RIVER PROTECTION PROJECT – WASTE TREATMENT PLANT

ENGINEERING SPECIFICATION

FOR

Vessel-Mounted Vertical Transfer Pumps - WTP HLW Facility

Contents of this document are Dangerous Waste Permit affecting.

Content applicable to ALARA? ☒ **Yes** ☐ **No**

ADR No.
24590-WTP-ADR-M-03-017

Rev
1

Quality Level
Q
DOE Contract No. DE-AC27-01RV14136

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SPECIFICATION No.
24590-WTP-3PS-MPC0-T0009

Rev
2

Revision History

Revision	Reason for Revision
0	Issued for Purchase - includes identified corrections.
1	Revised sections as noted.
2	Completely revised: Removed data as noted in the Equipment Datasheets; incorporated SCNs 24590-WTP-3PN-MPC0-00024, -00026, and -00028; Changed specification from CM to Q; clarified Quality Level of pump vs. HFP piping/interface as noted; removed ECI documents. Major revision, no sidebars used.

Notice

Please note that source, special nuclear, and byproduct materials, as defined in the Atomic Energy Act of 1954 (AEA), are regulated at the US Department of Energy (DOE) facilities exclusively by DOE acting pursuant to its AEA authority. DOE asserts that pursuant to the AEA, it has sole and exclusive responsibility and authority to regulate source, special nuclear, and byproduct materials at DOE-owned nuclear facilities.

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1 Scope

1.1 Project Description and Location

The Hanford Tank Waste Treatment and Immobilization Plant (WTP) is a complex of waste treatment facilities where the US Department of Energy's (DOE) Hanford Site tank waste will be put into stable glass form. The WTP contractor will design, build, and start up the WTP pretreatment and vitrification facilities for the DOE Office of River Protection (ORP). The waste treatment facilities will pretreat and immobilize high-level waste (HLW) at the Hanford Site.

The Hanford Site occupies an area of about 560 square miles along the Columbia River, north of the city of Richland, Washington. The WTP facility will be constructed at the east end of the 200 East Area of the Hanford Site. Benton, Franklin, and Grant counties surround the Hanford Site.

1.2 Scope Covered by this Specification

Design, furnish materials for, fabricate, package, test, and prepare for shipment complete pump units and appurtenances in accordance with this specification, including the following:

1.2.1 Remote vessel-mounted vertical transfer pumps equipped with motor, wiring and conduit, close tolerance remote handling components, eductor primer and jumper nozzle connections, electrical jumper connectors, all required piping, including HFP piping from pump mounting plate to PUREX nozzle connections; guide bars and nut retainer, in accordance with this specification; acquisition services documents; and attachments. Installation of remote jumper nozzle connections and electrical jumper connections provided by Buyer as Government Furnished Property (GFP). The Seller's scope is attachment of the connectors only; the connectors themselves are not in the scope of this specification. Refer to Appendix C, Connectors, and Appendix D, Items Supplied by Buyer (GFP), for details.

1.2.2 Special tools required for installation and maintenance.

1.2.3 Shop painting of exposed steel surfaces; stainless steel surfaces shall not be painted.

1.2.4 Operations and maintenance manuals.

1.2.5 Deleted

1.2.6 One motor stand suitable for remote placement, retrieval and movement of pump motor.

1.3 Scope Not Covered by this Specification

1.3.1 Pump mounting flange bolt fasteners.

1.3.2 Remote water, slurry, and power jumpers or instrumentation beyond first connection to factory assembled package.

1.3.3 Material unloading, unpacking, inspection, storage, and installation labor at the job site.

1.3.4 Motor adjustable speed drive.

1.4 Definitions

For equipment covered in this specification, terms are defined as follows:

