shield Plugs	5-7
5.4.11	Prevention of Backflow to the Multi-Canister Overpack	5-7
5.4.12	Multi-Canister Overpack Offgas Radioactivity and Water Control	5-8
5.4.13	Condenser Water Control	5-8
5.4.14	Prevention of Bulk Water Freezing	5-8
5.4.15	Vacuum System Performance	5-8
5.4.16	Vacuum and Purge System Helium Gas Supply Control	5-8
5.4.17	Hydrogen and Water Vapor Monitoring of Residual Gas	5-9

**CONTENTS (Continued)**

5.5 SYSTEM PARAMETERS/SETPOINTS/LIMITATIONS .....	5-9
5.5.1 Process Parameters and Setpoints .....	5-9
5.5.2 Operating Limits .....	5-9
5.5.3 Precautions .....	5-11
5.5.4 Recovery Procedures .....	5-11
6.0 SYSTEM OPERATION .....	6-1
7.0 SYSTEM SURVEILLANCE, TESTING, AND MAINTENANCE .....	7-1
7.1 CORRECTIVE AND PREVENTIVE MAINTENANCE .....	7-1
7.2 SURVEILLANCE AND IN-SERVICE INSPECTION .....	7-1
7.3 EQUIPMENT CALIBRATION .....	7-2
8.0 SYSTEM DESIGN ANALYSIS .....	8-1
8.1 POTENTIAL SYSTEM AND COMPONENT FAILURE .....	8-1
8.2 SYSTEMS SPECIAL HAZARDS TO WORKERS .....	8-1
8.3 MARGINS OF SAFETY .....	8-1
8.4 CRITICAL ENGINEERING STUDIES AND CALCULATIONS .....	8-2
9.0 REFERENCES .....	9-1
9.1 INDUSTRY STANDARDS AND CODES .....	9-1
9.2 GOVERNMENT DOCUMENTS .....	9-4
9.3 SPENT NUCLEAR FUEL PROJECT DOCUMENTS .....	9-5
9.4 DRAWINGS .....	9-6
APPENDIX A	
DRAWING AND SPECIFICATION LISTS .....	A-1

**LIST OF TABLES**

5-1. Physical Capabilities and Limitations of Vacuum and Purge System Components .....	5-9
--	-----

# LIST OF TERMS

ALARA	as low as reasonably achievable
CVDF	Cold Vacuum Drying Facility
HEPA	high-efficiency particulate air (filter)
MCO	multi-canister overpack
MCS	monitoring and control system
PES	process equipment skid
PWC	process water conditioning (system)
SCHe	safety class helium (system)
SCIC	safety class instrumentation and control (system)
SSC	structure, system, and component
TBD	to be determined
VPS	vacuum and purge system

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## 1.0 INTRODUCTION

This system design description addresses the vacuum and purge system (VPS) as an independent system. The discussion that follows is limited to the VPS and interfaces with associated systems. Drawings H-1-82351, *Cold Vacuum Drying Facility Process Equipment Skid Piping* (sheets 1 through 5); H-1-83766, *Cold Vacuum Drying Facility Process System P&ID* (sheets 1 and 2); and H-1-83767, *CVDF Vacuum Purge Chilled Water System P&ID*, depict the relationships of the different VPS subsystems.

This system design description, with the other elements of definitive design packages, provides a complete picture of the cold vacuum drying system. Elements of this design description include functions, requirements, and descriptions. Other documents comprising the definitive design of the VPS include the following:

- Project design requirements (HNF-SD-SNF-DRD-002)
- Safety equipment list (HNF-SD-SNF-SEL-002)
- Safety Analysis Report (HNF-SD-SNF-SAR-002)
- Contract drawings (see Appendix A)
- Procurement specification (see Appendix A)
- Data and calculation matrix tracking list (SNF-3001)
- Sequence of operations (see HNF-2356)

### 1.1 SUMMARY DESCRIPTION OF EQUIPMENT

The VPS consists of a single vacuum pump for vacuum operations, and a condensing assembly to dry process gases, valves, traps, filters, instrumentation and ducting that achieve and maintain the required operating pressures in the multi-canister overpack (MCO). A schematic of the VPS equipment arrangement for a typical process bay is shown in Drawings H-1-82160, *Cold Vacuum Drying Facility P&ID Legend*, and H-1-83766 (sheets 1 and 2). Interfaces with associated systems are also included in these drawings to show functionality.

### 1.2 ROLE OF SYSTEM IN PROCESS

The role of the VPS is to assist in the removal of bulk water from within the MCO and to then dry the MCO contents under vacuum and helium gas purging using a cycle of evacuation and helium gas backfill/purge stages. The final product is a dried MCO backfilled with helium gas.

### 1.3 TECHNICAL RESPONSIBILITY OF SYSTEM DESIGN DESCRIPTION

The VPS system design authority engineer is responsible for the accuracy and technical content of this system design description. Any questions on the system are addressed by the design authority.

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## 2.0 SYSTEM DEFINITION

### 2.1 GENERAL DESCRIPTION

There is one VPS for each process bay. The main components of the VPS are located on the process equipment skid (PES). VPS piping is routed through the process hood support stand where some VPS instrumentation and valves are located. The VPS supports several vital functions of cold vacuum drying of spent nuclear fuel in an MCO. These functions are listed in the following subsections.

#### 2.1.1 Bulk Water Removal from the Multi-Canister Overpack

The VPS assists in the bulk liquid removal from the MCO. Bulk liquid is withdrawn from the MCO through a long dip tube by the process water conditioning (PWC) system eductor. Helium gas is supplied to the MCO headspace during this liquid removal step. This helium gas supplied through the VPS via a short MCO dip tube maintains a moderate MCO headspace motive pressure to assist in liquid removal from the MCO. The liquid removed is transferred to the PWC system for treatment by ion exchangers and filters to remove the bulk of the entrained and insoluble radioactive species.

#### 2.1.2 Helium Gas Purge of the Multi-Canister Overpack Atmosphere

After the liquid is removed from the MCO, the MCO is purged through the short dip leg as the lines to the long dip leg are flushed to the PWC system. After the flush the monitoring and control system (MCS) switches helium gas flow from the short dip leg to the long dip leg and the MCO is purged and vented through the VPS. Water is removed from the MCO in the form of water vapor.

#### 2.1.3 Vacuum Pump-Down of the Multi-Canister Overpack Atmosphere

The MCO is evacuated to  $< 13$  Pa (0.1 torr) through the short dip leg via the VPS to remove residual water from the MCO fuel. The water vapor removed from the MCO is condensed in the VPS condenser, collected in the condensate collection tank, and transferred to the PWC system for treatment and transport back to the K-West basin. The dry gases passing through the condenser are discharged to the Cold Vacuum Drying Facility (CVDf) process ventilation system for filtering and discharge.

#### 2.1.4 Multi-Canister Overpack Acceptance Testing (Pressure Rebound and Helium Leak Testing)

A pressure rebound test is conducted on the MCO by isolating the MCO at the  $< 13$  Pa (0.1 torr) vacuum and monitoring the pressure for a one hour period. If the pressure remains at  $< 400$  Pa (3 torr) for this rebound test, the fuel is considered to satisfy the dryness criteria for interim storage. If the MCO does not pass this test, then repeat helium purge, evacuation steps, and pressure rebound testing are continued until the criteria is satisfied.

A proof mode is conducted in which the MCO is maintained at  $< 1.6$  kPa (12 torr) pressure for up to 28 hours. After a successful demonstration (additional time may be required to reach the 28 hours at the low pressure) of the proof mode a final pressure rebound test is conducted. Testing and treatment are to be repeated as necessary to meet the criteria. Upon successful completion of the proof mode and final pressure rebound testing the MCO is cooled to less than  $25^{\circ}\text{C}$  ( $77^{\circ}\text{F}$ ) for three hours and backfilled with helium to 40.0 to 60.7 kPa<sub>a</sub> (5.8 to 8.8 lbf/in<sup>2</sup> gauge) pressure and then shipped to the Canister Storage Building.

## 2.2 SYSTEM BOUNDARIES

The VPS is confined within the boundaries of the PES and process hood with connecting flexible pipe between them. Each PES occupies a space 5.49 m (18 ft) east-west, 1.83 m (6 ft) north-south, and 3.05 m (10 ft) high. The PESs are located 0.914 m (3 ft) from the north wall of each process bay, centered between the east and west walls. The process hood support stand is 3.05 m (10 ft) east-west, 1.07 m (3 ft, 6 in.) north-south, and 1.22 m (4 ft) high, centered east-west and bolted to the north mezzanine overhanging each process bay.

## 2.3 SYSTEM INTERFACES

The PES has 12 major interfaces with the cold vacuum drying process. These interfaces are described in the following subsections.

### 2.3.1 Electrical System

The VPS interfaces with the cold vacuum drying electrical system. All instrumentation electrical requirements are supplied through the MCS except the residual gas analysis power, which is supplied through other facility conduits. All electrical equipment is hard wired. The electrical equipment for each VPS includes a vacuum pump, which is wired to 480 V (ac), 3-phase power and trace heat elements on selected VPS piping.

### 2.3.2 Monitoring and Control System and Safety-Class Instrumentation and Control System

The VPS interfaces with the MCS and the safety class instrumentation and control (SCIC) system. All instrumentation and control wiring is routed to terminal blocks in junction boxes located on the PES and process hood.

### 2.3.3 Facility Deionized Water Supply

The VPS interfaces with the CVDF deionized water supply. The MCO drain line process water conditioning PWC-\*01-SS-1" and a portion of VPS-\*01-SS-1" are flushed using water supplied by DI-\*03-SS-3/4" that joins VPS-\*01-SS-1 at gas operated valve VPS-GOV-1\*11 and VPS-GOV-1\*17. The DI line connects to a quick disconnect DI/He-QD-\*110. A set flow to the VPS of 6 gpm at 20 psig is provided by the DI water system.