II over I	Pump and motor stand designed such that no component fails and impacts the vessel, internals, or other nearby ITS SSCs as a result of a Seismic Category I event.
C5	Plant areas and associated ductwork that are in direct contact with radioactive material and that prevent the spread of radioactive material to adjacent zones under both normal and abnormal operating conditions. All vessels and pumps referenced in this specification are located in this level of confinement zone.
Cantilevered	A specific pump configuration where the bearings supporting the rotating pump shaft are positioned at one end of the shaft, leaving the remainder of the shaft unsupported.
Casing	The volute casing or bowl assembly, depending on the pump used for these applications.
Government Furnished Property (GFP)	Components procured by the Buyer and shipped to the Seller for fabrication of the HLW pumps. Components include both Hanford electrical connectors and PUREX nozzles.
High-Level Waste (HLW)	Items associated with the HLW Facility.
HFP Piping	As used in this specification, the discharge piping between the pump mounting plate and the PUREX fitting outside of the vessel boundary. (Reference Figure 1)
Jumper	A section of pipe, electrical power cord, or instrumentation wire that is constructed and supported in such a way that facilitates its installation and removal in remote locations using cranes and robotic manipulator arm. Jumpers are fitted with special nozzles and connectors that allow for proper remote mating and detachment.
Quality Level Q	Quality Level Q component, components, or system of components must be fabricated, assembled and tracked per applicable codes, standards and specifications detailed by Buyer.
Quality Level CM	Quality Level CM component, components, system of components must be fabricated, assembled, and tracked compliant with codes, standards, and specifications detailed by the Buyer.
Remote	For the purposes of this specification, equipment located in the radioactive HLW Facility that can be accessed only by cranes and remote lifting fixtures with robotic manipulator arm, not through direct human contact.
Safety Significant (SS) SSC	SSCs whose preventive or mitigative function is a major contributor to defense in depth or worker safety as determined from safety analyses.
Vertical Pumps	Pumps that mount to a head nozzle of a vessel in the vertical position.

2 Applicable Documents

2.1 General

2.1.1 Work shall be performed in accordance with the codes, standards, and documents listed below, which are an integral part of this specification, and to the extent referenced herein.

2.1.2 When specific chapters, sections, parts, or paragraphs are listed following a code, industry standard, or reference document, only those chapters, sections, parts, or paragraphs of the document are applicable and shall be applied. For codes and standards referenced in this specification the specified revision or effective date identified, as well as the specific revision or effective date of codes and standards that they incorporate by reference (daughter codes and standards), shall be followed. A supplier deviation disposition request (SDDR) must be submitted for approval if the Seller intends to use codes and standards referenced in this specification with a different date or revision.

2.1.3 Unless otherwise specified herein or on drawings, work under this specification shall be performed in accordance with the codes, standards, and publications to the extent indicated by the references herein. If a date or revision is not listed, the latest issue, including addenda, at the time of original award shall apply. Any component not specifically covered by a referenced code, standard or publication shall conform to a relevant ASME and/or ASTM standard.

2.1.4 When more than one code, standard, or referenced document covers the same topic, the requirements for all must be met with the most stringent combination of requirements. All conflicts between documents must be resolved via the Buyer prior to proceeding.

2.1.5 Export Controlled Information (ECI) - Technical information related to PUREX connectors has been determined to be ECI. This information will be transmitted in the appropriate material requisition (MR).

2.2 Industry Standards

Sponsor	Number	Subject
ABMA	Std. 7	American Bearing Manufacturers Association – Shaft and Housing Fits for Metric Radial Ball and Roller Bearings
ABMA	Std. 9	American Bearing Manufacturers Association – Load Ratings and Fatigue Life for Ball Bearings
ABMA	Std. 20	American Bearing Manufacturers Association – Metric Ball and Roller Bearings (Except Tapered Roller Bearings) Conforming to Basic Boundary Plans: Boundary Dimensions, Tolerances, and Identification
AISC M016-89	9th Edition	Manual for Steel Construction – Allowable Stress Design as tailored by Buyer, *Safety Requirement Document Volume II*, 24590-WTP-SRD-ESH-01-001-02; see Appendix G
ASME	B31.3, 1996	*Process Piping* as tailored by Buyer in 24590-WTP-SRD-ESH-01-001-02; see Appendix I