### 2.3.4 Facility Instrument Air

The VPS interfaces with CVDF instrument air supply. Air to all VPS pneumatically-operated valves, instruments, and controls located on the PES are supplied through line IA-\*01-SS-1" from the instrument air header. Air is supplied through line IA-\*03-SS-1" to all VPS pneumatically-operated valves, instruments, and controls located on the process hood support stand.

### 2.3.5 Process Equipment Skid and Process Hood Support Stand

The VPS interfaces with the PES and process hood support stands. Piping, equipment, instrumentation, and controls are attached to the PES support structure and the process hood support stands.

### 2.3.6 Vacuum and Purge System Chilled Water System

The VPS interfaces with the VPS chilled water system. Chilled water is supplied through the VPS chilled water supply line VPSCHW-\*01-SS-1" to the tank jacket VPS-CLR-2\*17 and through supply line VPSCHW-\*03-SS-1" to the condenser VPS-COND-2\*13. Line VPSCHW-\*02-SS-1" returns the chilled water to the VPS chilled water system.

### 2.3.7 Facility Helium Supply

The VPS interfaces with the facility helium system for use in the initial MCO bulk water removal step, for MCO purging during drying operations, and for the shaft seal on vacuum pump VPS-P-2\*11. Facility helium supply line He-\*03-SS-1" supplies helium for bulk water removal, He-\*01-SS-1" provides the purge supply, and He-\*04-ST-¼" supplies the seal.

### 2.3.8 Facility Heating, Ventilation, and Air Conditioning System

The four VPSs interface with the CVDF heating, ventilation, and air conditioning system. The output of vacuum pumps VPS-P-2\*11, pressure control valves PCV-2\*37, and pressure relief valves SRV-2\*17 discharge to process vent lines PV-\*01-SS-1".

### 2.3.9 Safety-Class Helium System

The four VPSs interface with their respective safety class helium (SCHe) systems at the MCOs. The SCHe system is included to place and hold the process system in the fail state if a seismic alarm occurs, an air inleak protection system alarms, or the MCS system has a critical failure. The SCHe system lines connected to VPS lines VPS-\*01-SS-1" and VPS-\*02-SS-1" to supply helium on demand are SCHe-\*09-SS-1", SCHe-\*10-SS-1", SCHe-\*11-SS-1", and SCHe-\*12-SS-1".

### 2.3.10 Process Water Conditioning System

The four VPSs interface with the PWC system in condenser VPS-COND-2\*13 where the VPS condensed water, condensed from the MCO offgases, is transferred from the collections tanks VPS-TK-2\*16 through lines PWC-\*02-SS-1" to the PWC system feed header PWC-\*01-SS-1" via lines PWC-\*03-SS-1".

### 2.3.11 Tempered Water System

The four VPSs indirectly interface with their respective tempered water systems at the MCOs. The temperature of the MCOs and their offgases is controlled at specific temperatures during the liquid removal and vacuum drying processes, and leak testing periods by circulating heated/cooled water from the tempered water system through the cask-MCO annulus.

### 2.3.12 Tempered Water Cooling System

The four VPSs interface with their respective tempered water cooling systems. The operating temperature of the VPS vacuum pump, VPS-P-2\*11, is maintained during the vacuum drying processes, by circulating cooled water from the tempered water cooling system through the vacuum pump casing.

### 3.0 SYSTEM FUNCTION

#### 3.1 SYSTEM CLASSIFICATION

The VPS performs safety-class isolation functions between the MCO and isolation valves located on the process hood support stand. VPS piping between these valves and the MCO form the primary confinement barrier for release of contamination. These are considered safety class primary confinement and are designed to performance category 3 standards as defined in the DOE-STD-1020-94, *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities*. The rest of the VPS is designated general service and is designed and tested to those standards. Designations are given as required by HNF-SD-SNF-SAR-002, *Safety Analysis Report for the Cold Vacuum Drying Facility, Phase 2, Supporting Installation of Processing Systems*. Safety and Performance category designations of the equipment, piping, valves and instruments, shown in the piping and instrumentation diagrams is given in HNF-SD-SNF-SEL-002, *Spent Nuclear Fuel Project Cold Vacuum Drying Facility Safety Equipment List*.

##### 3.1.1 Safety-Class Piping and Equipment

The piping, valves and instruments on the VPS from gas-operated valve VPS-GOV-1\*05 (safety class) to the MCO on VPS-\*02-SS-2" and from VPS-GOV-1\*11 (safety class) to the MCO on VPS-\*01-SS-1", including the valves, are designated safety class and performance category 3. There is a safety class and performance category 3 designation for the process hood support stand that supports this VPS equipment.

##### 3.1.2 General Services Piping and Equipment

The support structure for the VPS and all equipment contained within it are designated general services and all structural components and equipment anchorage are performance category 2 for the PES.

#### 3.2 CVDF SAR SAFETY FUNCTIONS

The CVDF SAR, HNF-SD-SNF-SAR-002, defines the safety functions for the VPS. These functions are defined in Section 4.3.5.1 of the CVDF SAR and are summarized as follows.

1. Provide the safety-class function of isolation of the MCO from the VPS upon SCIS system actuation of the VPS isolation valves.
2. Initiate the safety-class process instruments signals to the SCIC system to initiate SCIC activation that is credited to the MCO design basis accidents.
3. Perform the above functions to prevent or mitigate the safety-significant consequences of the MCO gaseous release, MCO internal hydrogen explosion or external to MCO hydrogen explosion.

4. Provide additional water isolation of the the MCO from potential water ingress sources during and after the proof of dryness operation.
5. Provide safety-class instrumentation that are utilized during the pressure rebound tests.

### 3.3 Non-SAR SAFETY FUNCTIONS

#### 3.3.1 Radiation Protection

The following list of radiation protection features has been considered and incorporated into the design of the VPS as appropriate to meet as low as reasonably achievable (ALARA) exposure requirements and design guidelines.

Engineering Controls. Engineering controls considered to achieve ALARA goals include the following.

1. Confinement systems, such as process piping, vessels, and structural enclosures.
2. Ventilation systems that ensure negative pressure and flow toward the areas with highest contamination risk.
3. Compartmentalization to isolate higher risk areas.
4. Equipment location and arrangement so that servicing and replacement can be accomplished away from high-risk areas.
5. Waste treatment and handling systems to minimize releases.
6. Inclusion of decontamination features.
7. Automation of the process so that operators need not be present in the radiation field in order to operate the process.
8. Arrangement designed so as to maximize the distance between operators and sources.
9. Traps where radioactive material can accumulate in the systems minimized and provisions included for periodic decontamination of the process system.
10. Local shielding, including piping and vessel materials, to minimize source terms.
11. Communication and observation systems to monitor operators when in the radiation field.

Maintenance Features. The following maintenance features were considered to reduce exposure of personnel.

1. Use of modular construction to expedite replacement.

2. Decontamination of equipment or piping prior to replacement or maintenance; equipment and piping selection basis included ease of decontamination.
3. High or enhanced system performance to reduce maintenance requirements.
4. Selection of components that do not require lubrication or regular service.

### **3.3.2 Natural Phenomena Hazard Mitigation (Seismic)**

The safety class VPS support structure (Process Hood Stand) and attachments are performance category 3. All general services VPS structures, systems, and components (SSCs) have been evaluated for their potential to prevent safety class SSCs from performing their functions.

### **3.3.3 Worker Safety Hazards Protection**

The VPS design has been evaluated against and complies with the required codes, standards, and regulations for industrial safety and hygiene.

## **3.4 ENVIRONMENTAL FUNCTIONS**

The VPS provides essential support to environmental functions (SSCs) by providing safety class isolation and safety significant confinement of the radioactive effluents. All safety class and safety significant components are designed to function under worst case internal and external environmental conditions. The safety basis internal conditions and specific external environmental conditions for safety are listed in HNF-SD-SNF-SEL-002. The VPS is protected from high winds and tornadoes by the structure of the CVDF. Flooding, lightning, and snow load protections are provided by the placement and design of the CVDF.

## 4.0 SYSTEM REQUIREMENTS

### 4.1 OPERATIONAL AND FUNCTIONAL REQUIREMENTS AND BASIS FOR REQUIREMENTS

Operational and functional requirements are taken from HNF-SD-SNF-DRD-002, *Cold Vacuum Drying Facility Design Requirements*, Section 5.0, "Process System Design Requirements." In the following subsections these requirements are listed in italics followed by their basis.

#### 4.1.1 Water Removal from Multi-Canister Overpack

*Water from the MCO shall be transferred through a drain pipe system to a collection tank/purification system shared by all the process bays. The water shall be drawn from the bottom of the MCO through the MCO draw tube. A screen will prevent particulates larger than 2 mm (0.08 in.) from exiting the MCO (MCO Design Report). Water removed from the MCO shall be filtered as close to the MCO as practical to minimize the migration of radioactive particulates to downstream equipment. (Note: "MCO Design Report" is HNF-SD-SNF-DR-003.)*

**Basis:** A common collection point/system minimizes the expense and contamination issues associated with the PWC system. Drawing the water from the bottom of the MCO ensures that most of the MCO water is being removed. Screening the effluent from the MCO keeps the pieces of the fuel rods within the MCO. Water removed from the MCO is filtered as close to the bottom of the MCO as practical MCO design provides for high-efficiency particulate air (HEPA) filtration of exiting gases and straining of liquids within the MCO to minimize the migration of radioactive particulates to downstream equipment. Helium is supplied through the VPS to the MCO headspace to assist this operation.