Sponsor	Number	Subject
ASME BPVC	Sec. V, 2004	American Society of Mechanical Engineers – Boiler and Pressure Vessel Code, Nondestructive Examination
ASME BPVC	Sec. IX, 2004	American Society of Mechanical Engineers – Boiler and Pressure Vessel Code, Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators
ASME/ANSI	Y14.5M, 1994	American Society of Mechanical Engineers / American National Standards Institute – Dimensioning and Tolerancing
ASTM	A276, 2000	American Society for Testing and Materials – Specification for Stainless Steel Bars and Shapes
ASTM	A802, 2001	American Society for Testing and Materials – Standard Practice for Steel Castings, Surface Acceptance Standards, Visual Examination
ASTM	G48	Standard Test Methods for Pitting and Crevice Corrosion Resistance of Stainless Steels and Related Alloys by use of Ferric Chloride Solution
HI	HI2.6, 2000	Hydraulic Institute Standards – American National Standard for Vertical Pump Tests
NEMA	MG-1, 1998	National Electrical Manufacturers Association – Motors and Generators

2.3 Safety/Quality/Seismic Classifications

All HLW pump components related to the vessel confinement boundary provide confinement of liquid. The pumps are Quality Level CM and Seismic Category (SC) II using II-over-I criteria (see Section 1.4 for definitions).

The discharge piping from the top of the pump mounting plate to the PUREX flange connection including the PUREX flange and supports is considered HFP piping. HFP piping has a SS SSC designation, is Quality Level Q, and Seismic Category SC-III. Reference Figure 1 for HFP piping and pump interface.

2.4 Engineering Specifications

- 24590- WTP-3PS-FB01-T0001, *Structural Design Loads for Seismic Category III & IV Equipment and Tanks.*
- 24590-WTP-3PS-AFPS-T0001, *Engineering Specification for Shop Applied Special Protective Coatings for Steel Items and Equipment.* Appendix D, Item 4.20 System Code T
- 24590-WTP-3PS-G000-T0002, *Engineering Specification for Positive Material Identification (PMI) for Shop Fabrication.*
- 24590-WTP-3PS-G000-T0003, *Engineering Specification for Packaging, Handling and Storage Requirements.*
- 24590-WTP-3PS-G000-T0014, *Engineering Specification for Supplier Design Analysis.*

- 24590-WTP-3PS-M000-T0002, *General Specification for Mechanical Handling Equipment Design & Manufacture*, Sections 5.2.8 and 5.2.10.
- 24590-WTP-3PS-MUMI-T0002, *Engineering Specification for Low Voltage Induction Motors*.
- 24590-WTP-3PS-NW00-T0002, *Chemical Requirements for Materials Used in Contact With Austenitic Stainless Steel and Nickel Based Alloys.*
- 24590-WTP-3PS-PS02-T0002, *Engineering Specification for Cold Bending of Pipe.*
- 24590-WTP-3PS-SS00-T0001, *Engineering Specification for Welding of Carbon Structural Steel.*
- 24590-WTP-3PS-SS00-T0002, *Engineering Specification for Welding of Structural Stainless Steel and Welding of Structural Carbon Steel to Structural Stainless Steel.*
- 24590-WTP-3PS-SS90-T0001, *Seismic Qualification of Seismic Category I & II Equipment and Tanks.*

2.5 Referenced Drawings

See Figure 1 and Figure 2 for HLW pump configuration.