#### 4.1.2 Evacuation of Multi-Canister Overpack Drain Line

*The drain line shall be capable of being evacuated. The vacuum shall be sufficient to draw liquid from the bottom of the MCO to the highest point in the PWC system, overcome the pressure drop in the local filter, and achieve a flowrate sufficient to drain the MCO in approximately 0.5 hours or less.*

*The drain pipe system shall be designed to be leak tight and should minimize the potential for contamination spread to other process bays should any leak develop. Local filtration and non-pressurized transfer lines shall be used if at all practical.*

**Basis:** Evacuation of the PWC system drain line is required for contamination control purposes. The 0.5 hour drain time criteria is needed for design throughput purposes. The eductor is rated to draw 0.000315 cm<sup>3</sup>/s (5 gal/min) from the MCO at atmospheric pressure. For the maximum liquid content of 0.568 m<sup>3</sup> (150 gal) of liquid, 30 minutes is required for removal at atmospheric pressure. A helium gas head pressure of 27.6 kPa<sub>g</sub> (4 lbf/in<sup>2</sup> gauge) is maintained in the



MCOs via the VPS during the liquid removal process which reduces the time required for transfer to less than 30 minutes.

#### 4.1.3 Helium Pressure for Water Transfer

*The helium system connections to the MCO shall be used to pressurize the head space above the water in the MCO as it is transferred.*

Basis: As an added motive force, pressurizing the MCO headspace with helium to 27.6 kPa<sub>g</sub> (4 lb/in<sup>2</sup>) aids in bulk water removal. Helium gas is added to the MCO through the VPS. Helium is added from lines He-\*03-SS-1" via the respective VPS lines VPS-\*02-SS-2".

#### 4.1.4 Isolation Valve Sealing

*There shall be an isolation valve in the drain line near the MCO. This valve is open during water transfer and closed during the drying process. The valve must seal well enough that leakage through it will not prevent the MCO from attaining its ultimate vacuum requirement.*

Basis: Isolation of the MCO and PWC system is needed for safety class accident scenarios and for isolation between the processing elements within the CVDF. The VPS is used to withdraw gases from the MCO and establish the necessary vacuum in the MCO while relying on the isolation valve seal to prevent unacceptable leak through.

#### 4.1.5 Flushing of Multi-Canister Overpack Plug Valve and Line

*The MCO plug valve operator which is exposed to contaminated water flow shall be injected with deionized water into the operator body while the purge gas flows immediately after the last water has been drawn from the MCO. The rinse water shall clean the drain line and be collected in the PWC system.*

Basis: MCO valve operators are manually handled. For purposes of ALARA, it is important to remove as much radioactive contaminants as possible from the valves (VPS-GOV-1\*02) prior to handling. The contaminated rinse water follows the MCO liquid to the PWC system for processing. The VPS assists in this operation by providing the purge gas flow.

#### 4.1.6 Multi-Canister Overpack Gas Removal

*The VPS shall remove gas species (volumetric, off-gassing, residual free water, water-fuel reaction products, and in-leakage) from the MCO so that the contents of the MCO are dried until a vacuum < 67 Pa (0.5 torr) is achieved and until a one-hour pressure rise test started when the pressure is < 67 Pa (0.5 torr) does not result in a final pressure above 400 Pa (3.0 torr).*

Basis: The stated criteria were developed to provide assurance that the final sealed and stored MCO would not develop flammable hydrogen concentrations.

#### 4.1.7 Helium Purge of Multi-Canister Overpack Atmosphere

*The system shall be configured to enable injection of helium into the MCO periodically so that an evacuation-purge cycle can be operated.*

Basis: The helium provides a diluting and removal agent against the build-up of flammable hydrogen concentrations. The MCO purged gases are withdrawn by the VPS through lines VPS-\*02-SS-2".

#### 4.1.8 Vacuum Capability of Vacuum System

*The VPS shall have the capability of pumping down the MCO to operating basis pressure level of 67 Pa (0.5 torr) or lower. This condition assumes that the VPS and MCO are leaktight to the MCO operating level basis (0.01 Pa-L/sec [1 x E-4 atm.cc/sec]).*

Basis: Final vacuum drying and execution of the acceptance pressure rise test requires a pressure level of 67 Pa (0.5 torr).

#### 4.1.9 Process Valves Operation

*All valves shall have remotely activated operators. All valves shall fail to a fail-safe position upon loss of control air, control signal, or electric power. The valves may have elastomer seals. This requirement is dictated due to the low vacuum requirements. No code requirements are stipulated for the vacuum valves having safety classifications of safety significant or general service.*

Basis: Computer-controlled process actuators minimize the probability of human errors. Fail-safe operators are required to mitigate problems from accident and off-normal scenarios.

#### 4.1.10 Helium Leak Check of Top Shield Plugs

*The VPS shall be designed to assist in the helium leak checking of the MCO top shield plugs following the completion of the cold vacuum drying process.*

Basis: Backfilling of the MCO with a highly pure inert gas at a positive pressure is necessary to minimize the presence of constituents that react with uranium metal and metal hydrides in the fuel elements, thereby inhibiting the corrosion process and providing interim stabilization of the fuel. Helium leak checking of the MCO ensures leak tightness of the MCO.

#### 4.1.11 Prevention of Back-Flow to the Multi-Canister Overpack

*The VPS shall be designed to preclude back flow of water or organic material into the MCO. Backstreaming of vacuum pump oil and suck-back of condensed moisture or any leaks of glycol-based condenser coolant into the MCO shall be precluded. Contamination of downstream equipment shall also be precluded due to its potential to damage the equipment or reintroduce contaminants back into the MCO. Prevention of introduction of water or organic materials into the MCO is an OCRWM issue (see appendix F of DRD), and a safety issue.*

**Basis:** The purpose of the process is to remove hydrogen containing compounds from contact with the fuel rods. Water, glycol, or organic oils all represent hydrogen-bearing compounds that could be broken down into free hydrogen within the MCO, and hence, must be precluded to accomplish the processing mission.

#### 4.1.12 Multi-Canister Overpack Offgas Radioactivity and Water Control

*Gas drawn from the MCO shall be filtered as close to the MCO as can be reasonably configured to minimize the migration of radioactive dust particles through the VPS. Water in the vacuum pump stream and circulating helium gas stream shall be condensed. The water shall be directed to the PWC system.*

**Basis:** The MCO internal HEPA filter on the short dip tube filters all gas exiting the VPS. Water vapor is condensed from this gas stream by the VPS condenser. This condensed water is collected and transferred to the PWC system for radioactivity removal.

#### 4.1.13 Condenser Water Control

*Water collected from the condenser shall be transferred into the PWC system. Positive features are provided to prevent the inadvertent transfer of condensed liquid back into the MCO from credible equipment failure or process upset.*

**Basis:** Condensed water from the MCO contains radioactive contaminants and needs to be processed through the PWC system. The condensed water is collected in a receiver tank which has a high-level switch interconnected with valves from the MCO to the VPS condenser. If a high level is detected the valves are closed to terminate gas flow from the MCO and thus prevent liquid backflow to the MCO. The purpose of the VPS is to remove most of the bulk and residual water and most of the waters of hydration from contact with the fuel rods. Water represents a hydrogen bearing compound that could be broken down into free hydrogen within the MCO, and hence, must be precluded to accomplish the processing mission.

#### 4.1.14 Prevention of Bulk Water Freezing

*The inert gas purge controller shall be capable of throttling the vacuum pump such that the pressure inside the MCO is maintained at 0.7 kPa (5 torr) or more to prevent freezing of bulk water during initial pumpdown. At this pressure, the water in the MCO does not freeze as the equilibrium vapor pressure of water at 0 °C (32 °F) is 0.6 kPa (4.56 torr).*

Basis: Blockage represents one of the failure modes against which process lines must be guarded. Freezing would cause failure, thus the potential must be mitigated.

#### 4.1.15 Vacuum System Performance

*After the bulk water is removed, the pumping system shall have the capability of achieving a pressure of 67 Pa (0.5 torr) for final water vapor removal.*

Basis: The stated criteria were developed to provide assurance that the final sealed and stored MCO would not develop flammable hydrogen concentrations.

#### 4.1.16 Vacuum and Purge System Helium Gas Supply Control

*The VPS shall control the introduction of helium gas for backfilling the MCO (normal shutdown) and in case of off normal (non-emergency) shutdown conditions.*

Basis: The control system that drives the main cold vacuum drying is also the one that controls safety to provide maximum assurance of proper operation.

#### 4.1.17 Hydrogen and Water Vapor Monitoring of Residual Gas

*A residual gas monitoring system shall be provided that will measure the concentration of hydrogen and water vapor gas species and shall determine the gas concentration to 1 ppm. A residual gas analyzers, based upon quadrupole or mass sector design shall measure the gas species partial pressure over the range of 1 to 100 atomic mass units minimum and detect partial pressures to  $1 \times 10^{-4}$  Pa ( $1 \times 10^{-6}$  torr).*

Basis: The stated criteria were developed to provide assurance that the final sealed and stored MCO does not develop flammable hydrogen concentrations. A key component of the cold vacuum drying system is assurance that the process criteria have been achieved. The residual gas analysis provides the assurance that the process criteria have been met.

#### 4.1.18 Specific Design Requirements for Safety-Class Equipment

Specific design requirements are identified for safety class, safety significant, and general service SSCs. The following information is provided for individual system components in HNF-SD-SNF-SEL-002:

1. Name
2. Indicator number
3. Type/description
4. Make/model/S/N
5. Operating parameters and alarm set points
6. Identified accident parameters/environmental conditions
7. Safety function/safety SSCs
8. Material type
9. Required codes and standards.

## 4.2 STRUCTURAL REQUIREMENTS

All VPS tanks, valves, components, instrumentation, controls, and support structures required to perform the safety class primary confinement functions are designed and qualified for performance category 3 as defined in DOE-STD-1020-94.

Structural components and equipment anchorage are performance category 2 on the PES and performance category 3 on the process hood. Structural welding is conducted per AWS-D1.1, *Structural Welding Code-Steel*.

## 4.3 MECHANICAL REQUIREMENTS

### 4.3.1 Piping and Vessel Leak Test

The assembled piping and vessel system passed a mass spectrometer leak detection test to better than  $1 \times 10^{-6} \text{ cm}^3_{\text{STP}} \text{ He/s}$ .

### 4.3.2 Process Vessels and Tanks

All VPS process equipment vessels and tanks are designed and fabricated per *Boiler and Pressure Vessel Code* (ASME 1995), Section VIII, "Rules for Construction of Pressure Vessels," Division 1, and *Heat Exchangers Mechanical Standards* (TEMA 1992).

### 4.3.3 Process Piping and Valves

All safety significant and general service VPS process equipment piping and valves are designed and fabricated per ANSI/ASME B31.3, *Process Piping Code*, and ANSI/ASME B16 Standards series, *Fittings, Flanges, and Valves*.

All safety-class VPS process equipment piping and valves are designed and fabricated per ANSI/ASME B31.1, *Power Piping Code*.

#### 4.3.4 Process Pumps and Compressors

The VPS process equipment vacuum pumps are designed and constructed in accordance with vacuum industry standard practices.

#### 4.3.5 Process Heat Exchangers

The VPS process heat exchangers (condensers) are designed and fabricated per *Boiler and Pressure Vessel Code* (ASME 1995), Section VIII, "Rules for Construction of Pressure Vessels," Division 1, and TEMA (1992).

#### 4.3.6 All Safety-Class Electrical Installations

All safety-class electrical components are designed and fabricated per IEEE-603, *Standard for Design Qualification of Safety Systems for Nuclear Power Generating Stations*, and all safety-significant electrical components are designed and fabricated per IEEE-577, *Standard Requirements for Reliability Analysis in the Design and Operation of Safety Systems for Nuclear Power Generating Stations*.

### 4.4 MATERIALS REQUIREMENTS

The materials of construction for the various SSCs meet the requirements listed in the following subsections.

#### 4.4.1 American Society for Testing and Materials (ASTM)

- A36, *Standard Specification for Structural Steel*
- A105, *Standard Specification for Forgings, Carbon Steel, for Piping Components*
- A106, *Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service*
- A182, *Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service*
- A197, *Standard Specification for Cupola Malleable Iron*
- A240, *Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels*
- A269, *Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service*
- A276, *Standard Specification for Stainless and Heat-Resisting Steel Bars and Shapes*

- A307, *Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength*
- A312/312M, *Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipes*
- A354, *Standard Specification for Quenched and Tempered Alloy Steel Bolts, Studs and Other Externally Threaded Fasteners*
- A479, *Standard Specification for Stainless and Heat-Resisting Steel Bars and Shapes for Use in Boilers and other Pressure Vessels*
- A480, *Standard Specification for General Requirements for Flat-Rolled Stainless Heat-Resisting Steel Plate, Sheet, and Strip*
- A500, *Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes*
- A563, *Standard Specification for Carbon and Alloy Steel Nuts*
- F593, *Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs*
- F594, *Standard Specification for Stainless Steel Nuts.*

#### **4.5 INSTRUMENTATION AND CONTROLS**

All instrumentation and control equipment interface with the general service MCS and the SCIC system. Isolation from power transients and failures is provided such that safety functions are accomplished under power loss or transient conditions.

##### **4.5.1 Electronic Transmitters**

Local electronic transmitters for remote (and local) indications are provided when feasible.

##### **4.5.2 Local Control Stations**

Local control stations (hand-off-auto) for major electrical components are provided. The MCS is notified when equipment is taken out of "auto."

##### **4.5.3 Instrumentation Units**

Engineering units are used whenever possible. Instrumentation ranges shall cover both the expected normal range as well as upset and emergency conditions.

#### 4.5.4 Instrumentation and Control Equipment

Instrumentation and control equipment is standardized as much as is feasible.

#### 4.5.5 Emergency "Off" Buttons Implementation

Emergency "off" buttons are implemented where required based on the impact to personnel and equipment.

#### 4.5.6 Safety Significant and General Service Instrumentation and Control Design and Fabrication

All safety significant and general service instrumentation and control are designed and fabricated per ANSI/ISA-S5.1, *Instrument Symbols and Identification*; ANSI/ISA-S5.4, *Instrument Loop Diagrams*; ANSI/ISA-S18.1, *Annunciator Sequences and Specifications*; and ANSI/ISA-S20, *Specification Forms for Process Measurement and Control Instruments Primary Elements and Control Valves*.

### 4.6 RELIABILITY REQUIREMENTS

The actual life of the project is scheduled to be two years and the design life is five years. Adequate spare parts per the maintenance manuals must be on hand to handle any downtime situation in a timely manner.

### 4.7 ENVIRONMENTAL REQUIREMENTS

All safety-class components are designed to function under worst case internal and external environmental conditions. The VPS is seismically qualified for performance categories 2 and 3 (see HNF-SD-SNF-SEL-002). It is protected from high winds and tornadoes by the structure of the CVDF. Flooding, lightning, and snow load protections are provided by the placement and design of the CVDF.

### 4.8 INTERFACING SYSTEMS REQUIREMENTS

#### 4.8.1 Wiring to the Monitoring and Control System

All VPS instrumentation and control wiring to the MCS is per IEEE-577 to meet safety significant requirements for safety significant SSCs and per IEEE-603 to meet safety class requirements. The SCIC system provides safety class sensing, actuation logic, actuation signals, and control interfaces to prevent MCO fuel runaway reaction (over temperature) and MCO hydrogen explosion.



#### 4.8.2 Electrical Wiring to the Cold Vacuum Drying Facility

All VPS interfaces with the cold vacuum drying electrical system are through hard-wired connections with facility single-phase, 120 V (ac) electrical as needed. All wiring is per IEEE-577 to meet safety significant requirements for safety significant SSCs and per IEEE-603 to meet safety class requirements.

#### 4.8.3 Instrument Air for Vacuum and Purge System

The CVDF instrument air system via line IA-\*01-SS-1" is able to supply 621 kPa<sub>g</sub> (90 lbf/in<sup>2</sup> gauge) instrument air for the gas-operated valves on the VPS. This instrument air is also provided to the MCO cask lid sealing mechanism at 310 kPa<sub>g</sub> (45 lbf/in<sup>2</sup> gauge) via a pressure reducing valve.

#### 4.8.4 Cold Vacuum Drying Facility Helium Supply

The CVDF helium supply to the VPS vacuum pump via He-\*04-ST-¼" provides a helium purge to remove water from the pump. The CVDF helium supply to the VPS process line VPS\*10-SS-2" is provided at 27.6 kPa (4 lbf/in<sup>2</sup> gauge) via line He-\*03-SS-1" at a 0.00566 m<sup>3</sup><sub>STP</sub>/s (12 ft<sup>3</sup><sub>STP</sub>/min) maximum flow rate for MCO bulk water removal and MCO purge drying.

#### 4.8.5 Safety Class Helium Supply to the Multi-Canister Overpack

SCHe is supplied to the MCO through the VPS lines at a maximum pressure of 27.6 kPa<sub>g</sub> (8 lbf/in<sup>2</sup> gauge) through one in. lines.

#### 4.8.6 Chilled Water Supply

The VPS chilled water supply shall provide a minimum of 1,351 W (4,612 Btu/h) of chilling capacity to the VPS condenser and condensate holding tank per calculation CVD-10 (see SNF-3001).

#### 4.8.7 Tempered Water Cooling Water Supply

The TWC system water supply shall provide a maximum of 1 gpm of flow capacity to the VPS vacuum pump, VPS-P-2\*11.

#### 4.8.8 Deionized Water Supply

Deionized water is provided to the PES via line DI-\*01-SS-1" to flush line VPS-\*01-SS-1" and valves VPS-GOV-1\*11/1\*17 and VPS-V-\*019.

#### 4.8.9 Process Water Conditioning System Support

The PWC system receives water removed from the MCO by the VPS via line PWC-\*01-SS-1" and processes it to remove dissolved and suspended radionuclides. The PWC system is sized to process liquid from 410 MCOs in a 2-year period.

#### 4.8.10 Heating, Ventilation, and Air Conditioning Support

The heating, ventilation, and air conditioning system receives output of vacuum pump VPS-P-2\*11, pressure control valve PCV-2\*37, bypass line isolation valve VPS-GOV-2\*05 and pressure relief valve SRV-2\*17 connected to process vent line PV-\*01-SS-1".

#### 4.8.11 Multi-Canister Overpack Piping Connections

The VPS interfaces with the MCO at the MCO plug short dip leg valve and the long dip leg valve. Flow through the short dip leg is limited to about  $0.0472 \text{ m}^3_{\text{STP}}/\text{s}$  ( $100 \text{ ft}^3_{\text{STP}}/\text{min}$ ) and a maximum  $50 \text{ }^\circ\text{C}$  ( $122 \text{ }^\circ\text{F}$ ). The vacuum rating is limited to  $6.7 \text{ Pa}$  ( $0.05 \text{ torr}$ ) and pressure rating is limited to  $1034 \text{ kPa}_g$  ( $150 \text{ lbf/in}^2 \text{ gauge}$ ) design and  $68.7 \text{ kPa}_g \pm 15\%$  ( $10 \text{ lbf/in}^2 \text{ gauge} \pm 15\%$ ) operation.