- 24590-HLW-MV-HFP-00001, *Equipment Assembly HLW Melter 1 Feed Preparation Vessel HFP-VSL-00001 Sheet 1 of 4.*
- 24590-HLW-MV-HFP-00002, *Equipment Assembly HLW Melter 1 Feed Vessel HFP-VSL-00002 Sheet 1 of 4.*
- 24590-HLW-MV-HFP-00003, *Equipment Assembly HLW Melter 1 Feed Preparation Vessel HFP-VSL-00001 Sheet 2 of 4.*
- 24590-HLW-MV-HFP-00004, *Equipment Assembly HLW Melter 1 Feed Preparation Vessel HFP-VSL-00001 Sheet 3 of 4.*
- 24590-HLW-MV-HFP-00005, *Equipment Assembly HLW Melter 1 Feed Preparation Vessel HFP-VSL-00001 Sheet 4 of 4.*
- 24590-HLW-MV-HFP-00006, *Equipment Assembly HLW Melter 1 Feed Vessel HFP-VSL-00001 Sheet 2 of 4.*
- 24590-HLW-MV-HFP-00007, *Equipment Assembly HLW Melter 1 Feed Vessel HFP-VSL-00001 Sheet 3 of 4.*
- 24590-HLW-MV-HFP-00008, *Equipment Assembly HLW Melter 1 Feed Vessel HFP-VSL-00001 Sheet 4 of 4.*
- 24590-HLW-MV-HFP-00009, *Equipment Assembly HLW Melter 2 Feed Preparation Vessel HFP-VSL-00005 Sheet 1 of 4.*
- 24590-HLW-MV-HFP-00010, *Equipment Assembly HLW Melter 2 Feed Vessel HFP-VSL-00006 Sheet 1 of 4.*
- 24590-HLW-MV-HFP-00011, *Equipment Assembly HLW Melter 2 Feed Preparation Vessel HFP-VSL-00005 Sheet 2 of 4.*
- 24590-HLW-MV-HFP-00012, *Equipment Assembly HLW Melter 2 Feed Preparation Vessel HFP-VSL-00005 Sheet 3 of 4.*
- 24590-HLW-MV-HFP-00013, *Equipment Assembly HLW Melter 2 Feed Preparation Vessel HFP-VSL-00005 Sheet 4 of 4.*

- 24590-HLW-MV-HFP-00014, *Equipment Assembly HLW Melter 2 Feed Vessel HFP-VSL-00006 Sheet 2 of 4.*
- 24590-HLW-MV-HFP-00015, *Equipment Assembly HLW Melter 2 Feed Vessel HFP-VSL-00006 Sheet 3 of 4.*
- 24590-HLW-MV-HFP-00016, *Equipment Assembly HLW Melter 2 Feed Vessel HFP-VSL-00006 Sheet 4 of 4.*
- 24590-HLW-MV-HFP-00017, *Flange and Dowel Location HFP-VSL-00001/5 & HFP-VSL-00002/6.*
- 24590-WTP-M0-50-00016, *WTP Remote Fasteners.*
- 24590-WTP-M0-M10T-00012001, *WTP Remote impact Wrench.*
- 24590-HLW-M0-HSH-00081003, *Equipment Assembly HLW System HSH Design Proposal Drawing Adjustable Lifting Beams*
- 24590-WTP-M61-P23T-00005, *WTP Details - PUREX Male Connector (ECI).*
- 24590-WTP-M61-P23T-00040, *Kick-Off Plates PUREX Connector (ECI).*
- 24590-WTP-M61-P23T-00041, *WTP Lower Electrical Holder (ECI).*
- 24590-WTP-M61-P23T-00051, *WTP Assembly Upper Holder Electrical Connector (ECI).*

2.6 Referenced Equipment Datasheet

- 24590-HLW-MPD-HFP-00007, *HFP-VSL-00001 Sample Transfer Pump.*

3 Design Requirements

3.1 General

The Seller shall control the quality of items and services to ensure that the requirements of this specification, applicable codes and standards, MRs, motor and vertical pump data sheets, and other Acquisition Services documents are met.

3.2 Design Conditions

3.2.1 The equipment and appurtenances will be used in a plant that has a design life of 40 years. Vertical pumps shall be designed for a minimum service life of 20 years when subjected to normal periodic maintenance. HFP piping shall be designed to ensure confinement of the HLW concentrate/feed slurry/effluents for the 40-year life of the facility with consideration to the high radiation environment and the erosive/corrosive nature of the solids/mixture HLW. There shall be a 5-year maintenance interval with 100 % availability during that time.