#### 4.8.12 Process Equipment Skid and Process Hood Support Stand

The VPS piping, equipment, instrumentation, and controls are supported by the PES support structure and the process hood stand.

### 4.9 OPERABILITY

<List technical safety requirements. This section is intended to specifically address and list the technical safety requirements for the system. > TBD

### 4.10 TESTABILITY AND PERIODIC TESTING

The VPS shall have sufficient testability designed into it to permit the periodic measurement and calibration of all setpoints and adjustments that affect the manner in which the VPS performs. Periodic testing of VPS SSCs is dictated by the requirements of the individual components according to the respective manufacturer's recommended schedule and practice, and is administered by controlled procedures for all safety class and safety significant SSCs.

### 4.11 OPERATOR ACTIONS AND HUMAN FACTORS

The majority of VPS operation is automatically controlled by the MCS. The manual operator actions in the process sequences are field operator actions such as connecting the MCO valves, operating manual block valves, connecting quick-disconnect valves and control room operator actions

such as acknowledging alarms or instructing the MCS to proceed with the next step. Operators shall direct the MCS when to initiate a sequence. Valve state changes, heater temperature control, gas supply pressure control, process status notification, and system alarm notification are performed by the MCS. The coordination between the control room and the field operator for manual operations must be practiced. Additional evaluation is TBD on outside contract.

#### 4.12 SPECIAL CONSIDERATIONS

All aspects of the VPS are in compliance with the *Hanford Federal Facility Agreement and Consent Order* (Ecology 1994), commonly referred to as the Tri-Party Agreement, and in compliance with applicable federal, state, and local laws and American Indian treaty rights.

##### 4.12.1 As Low As Reasonably Achievable

Essential elements of the ALARA program are defined in G-10 CFR 835/B2-Rev.0, *Implementation Guide for Use with Title 10, Code of Federal Regulations, Part 835 Occupational Radiation Protection*. The ALARA program implemented at the Spent Nuclear Fuel Project facilities is documented in SNF-AP-5-006, *ALARA Goals, Training, and Control Level Administration*; SNF-AP-5-012, *Radiological ALARA Work Planning Process*; and SNF-AP-5-013, *Radiological ALARA Process*; which establish lines of responsibility for administering ALARA practices. A CVDF coordinator and committee oversee the CVDF ALARA practices.

##### 4.12.2 Decontamination and Decommissioning

A conceptual decontamination and decommissioning plan for the CVDF, as identified in the guidelines of DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*, is included in HNF-SD-SNF-SAR-002.

##### 4.12.3 Criticality

Criticality prevention at the CVDF is maintained by following the following U.S. Department of Energy Orders, Industry Consensus Standards, and U.S. Nuclear Regulatory Commission Rules.

- U.S. Department of Energy Orders
  - DOE Order 5480.20A, *Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities*
  - DOE Order 5480.23, *Nuclear Safety Analysis Reports*
  - DOE Order 5480.24, *Nuclear Criticality Safety*
  - DOE Order 6430.1A, *General Design Criteria*
- Industry Consensus Standards

- ANSI/ANS-8.3, *Criticality Accident Alarm System*
- ANSI/ANS-8.1, *Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors*
- ANSI/ANS-8.19, *Administrative Practices for Nuclear Criticality Safety*
- U.S. Nuclear Regulatory Commission Rules
  - 10 CFR 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste," specifically Section 72.124, "Criticality for Nuclear Criticality Safety."

#### 4.12.4 Fire Protection

All fire protection is designed and fabricated per the National Fire Protection Association.

#### 4.12.5 Hydrogen Control

Hydrogen protection from explosions requires hydrogen concentrations of less than 4 vol% in gases.

#### 4.12.6 Safety Class Electrical

All safety class electrical is designed and fabricated per IEEE-603, all safety significant or general services electrical is designed and fabricated per IEEE-577. See SNF-3073, *Cold Vacuum Drying Facility Effluent Drains System Design Description*.

### 4.13 QUALITY ASSURANCE

The VPS system fabrication quality assurance/control program is based on the safety classification of the SSCs as detailed in the Safety Equipment List (HNF-SD-SNF-SEL-002) and application of a graded approach as described in the Project Hanford Quality Assurance Program Description (HNF-MP-599).

### 4.14 REQUIRED CODES AND STANDARDS

#### 4.14.1 Code of Federal Regulations (CFR)

- 10 CFR 830.120, "Quality Assurance"
- 29 CFR 1910.120, "Occupational Safety and Health Standards."

#### 4.14.2 American Society of Mechanical Engineers (ASME)

- B16.5, *Pipe Flanges and Flanged Fittings* (ANSI-approved)
- B16.10, *Face to Face and End to End Dimensions of Valves*
- B16.11, *Forged Steel Fittings, Socket-Welding and Threaded* (ANSI-approved)
- B16.21, *Nonmetallic Flat Gaskets for Pipe Flanges*
- B16.25, *Buttwelding Ends*
- B16.34, *Valves Flanged, Threaded, and Welding End*
- B16.39, *Malleable Iron Threaded Pipe Unions Classes 150, 250, and 300* (ANSI-approved)
- B18.2.1, *Square and Hex Bolts and Screws Inch Series Including Hex Cap Screws and Lag Screws* (ANSI-approved)
- B31.1, *Power Piping Code* (ANSI-approved)
- B31.3, *Process Piping Code* (ANSI-approved)
- *Boiler and Pressure Vessel Code*
  - Section II, "Material Specifications, Welding Rods, Part C Electrodes, and Filler Metals"
  - Section VIII "Division I Rules for Construction of Pressure Vessels"
  - Section IX "Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators"
- NQA-1, *Quality Assurance Requirements for Nuclear Facilities Applications*.

#### 4.14.3 American Society of Nondestructive Testing

- SNT-TC-1A, *Recommended Practice*

#### 4.14.4 American Welding Society (AWS)

- D1.1, *Structural Welding Code-Steel*

**4.14.5 National Equipment Manufacturers Association (NEMA)**

- 250, *Enclosures for Electrical Equipment*

**4.14.6 National Fire Protection Association (NFPA)**

- 70, *National Electrical Code*

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## 5.0 SYSTEM DESCRIPTION

### 5.1 GENERAL SUMMARY

The VPS consists primarily of pumps, condensers, piping, valves, instrumentation, and controls mounted on the PES and process hood support stand. Each process bay is serviced by its separate VPS.

The VPS has a 4-stage roots vacuum pump, VPS-P-2\*11, that drives low-vacuum drying. Condenser VPS-COND-2\*13, in series with condenser tank VPS-TK-2\*16 and tank cooler VPS-CLR-2\*17, condenses moisture from the main processing stream prior to the pumps. The initial bulk water removal is accomplished by a pressurized facility helium system connection to the main processing stream that pressurizes the VPS system and MCO headspace.

### 5.2 PIPING AND INSTRUMENTATION DIAGRAM

The piping and instrumentation diagram for the VPS is depicted in H-1-83766. The valves, instruments, and equipment shown in the diagram are listed by tag numbers and described in HNF-SD-SNF-SEL-002.

### 5.3 SYSTEM ARRANGEMENT/CONFIGURATION

Please refer to the piping and instrument diagrams and mechanical layout drawings to gain a better understanding of the arrangement/configuration.

#### 5.3.1 Vacuum Line in Process Hood

VPS line VPS-\*02-SS-1" and -2" starts at the MCO and returns to the VPS portion of the PES. Line VPS-\*02-SS-2" is designated safety class from the MCO up to and including VPS-GOV-1\*05 (safety class).

- A. Line VPS-\*02-SS-1" connects to the MCO outlet valve VPS-V-\*010 and exits via of a flexible pipe connection on the process hood.
- B. Pressure transmitters PT-1\*36, PT-1\*08, PT-1\*37, and PT-1\*10 provide safety-class pressure or vacuum indication in VPS-\*02-SS-2" between the MCO and process control valves VPS-GOV-1\*09 and VPS-GOV-1\*05. Pressure indicators PI-1\*40 and PI-1\*41 provide safety class local visual readout at the hood stand.
- C. Process controlled valves VPS-GOV-1\*09 and VPS-GOV-1\*05 and associated control elements operate in series to provide safety class isolation in VPS-\*02-SS-1".
- D. Safety Class Helium system lines SCHE-\*11-SS-1" and SCHE-\*12-SS-1" connect to VPS-\*02-SS-1" to provide helium purge to the MCO upon SCIC initiation.



- E. The process hood portion of VPS-\*02-SS-1" terminates at the flexible pipe connection that adjoins the PES.

### 5.3.2 Vacuum Line and Associated Hardware on the Process Equipment Skid

VPS-\*02-SS-1" exits the process hood through a flexible pipe and enters the PES connecting to VPS-\*02-SS-2" then connects to condenser VPS-COND-2\*13. Temperature indicator TI-1\*07, gas monitor system AI-2\*13, and pressure indicator PI-2\*11 with all of their associated control elements monitor the condition of VPS-\*02-SS-2" prior to connection to VPS-COND-2\*13.

- A. Sampling line VPS-\*12-ST-¼" branches off VPS-\*02-SS-2" and is connected to the gas monitor system AI-2\*13. The residual gas analysis and associated control elements analyze the gases and relay information to the MCS as required. Valve VPS-V-\*029 controls flow into VPS-\*12-SS-¼" and valve VPS-V-\*032 provides a clibration connection for the gas monitor system. The exhaust from the gas monitor system is connected to VPS-\*13-ST-¼" which is then connected to VPS-\*09-SS-1"
- B. After monitoring and prior to connection to VPS-COND-2\*13, line VPS-\*09-SS-1" branches off VPS-\*02-SS-2" through relief valve SRV-2\*17, set at 68.7 kPa<sub>a</sub>  $\pm 15\%$  (10 lbf/in<sup>2</sup> gauge  $\pm 15\%$ ) and check valve VPS-CKV-\*050 to process vent PV-\*01-SS-1", providing pressure relief to the VPS and MCO.
  - (1) Line, VPS-\*08-SS-2", branches off VPS-\*09-SS-1" prior to the relief valve and reconnects to the main process stream on line VPS-\*10-SS-2", bypassing the condenser operations. VPS-\*08-SS-2" is controlled by process control valve VPS-GOV-2\*03 and associated control elements. This route is used for the helium purge in the initial bulk water removal, after the condenser is isolated during the vacuum cycle and for any helium purges through the VPS .
- C. Process control valve VPS-GOV-2\*22 and associated control elements controls the flow of VPS-\*02-SS-2" just prior to connection to VPS-COND-2\*13.

### 5.3.3 Vacuum and Purge System Condenser Operation

VPS-COND-2\*13 is located immediately above and directly connected to condenser tank VPS-TK-2\*16 and condenser tank cooler VPS-CLR-2\*17. VPS chilled water supply VPSCHW-\*01-SS-1" supplies VPS-CLR-2\*17 chilling VPS-TK-2\*16, then supplies and chills VPS-COND-2\*13 before returning to the VPS chilled water system via VPSCHW-\*02-SS-1".

- A. The condensed water is drawn from the bottom of VPS-TK-2\*16 and sent to the PWC system via line PWC-\*02-SS-1" controlled by process control valve VPS-GOV-2\*16 and associated control elements.

### 5.3.4 Vacuum and Purge System Condenser Tank and Exit Line

Line VPS-\*10-SS-2" connects the output of VPS-TK-2\*16 to its intersection with VPS-\*03-SS-2" and VPS-\*07-SS-1".

- A. Process control valve VPS-GOV-2\*21 and associated control elements block flow after VPS-TK-2\*16 and prior to VPS-\*08-SS-2" reconnecting. Pressure indicator PI-2\*09 and associated control elements monitor the line pressure after VPS-GOV-2\*21 and before the reconnect.
- B. Temperature indicator TI-2\*14 and associated control elements monitor the line temperature after the VPS-\*08-SS-2" reconnect and prior to the connection of VPS-\*03-SS-2".

### 5.3.5 Helium Additions and Vacuum Pumps

VPS-\*10-SS-2", He-\*03-SS-1", VPS-\*03-SS-2", and VPS-\*07-SS-1" intersect.

- A. He-\*03-SS-1" provides helium ballast input to the system at this point.
  - (1) Pressure control valve PCV-1\*27 is used to control helium flow rates into the intersection and process control valve He-GOV-1\*12 is used to control flow in the helium line prior to the intersection.
- B. VPS-\*03-SS-2" connects the intersection to vacuum pump VPS-P-2\*11.
  - (1) Process control valve VPS-GOV-2\*07 and associated control elements are used to control the flow of gas from VPS-\*03-SS-2" into VPS-P-2\*11. Pressure indicator PI-2\*08 and associated control elements monitor the line pressure at the pump inlet.
  - (2) VPS-P-2\*11 outlets directly to process vent PV-\*01-SS-1". Temperature indicator TI-2\*15 monitors the temperature out of the vacuum pump and check valve PV-KV-\*031 controls flow direction after VPS-\*04-SS-1", VPS-\*07-SS-1", and VPS-\*09-SS-1" all connect to PV-\*01-SS-1".
  - (3) Line He-\*04-ST-1/4" provides the helium supply for the shaft seal on VPS-P-2\*11. Helium flow in this line is controlled by valve He-V-\*063 and on associated rotameters located on VPS-P-2\*11.
  - (4) Line TWC-\*03-ST-1/2" feeds cooling water to the vacuum pump, VPS-P-2\*11, casing, and line TWC-\*04-ST-1/2" returns the cooling water to the TWC system. Flow of cooling water is controlled by a rotameter located on the vacuum pump.
- C. VPS-\*07-SS-1" travels from the intersection of VPS-10-SS-2", VPS-03-SS-2", and He-03-SS-1" to VPS-GOV-2\*05 and then connects to process vent PV-\*01-SS-1" bypassing pumping operations. Flow into the bypass line is controlled by process control valve VPS-GOV-2\*04 and associated control elements.

- D. VPS-\*04-SS-1" branches off VPS-\*07-SS-1" prior to VPS-GOV-2\*05 and connects to process vent PV-\*01-SS-1" providing pressure relief to the pump inlets. Flow is controlled by pressure control valve PCV-2\*37 (set at 6.89 kPa [1.0 lbf/in<sup>2</sup>]) providing pressure relief in VPS and MCO.

### 5.3.6 Process Control Skid Vacuum Connection to the Multi-Canister Overpack

VPS-\*01-SS-1", the vacuum purge system supply line, connects the VPS subsystem on the PES to the MCO.

- A. A 1 in. flexible pipe interconnects VPS-\*01-SS-1" from the PES to the process hood.
- B. VPS-\*01-SS-1" and deionized water supply DI-\*03-SS-3/4" meet at gas operated valve VPS-GOV-1\*11 through DI/He-QD-\*110.
- C. Valves VPS-GOV-1\*17 (safety class) and VPS-GOV-1\*02 (safety class) form the safety class boundary to the MCO.
- D. Helium line He-\*01-SS-1" connects to VPS-\*01-SS-1" after VPS-GOV-1\*17 to provide helium gas purge. Helium flow in VPS-\*01-SS-1" is controlled by valves He-GOV-1\*02, He-GOV-1\*06 and FV-1\*20 on He-\*01-SS-1".
- E. Safety class valve He-GOV-1\*02 and He-GOV-1\*06 provides safety class isolation in conjunction with VPS-GOV-1\*11 and VPS-GOV-1\*17.
- F. Pressure indicators PI-1\*34/1\*35 and PI-1\*08/1\*10 measures the pressure differential between VPS-\*01-SS-1" just prior to the MCO inlet and MCO-VPS outlet line VPS-\*02-SS-2". This pressure differential is utilized in assessing the MCO internal HEPA filter performance.
- G. Safety Class Helium system lines SCHE-\*09-SS-1" and SCHE-\*10-SS-1" connect to VPS-\*02-SS-1" to provide helium purge to the MCO upon SCIC initiation.
- H. VPS-\*01-SS-1" connects to and terminates at MCO inlet valve operator VPS-V-\*019 via a flexible pipe connection, providing process and mechanical interface to the MCO.

## 5.4 EXPLANATION OF HOW SYSTEM MEETS DESIGN REQUIREMENTS

From HNF-SD-SNF-DRD-002 the following design requirements for the VPS are defined. The following is a listing of each requirement in *italics* and how that requirement is met.

### 5.4.1 Water Removal from Multi-Canister Overpack

*Water from the MCO shall be transferred through a drain pipe system to a collection tank/purification system shared by all the process bays. The water shall be drawn from the bottom of*

*the MCO through the MCO draw tube. A screen will prevent particulates larger than 2 mm (0.08 in.) from exiting the MCO. Water removed from the MCO shall be filtered as close to the MCO as practical to minimize the migration of radioactive particulates to downstream equipment.*

How system meets requirements:

A 2 mm (0.08 in.) screen at the bottom of the long dip (draw) tube within the MCO filters the water prior to exiting the MCO. PWC-\*01-SS-1" provides the drain for the MCO. Line PWC-\*01-SS-1" connects with the similar lines from all the bays with the combined line PWC-001-SS-1" feeding the PWC system receiver tanks.

#### **5.4.2 Evacuation of Multi-Canister Overpack Drain Line**

*The drain line shall be capable of being evacuated. The vacuum shall be sufficient to draw liquid from the bottom of the MCO to the highest point in the PWC system, overcome the pressure drop in the local filter, and achieve a flow rate sufficient to drain the MCO in approximately 0.5 hours or less. The drain pipe system shall be designed to be leak tight and to minimize the potential for contamination spread to other process bays if any leak develops. Local filtration and non-pressurized transfer lines shall be used, if at all practical.*

How system meets requirements:

There are two motive forces active during bulk water removal. Helium pressure of 27.6 kPa<sub>g</sub> (4 lbf/in<sup>2</sup> gauge) fed through VPS-\*02-SS-2" into the headspace of the MCO acts to push the water out of the long draw tube. Eductor valve PWC-EJR-4031 on PWC-\*01-SS-1" on the PWC skid is sized to draw 0.000315 m<sup>3</sup>/s (5 gal/min) from the MCO. PWC-EJR-4031 alone can drain the MCO in the prescribed 30 minutes, the addition of the 27.6 kPa<sub>g</sub> (4 lbf/in<sup>2</sup> gauge) pressure "push" expedites the process. All lines have been designed and tested to high-leak tightness standards (see mechanical requirements).

#### **5.4.3 Helium Pressure for Water Transfer**

*The helium system connections to the MCO shall be used to pressurize the head space above the water in the MCO as it is transferred.*

How system meets requirements:

He-\*03-SS-1" supplies 27.5 kPa<sub>g</sub> (4 lbf/in<sup>2</sup> gauge) helium pressure into the VPS. It is routed through VPS-\*10-SS-2" to VPS-\*08-SS-2" to VPS-\*09-SS-2" to VPS-\*02-SS-2", which connects to the MCO headspace.