3.2.2 These pumps are generally categorized as remote (as defined in Section 1.4).

3.2.3 These pumps shall be designed for a radiation exposure life of not less than 5 years at the conditions specified in the Equipment Datasheet. Normal maintenance items shall be included, such as bearings, packing, seals, and gaskets, which, due to the remote radioactive environment, shall function with no maintenance required within that period.

3.2.4 The pumps shall provide confinement of the vessel contents to the environment and confinement of air in leakage to the vessel. This shall be accomplished with a remote gasket on the mounting plate (3.5.7.16) and shaft seals (3.5.7.11).

3.3 Conditions of Service

3.3.1 Pumps shall be capable of moving radioactive solutions or slurries (see Equipment Datasheet for Rheologies) in and out of remotely operated process cell vessels under conditions of service stated in the pump and electric motor data sheets.

3.3.2 These pumps shall be located in the HLW melter cave and exposed to a radioactive environment with expected radiation rates as described in the Equipment Datasheet.

3.3.3 See Equipment Datasheet for additional design conditions.

3.4 Environmental Conditions

3.4.1 The Seller shall provide pumps that meet the environmental conditions stated on the Equipment Datasheet.

3.4.2 See Equipment Datasheet for environmental conditions during normal and abnormal conditions.

3.5 Pump Construction

3.5.1 General

Reference Section 2.3 and 8.1 for pump quality designation.

3.5.2 Cantilever Pump Design Definition

For the purposes of this specification, a cantilever pump is a pump with a shaft and impeller that extends below the radial bearing (located above the mounting flange). Cantilever pumps shall have suction tailpipe and eductor priming assemblies. The pumps shall be completely self-draining. Cantilever pumps shall not have any bearings in the interior of the vessel.

3.5.3 Some design parameters are given on the Equipment Datasheet included in the MR.

3.5.4 Seller shall design and fabricate a pump test lifting beam assembly with two lifting hooks. These lifting hooks (dimensions and configuration of the hooks are shown in drawing 24590-HLW-M0-HSH-00081003) will facilitate a two-point lift by the lift beam that is in turn lifted by a single main crane hook. Lifting hooks shall be designed to lift 1.5 times the total dry pump weight and shall provide a straight plumb, 1/4-inch maximum from plumb, lift of a fully assembled pump.

Important: The lift beam shall hang plumb when not supporting the pump. Additionally, the pump shall be counter-weighted, if necessary, to provide a plumb lift while being hoisted by the test lift beam. Variation from vertical shall be 1/4-inch maximum from plumb.

3.5.5 Design calculations related to both the lifting assembly and lifting lug designs shall be submitted for Buyer review. (Section 10.2.4.2)

3.5.6 Pumps and HFP piping shall be designed in accordance with codes and standards listed in Section 2.2 quality and seismic classifications listed in Section 2.3, and controlled in accordance with the quality assurance requirements in Section 8.1.

3.5.6.1 The pump is a vertical and cantilever type as defined in Section 1.4. Figure 1 and Figure 2, HLW Remote Vessel-Mounted Vertical Transfer Pumps, illustrate the pump setting and vessel configuration.

3.5.6.2 Seller shall design all pump components (including casing, impeller, tailpipe, eductor piping, and discharge piping) and HFP piping with the necessary structural supports to withstand all the operating forces, including those from slurry agitation, without exceeding the infinite fatigue life stress value or compromising structural integrity of the pump. Such forces shall be determined and quantified during detailed design.

3.5.6.3 The pumps shall be designed to the dimensions and tolerances shown on Figure 1, Figure 2, the Equipment Datasheet, and in accordance with ASME Y14.5M, *Dimensioning and Tolerancing*. Interfacing dimensions and tolerances are of extreme importance, since the HLW pumps will be remotely removed from and reinstalled onto vessels of equal or greater dimensional and tolerance requirements. Pumps will also interface remotely with close tolerance remote process jumpers at all pump nozzle connections.