#### **5.4.4 Isolation Valve Sealing**

*There shall be an isolation valve in the drain line near the MCO. This valve shall be open during water transfer and closed during the drying process. The valve must seal well enough that leakage through it does not prevent the MCO from attaining its ultimate vacuum requirement.*

How system meets requirements:

Process control valves VPS-GOV-1\*30 and VPS-GOV-1\*03 in series provide safety class isolation capability to the drain line. The valves are selected and factory-tested to standards beyond those required.

#### 5.4.5 Flushing of Multi-Canister Overpack Plug Valve and Line

*The MCO plug valve operator that is exposed to contaminated water flow shall be injected with deionized water while the purge gas flows immediately after the last water has been drawn from the MCO. The rinse water shall clean the drain line and be collected in the PWC system.*

How system meets requirements:

DI-\*03-SS-1" connects to VPS-GOV-1\*11 on VPS-\*01-SS-1" providing a deionized water flush to the affected valve operator, VPS-V-\*019, draining into the PWC system via PWC-\*01-SS-1".

#### 5.4.6 Multi-Canister Overpack Gas Removal

*The VPS shall remove gas species (volumetric, off-gassing, residual free water, water-fuel reaction products, and in-leakage) from the MCO so that the contents of the MCO are dried until a vacuum < 67 Pa (0.5 torr) is achieved and until a one hour pressure rise test started when the pressure is < 67 Pa (0.5 torr) does not result in a final pressure above 400 Pa (3.0 torr).*

How system meets requirements:

The process design calculations indicate that the specified process dries the MCO contents to the stated criteria.

#### 5.4.7 Helium Purge of Multi-Canister Overpack Atmosphere

*The system shall be capable of injecting helium into the MCO periodically so that an evacuation-purge cycle can be operated.*

How system meets requirements:

He-\*01-SS-1" connects to VPS-\*01-SS-1" providing a helium supply for purge/evacuation to the MCO inlet valve operator.

#### 5.4.8 Vacuum Capability of Vacuum System

*The VPS has the capability of pumping down the MCO to the operating basis pressure level of 67 Pa (0.5 torr) or lower. This condition assumes that the VPS and MCO are leaktight to the MCO operating level basis (0.01 Pa-L/cm<sup>3</sup>/sec [1 x 10<sup>-4</sup> atm. cc/sec]).*

How system meets requirements:

The VPS and MCO have been leak-tested to standards two orders of magnitude tighter than 0.01 Pa-L/s ( $1 \times 10^{-4}$  atm.  $\text{cm}^3/\text{s}$ ). VPS-P-2\*11 can reach 3.1 Pa absolute (0.023 torr) pressure, an order of magnitude greater than required.

#### 5.4.9 Process Valves Operation

*All valves shall have remotely activated operators. All valves shall fail to a fail-safe position upon loss of control air, control signal, or electric power. The valves may have elastomer seals. This requirement is dictated due to the low vacuum requirements. No code requirements are stipulated for the vacuum valves having safety classifications of safety significant or general services.*

How system meets requirements:

All isolation valves have remotely-activated operators. All valves assume a fail-safe position upon loss of control air, control signal, or electrical power. The valve seals are reinforced TFE. GOV and sample ball valves are 100% tested to bubble-tight standards ( $1 \times 10^{-4}$  atm. $\text{cm}^3$  He/s). All ball valves and integral bonnet needle valves are rated at less than 0.1  $\text{cm}^3_{\text{STP}}/\text{min}$  nitrogen at 6.87 MPa (1,000 lbf/in<sup>2</sup> gauge).

#### 5.4.10 Helium Leak Check of Top Shield Plugs

*The VPS shall be designed to assist in the helium leak-checking of the MCO top shield plugs following the completion of the cold vacuum drying process.*

How system meets requirements:

The VPS achieves a partial vacuum inside the connectors, allowing the use of a helium bag enclosure around the connector for helium leak testing. Alternatively, the VPS can facilitate the pressurization of the connectors with helium allowing the use of a helium sniffer on the exterior of the connectors.

#### 5.4.11 Prevention of Backflow to the Multi-Canister Overpack

*The VPS shall be designed to preclude back flow of water or organic material into the MCO. Backstreaming of vacuum pump oil and suck back of condensed moisture or any leaks of glycol based condenser coolant into the MCO shall be precluded. Contamination of downstream equipment shall also be precluded due to its potential to damage the equipment or reintroduce contaminants back into the MCO. Prevention of introduction of water or organic materials into the MCO is an OCRWM issue, see Appendix F (of DRD) and a safety issue.*

The process equipment is oil-free, precluding oil-based contamination. The condenser coolant is chilled water, not glycol. HEPA filter VPS-F-1\*11 on VPS-\*01-SS-1" prevents backflow contamination from spreading into the process equipment.

#### 5.4.12 Multi-Canister Overpack Offgas Radioactivity and Water Control

*Gas drawn from the MCO is filtered as close to the MCO as can be reasonably configured to minimize the migration of radioactive dust particles through the VPS. Water in the vacuum pump stream and circulating helium gas stream is condensed. The water is directed to the PWC system.*

The MCO internal HEPA filters all gas exiting the MCO. The condenser assembly (condenser VPS-COND-2\*13, condenser tank VPS-TK-2\*16, and condenser tank cooler VPS-CLR-2\*17) acts to remove water from the recirculating gas stream. PWC-\*02-SS-1" drains VPS-TK-2\*16, where the condensate collects, to the PWC system.

#### 5.4.13 Condenser Water Control

*Water collected from the condenser is transferred into the PWC system. Positive features are provided to prevent the inadvertent transfer of condensed liquid back into the MCO from credible equipment failure or process upset.*

PWC-\*02-SS-1" drains VPS-TK-2\*16, where the condensate collects, to the PWC system. Level switch high LSH-2\*25, in conjunction with VPS-GOV-2\*22/1\*09/1\*05, all work to prevent condensate backflow. A non-credible multiple simultaneous failure is required.

#### 5.4.14 Prevention of Bulk Water Freezing

*The helium gas purge controller is capable of throttling the vacuum pump such that the pressure inside the MCO is maintained at 0.7 kPa (5 torr) or more to prevent freezing of bulk water during initial pump-down. At this pressure, the water in the MCO does not freeze as the equilibrium vapor pressure of water at 0 °C (32 °F) is 0.6 ka (4.56 torr).*

The purge controller is capable of adjusting helium flow to control process pressures within specified ranges.

#### 5.4.15 Vacuum System Performance

*After the bulk water is removed, the pumping system has the capability of achieving a pressure of 67 Pa (0.5 torr) for final water vapor removal.*

VPS-P-2\*11 can reach 3.1 Pa absolute (0.023 torr), an order of magnitude greater than required.

#### 5.4.16 Vacuum and Purge System Helium Gas Supply Control

*The VPS controls the introduction of helium gas for backfilling the MCO (normal shutdown) and in the case of off-normal (non-emergency) shutdown conditions.*

The MCS controls the facility helium (He-\*01-SS-1") that introduces helium for backfilling the MCO (normal shutdown) and in the case of off-normal (non-emergency) shutdown conditions.

#### 5.4.17 Hydrogen and Water Vapor Monitoring of Residual Gas

*A residual gas monitoring system is provided that measures the concentration of hydrogen and water vapor gas species, and determines the gas concentration to 1 ppm. RGAs, of quadrupole or mass sector design, measures the gas species partial pressure over the range of 1 to 100 atomic mass units minimum and detect partial pressures to  $1 \times 10^{-4}$  Pa ( $1 \times 10^{-6}$  torr).*

A quadrupole monitor is specified that meets and/or exceeds all requirements. This is covered to greater detail in SNF-3063, *Cold Vacuum Drying Facility Residual Gas Monitoring System Design Description*.

### 5.5 SYSTEM PARAMETERS/SETPOINTS/LIMITATIONS

#### 5.5.1 Process Parameters and Setpoints

See HNF-SD-SNF-SEL-002 for information about process parameters and setpoints.

#### 5.5.2 Operating Limits

Equipment, components, and systems that make up the PES have been selected to perform specific functions. To maintain functionality and confidence in the operability of the system, the operating limits shown in Table 5-1 must be complied with. Violation of any of these limitations requires the replacement of the affected part prior to active service.

Table 5-1. Physical Capabilities and Limitations of  
Vacuum and Purge System Components.

Tag number	Description	Physical capabilities	Physical limitations
VPS-P-2*11	Four-stage roots vacuum pump	0.016 m <sup>3</sup> /s (34 ft <sup>3</sup> /minute) nominal displacement, helium gas purge system with flow meter and stainless gas flow tubing; non-return exhaust valve; 440/480 V (ac), 3-phase; 40 KF inlet, 25 KF outlet; 13.3 kPa absolute (100 torr) max. sustained pressure	60 m <sup>3</sup> /h; 101.3 kPa absolute (1,000 mbar) max. intake pressure, intake pressure exceeding 17.3 kPa (130 torr) for a period greater than 0.5 hours
VPS-COND-2*13	Condenser	2,343 W (8,000 Btu/h), 0.016 m <sup>3</sup> /s (34 ft <sup>3</sup> /min) flow rate	1.03 MPa <sub>g</sub> (150 lbf/in <sup>2</sup> gauge), 196 °C (384 °F)
VPS-TK-2*16	Condenser tank	0.038 m <sup>3</sup> (10 gal) SS	207 kPa <sub>g</sub> (30 lbf/in <sup>2</sup> gauge)
VPS-CLR-2*17	Condenser tank cooler	SS; 0.000252 m <sup>3</sup> /s (4 gal/min) coolant flow rate	1.10 MPa <sub>g</sub> (160 lbf/in <sup>2</sup> gauge)

HEPA = high-efficiency particulate air (filter).