3.5.6.4 The critical tolerances for location, flatness, parallelism of working plane, and nozzles will be strictly enforced. Jigs or gauges shall be used to ensure consistency and compatibility between pumps and shall be furnished by the Seller. All measurements shall be referenced to the temperature specified in Appendix E, Final Dimensional Measurements of Pumps by Seller.

3.5.6.5 In order to verify all the specified dimensions, the Seller shall provide a, b, and c on submitted design drawings.

a Establish x-y coordinates of all guide-pin holes, remote connectors, stud holes, and mounting plate centerlines with reference to the master dowel hole.

b Establish the bottom of the mounting plate as the horizontal datum plane from which pump elevations can be measured.

c Represent all coordinates and targets to be used for precision dimensional verification with easily defined permanent machined features that are not subject to interpretation.

d Deleted

3.5.6.6 As-built dimensions shall be established by Seller's methods to decimal inch dimensions (number of decimal places, two or three, according to respective required dimensions) and submitted with a tolerance control procedure to establish and verify horizontal and vertical centerlines, precise horizontal and vertical measurements, flatness, and datum planes of all interface points.

3.5.6.7 Mounting plates shall be fabricated with impact wrench positioners, nut cups, and guide pinholes sized and located as shown on Figure 1 and Figure 2.

3.5.6.8 Remote connectors shall be attached and located as shown on Figure 1 and Figure 2 to facilitate proper mating and remote replacement of jumper assemblies. The Seller shall design and fabricate the support arrangement for the remote connectors shown, to accommodate a maximum resultant force (all moments zero) of 2000 lb and a maximum resultant moment (all

forces zero) of 2900 ft-lb per nozzle. Simultaneous loading of all nozzles shall be the basis of support design below the nozzle kick plate. Support design must not encroach on space required for remote impact wrench (see Figure 1 and Figure 2). Remote connector nozzles and components are required and will consist of the types listed below.

a Remote connector nozzles for process and priming and nut retainer (see Figure 1 and Figure 2)

b One electrical lower holder (see Figure 1 and Figure 2)

c Grease connector for in-place relubrication of bearings (see Section 3.5.7.4)

Note: Appendices C and D detail which nozzles and connectors are supplied by the Buyer.

3.5.6.9 The pump shall be remotely replaceable through a vessel nozzle by means of an overhead crane equipped with an adjustable span lifting beam, impact wrench, a closed circuit television system for remote viewing, and a power manipulator for smaller, more complex functions. Remote handling and potential radiation exposure require special pump attachments and configuration approaches (see following sections) to be furnished by the Seller. Additionally, the pumps shall be designed to accommodate operational envelopes for the adjustable span lifting beam, impact wrench and power manipulator. All remote handling interfaces shall be subject to Buyer review prior to fabrication.

3.5.6.10 Seller shall fabricate and weld in place guides to protect the pump during insertion and removal through the vessel nozzle. Three equal radially spaced guides shall be installed on each pump.

3.5.6.11 Guides shall be welded at one end only to allow for pump disassembly. Guides shall be designed to facilitate remote installation and removal of pumps through the vessel nozzle.

3.5.6.12 Pumps shall be designed to minimize the radiation exposure time of maintenance personnel. The connector nozzle configuration (Figure 1 and Figure 2), required nozzle supports, and electrical wiring to motor shall all be designed to minimize time required to remove and replace motor (see Section 3.7.2.2).

3.5.6.13 HLW pumps shall be a two-piece design with a remotely detachable motor for removal and maintenance or replacement. The motor assembly/pump interface shall incorporate master and slave guide pins and remote stud and nut configuration similar to the pump/vessel interface. Main coupling between the vertical pump shaft and drive motor shaft shall be solid steel male-female spline type, statically balanced, and designed for all conditions of service indicated in the vertical pump datasheet and this specification. Couplings shall be completely self-aligning and splined on the pump side to allow remote removal and installation of drive motor. The remote removal and installation of the drive motor, including the self-aligning feature of splined couplings, shall be demonstrated as outlined in Section 6.4. The motor or pump shall be free to spin to allow remote engagement of splined coupling.

3.5.6.14 Motor shall be mounted on a machined surface. The Seller shall provide a machined notch in the motor mounting plate to indicate the proper motor orientation upon reassembly of motor and motor mounting plate which is viewable from crane mounted cameras.

3.5.7 General Pump and Piping Requirements – HLW

3.5.7.1 Pump casings shall be hydrostatically tested in accordance with Section 6.2. Castings shall be sound and free from cracks, pits, or nodules in accordance with Section 5.1.1.

3.5.7.2 Two or more bearings shall support the vertical rotating pump shaft. To improve the stability of the rotating assembly, the bearings shall be preloaded, if necessary, according to bearing size. The load on the thrust bearing shall consist of the sum of the weight of the rotating assembly and the hydraulic thrust and moment from radial thrust and the preload. The load on the radial bearing shall consist of radial components and preload only.

3.5.7.3 All bearings shall be cartridge or standard width, single row radial ball, deep groove (Conrad type) or angular contact type, ABMA Standard 20, Class 3 Internal Clearance, and selected to give 100,000 hours minimum L_{10} rating life in conformance with ABMA Standard 9.

3.5.7.4 Bearings and bearing seals shall withstand all conditions of service as stated in vertical pump datasheet. Bearing seals shall be designed for the least possible drag on the inner race of the bearing to minimize heat build-up and premature failure. Shaft and housing fits shall be in accordance with ABMA Standard 7.

3.5.7.4.1 The Seller shall provide in-place re-greasing for the bearings to allow for re-lubrication of the bearings without removing any components of the pump assembly from their installed positions. Seller to provide regreasing schedule and quantity. In-place re-greasing for HLW remote vertical pumps will be facilitated using a power manipulator and BUYER supplied low pressure (250 psi) grease gun on the overhead crane, which will interface with the grease connector. The SELLER shall provide Staubli grease connectors located within 6 inches of the bearings, to minimize opportunities for the grease line to clog due to radiation hardening. The piping is to be braced for manipulator loads. A collection device for the excess grease that may be present during remote greasing shall be provided. As an alternative, sealed-for-life ball bearings are acceptable for the pump; Buyer to review sealed-for-life bearings and approve before fabrication.

3.5.7.5 Bearings shall be lubricated with Chevron SRI Grease 2 (NLGI Grade 2), as detailed in Appendix C of 24590-WTP-3PS-M000-T0002, *General Specification for Mechanical Handling Equipment Design & Manufacture,* or an approved equivalent radiation-resistant grease in an amount determined by bearing manufacturer. If an alternate grease is recommended, all appropriate technical information shall be submitted for Buyer acceptance.

3.5.7.6 Thrust bearings shall provide full load capabilities if the normal rotation direction of the pump is reversed.

3.5.7.7 Shafts of solid construction are preferred and shall be designed to carry their loadings without exceeding their normal limits of combined stress, taking into account fatigue stress due to change in load or speed. The first lateral critical speed of shafts and impellers shall be at least 20 % above the maximum operating speed.

3.5.7.8 The Seller shall ensure a smooth, even impeller finish and uniformity of shape and finish on the vanes and the space between. The acceptance criteria for impeller finish is a machine finish RMS of at least 63 micron or 56 RA. Surface finish is to be verified by a Profilometer and reported per Section 10.2.3.7.

3.5.7.9 The bearing frame shall be constructed and bearing centers spaced so that the shaft and impeller assembly will have proper support to minimize vibration, as detailed in the following Section.

3.5.7.10 Maximum Allowable Vibration Limits

3.5.7.10.1 Motor, shaft, and impeller vibration amplitude shall not be more than 0.002 inches peak-to-peak, measured normal to pump shaft axis and not more than 10 inches above the impeller centerline, in air at motor speed, filtered to shaft speed.