SS = safety significant.



### 5.5.3 Precautions

System controls and presets preclude violation of system and component limitations under normal operations. Operations beyond normal conditions require inspection of the effected components to determine if operation limits have been exceeded. Items of special concern are noted in the operations manuals and equipment index listed in HNF-SD-SNF-SEL-002 for the respective equipment and are integrated into the normal operating procedures.

### 5.5.4 Recovery Procedures

Recovery from breakdown entails replacement and acceptance of the replacement part or component per operating procedures. Once replacements and acceptances are complete, a normal start-up procedure can be carried out to return to operations. Recovery from specific process upsets are described in HNF-2356, *Spent Nuclear Fuel Project Cold Vacuum Drying Facility Operations Manual*.

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## **6.0 SYSTEM OPERATION**

VPS operations are controlled by the MCS and are an integrated subset of the MCS sequence of operations. For a detailed sequence of operations, please refer to HNF-2356 and Appendix D of W-441-P003, *The Fabrication and Procurement Specification for the Monitoring and Control System*.

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## 7.0 SYSTEM SURVEILLANCE, TESTING, AND MAINTENANCE

The VPS is designed to operate through the design life of the equipment (five years) without regularly scheduled facility shutdowns for maintenance. System maintenance activities are limited to maintenance due to failures. Additional maintenance activities and procedures may be scheduled if system surveillance, testing, or maintenance identifies additional requirements. All maintenance is performed under controlled procedures using approved (quality assurance-qualified) equipment and materials. Only spare parts meeting design criteria are procured and used. The equipment has been designed for efficient maintainability. The surveillance, testing, and maintenance of the system are achieved at minimum cost and level of support services per DOE Order 6430.1A, Section 1300-12.4.10.

### 7.1 CORRECTIVE AND PREVENTIVE MAINTENANCE

- A. Maintenance features, including replacement of valves and piping connected to the primary barrier, are designed so that these activities are carried out under heating, ventilation, and air conditioning in-flow or isolation.
- B. Equipment and components have been located away from potentially contaminated areas, whenever practical, to reduce contact with contamination and to minimize situations causing breach of containment.
- C. Modular design has been incorporated to facilitate change-out of systems requiring timely repair and/or special skills, and to reduce problems associated with equipment removal and repair.
- D. Commercial equipment, components, and parts are used wherever feasible to reduce procurement, maintenance, training, and inventory costs.

### 7.2 SURVEILLANCE AND IN-SERVICE INSPECTION

Surveillance and in-service inspections need to be conducted per the manufacturer's recommendations for the respective components. Surveillance, as dictated by the respective manuals, is incorporated into standard operating procedures. Operators are expected to report, and supervisors are expected to investigate, any occurrences not regularly experienced during normal operations.

Accommodations have been made for both manual and electronic inspection of VPS equipment. The safety class and safety significant systems are under administrative control for all testing, surveillance, and maintenance, which are performed according to controlled procedures.

System operability is verified by surveillance of the system's component states before enabling the system for each MCO process cycle. The system requires that additional surveillance be conducted, if required, to be operational beyond one normal processing cycle.

### 7.3 EQUIPMENT CALIBRATION

- A. All equipment must be calibrated and recalibrated according to the respective manufacturer's recommended schedule and practice. Calibration and test connections are provided to enable in-service testing and calibration when practical. All safety class and safety-significant components were supplied, calibrated, and are traceable back to the National Institute of Standards and Technology. All safety class and safety significant components must additionally be recalibrated per controlled procedures and standards.
- B. Equipment and instrumentation have local and remote readouts when available.
- C. Automatic "on-line" calibration has been specified when available.
- D. Modular replacement has been employed.

## 8.0 SYSTEM DESIGN ANALYSIS

### 8.1 POTENTIAL SYSTEM AND COMPONENT FAILURE

The list of potential system accidents with the potential to cause unacceptable consequences as reported and further discussed in HNF-SD-SNF-SAR-002 are as follows:

1. MCO thermal runaway reaction
2. MCO internal hydrogen explosion
3. MCO external hydrogen explosion
4. Radioactive gaseous release
5. Radioactive liquid release.

The safety features required to preclude or mitigate the above postulated accidents are also listed in HNF-SD-SNF-SAR-002.

### 8.2 SYSTEMS SPECIAL HAZARDS TO WORKERS

Standard industrial hazards are defined in DOE-STD-3009-94 as those hazards that "are routinely encountered in general industry and construction, and for which national consensus codes and/or standards (e.g., Occupational Safety and Health Administration, transportation safety) exist to guide safe design and/or operational parameters." The standard industrial hazards were screened to identify those that can contribute to the uncontrolled release of radioactive or hazardous material. The hazards that were not identified to contribute to the radioactive releases or hazardous material exposures at CVDF are covered by the above standards and are not further addressed in this report.

Those hazards which were identified to potentially contribute to radioactive releases or hazardous material exposures were identified in HNF-SD-SNF-SAR-002 and classified as to the material at risk and the frequency category of occurrence. Forty-four candidate accidents are identified in HNF-SD-SNF-SAR-002 to have sufficient material at risk and frequency of occurrence to affect the workers. The safety precautions required to preclude or mitigate these accidents are listed in the HNF-SD-SNF-SAR-002.

### 8.3 MARGINS OF SAFETY

The radiation protection safety basis for the Spent Nuclear Fuel Project facilities is comprised of the following documents:

- 10 CFR 835, "Occupational Radiation Protection"
- DOE/EH-0256T, *U.S. Department of Energy Radiological Control Manual*
- HSRCM-1, *Hanford Site Radiological Control Manual*
- U.S. Nuclear Regulatory Commission Rules and Regulatory Guides that have been determined to be applicable to the design, construction, and operation of these facilities.

Minimizing radiation exposure to ALARA is a fundamental principle of radiation protection for the Spent Nuclear Fuel Project.

#### **8.4 CRITICAL ENGINEERING STUDIES AND CALCULATIONS**

Calculations in support of the VPS design are located in SNF-3001, *CVDF Data and Calculation Matrix Tracking List*.



## 9.0 REFERENCES

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Section II, "Material Specifications, Welding Rods, Part C Electrodes, and Filler Metals"

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Section IX "Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators"

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## 9.2 GOVERNMENT DOCUMENTS

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10 CFR 830.120, "Quality Assurance Requirements," *Code of Federal Regulations*, as amended.

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#### 9.4 DRAWINGS

H-1-82160, *Cold Vacuum Drying Facility P&ID Legend*, Rev. 1, Numatec Hanford Corporation, Richland, Washington.

H-1-82351, *Cold Vacuum Drying Facility Process Equipment Skid Piping*, Rev. 0, Numatec Hanford Corporation, Richland, Washington.

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H-1-83767, *CVDF Vacuum Purge Chilled Water System P&ID*, Rev. 3, Numatec Hanford Corporation, Richland, Washington.

# **APPENDIX A** **DRAWING AND SPECIFICATION LISTS**

## **DRAWING LIST**

Vacuum and purge system and interface drawings are listed in Table A-1 by drawing numbers. The primary drawing title of most drawings is *Cold Vacuum Drying Facility*. The secondary title, drawing numbers, revision numbers, and number of sheets with each subpackage are listed in Table A-1. Complete sets of drawings are located with the Spent Nuclear Fuel Project files for the Cold Vacuum Drying Facility project.

Table A-1. Vacuum and Purge System and Interface Drawings.

Drawing number	Revision number	Title	Sheet number
Piping and instrumentation diagrams			
H-1-82160	0	P&ID Legend	1 of 1
H-1-82163	2	Process Equipment Skid P&ID MCO/Temp. Water Sys.	1 of 1
H-1-83766	4	Process System P&ID	1 of 2
H-1-83766	4	Process System P&ID	2 of 2
H-1-83767	3	Vacuum Purge Chilled Water System P&ID	1
Piping			
H-1-82351	0	Process Equipment Skid Piping General Arrangement	1 of 5
H-1-82351	0	Process Equipment Skid Piping Plan and Elevation	2 of 5
H-1-82351	0	Process Equipment Skid Piping Plan and Section	3 of 5
H-1-82351	0	Process Equipment Skid Piping Plan and Section	4 of 5
H-1-82351	0	Process Equipment Skid Piping Section and Details	5 of 5
Equipment and structure			
H-1-82097	--	Unassigned	
H-1-82352	1	Structural skids-VPS and MCTC	1 of 1
H-1-82353	0	Structural skids-VPS and MCTC Skid Details	1 of 1
H-1-82361	0	Process Equipment Skid Cond. Tank VPS-TK-2*16	1 of 1
H-1-82362	0	Process Equipment Skid Recirc. Tank TW-TK-3*12	1 of 1
Instrumentation			
H-1-82302	N	Process Equipment Skid Junction Box Assembly	1 of 3
H-1-82302	N	Process Equipment Skid Connection Diagram	2 of 3
H-1-82302	N	Process Equipment Skid Connection Diagram	3 of 3

**SPECIFICATION LIST**

The vacuum and purge system is part of two specifications listed in Table A-2. The vacuum and purge system is procured as part of the process equipment skid and process hood procurement packages.

Table A-2. Procurement Specifications.

Specification number	Title
W-441-P1, 1998	Procurement Specification for the Fabrication, Acceptance Testing, and Shipment of the Cold Vacuum Drying Facility Process Skid and System Equipment
W-441-P3, 1998	Procurement Specifications for the Fabrication, Acceptance Testing, and shipment of the Cold Vacuum Drying System Monitoring and Control System
W-441-P4, 1998	Procurement Specification for the Fabrication, Acceptance Testing, and Shipment of the Cold Vacuum Drying Facility Process Hood and System Equipment