3.5.7.10.2 The pump vibration amplitude shall not be more than 0.001 inches peak-to-peak, measured on the surface of the lower bearing housing normal to shaft axis, in air at motor speed, filtered to shaft speed.

3.5.7.10.3 The pump casing vibration amplitude shall not be more than 0.003 inches peak-to-peak measured outside the surface of the casing normal to shaft axis, pumping water at the design rate, filtered to shaft speed.

3.5.7.10.4 Vibration test results for each pump shall be subject to Buyer review prior to shipping the pumps.

3.5.7.11 Shaft seals shall be installed to confine air inflow at the point of pump shaft entry to the vessel. Seller shall furnish and install a low pressure, non-lubricated stuffing box packed with Grafoil or approved equivalent split-ring, with a minimum compressed axial pitch length of 4 inches. Seller also shall provide a temporary identification tag to caution against adjusting the Grafoil seal after pump delivery. The stuffing box shall also meet the following requirements: a) minimum of six rings, b) minimum ring size of 1/2 in. by 1/2 in., and c) designed for ease of replacement of rings.

3.5.7.12 An installed priming system is required to permit pump startup when vessel fluid level is below the pump impeller. The priming system shall be a water eductor type of the general configuration shown on Figure 1 and shall be capable of starting the pump over the full range of conditions shown on the vertical pump datasheet and described in this specification. The priming system shall be able to start the pump from a vessel low fluid level as described in the Equipment Datasheet. Available water pressure at the primer nozzle will be as indicated on vertical pump datasheet. The priming system shall be capable of starting pumps without exceeding the maximum priming liquid volume as stated on the vertical pump datasheet. Priming capabilities shall be tested and verified (Section 6.3.5).

3.5.7.13 All pumps shall be provided with keyed impellers with separate threaded lock nuts and double (jam) nuts to secure the pump impeller.

3.5.7.14 The pump and HFP piping attached to the pump shall meet all requirements of ASME B31.3 1996. Pipe supports shall be designed and constructed in accordance with ASME B31.3 and AISC M016.

3.5.7.15 The maximum pump/motor weight including all connections and appurtenances shall not exceed 3600 lb.

3.5.7.16 A 1/2 inch thick remote gasket will be provided by Buyer to seal the pump and vessel nozzle.

3.5.7.17 A 2-inch diameter pin has been designed that is attached to the vessel bottom, and a maximum force on the pin has been calculated to be 1130 lb. An arm attached to the pump suction nozzle slips over the pin to stabilize the pump. The Seller shall design and supply the stabilizing arm. The Seller shall also design the pump for hydrodynamic forces based on a slurry velocity normal to the pump of 5.00 ft/sec with viscosity and density as indicated in Equipment Datasheet. See drawings 24590-HLW-MV-HFP-00001 through -00017 for further details (e.g., nozzle orientation, stabilizing pin location, agitator location).

3.5.7.18 The Seller shall perform calculations for Buyer review providing thrust, torque, and moments on the vessel nozzle supporting the pump due to pump operation and vessel agitator induced flow effects.

3.6 Operational and Design Requirements

3.6.1 The pump head capacity curve (Section 6.3.3) shall be continuously rising from maximum flow to shut-off.

3.6.2 Pump design pressure shall be not less than 25 % above the shut-off head at the specified suction pressure.

3.6.3 Pumping systems shall be designed to minimize cavitation. The pumps shall operate free of cavitation over the entire range of conditions indicated in Equipment Datasheet.

3.6.4 The Seller shall minimize rotational speed of shafts and impellers due to wear considerations and head losses encountered when pumping slurries at high speeds.

3.6.5 Frequency and length of operation for each pump is shown in Appendix A, Pump Operation Summary.

3.6.6 Startup torque shall be based on two times the normal running torque without priming water. (Slurry rheology is indicated in the Equipment Datasheet.)

3.7 Drivers

3.7.1 Motors

3.7.1.1 Drive motors shall conform to the requirements of 24590-WTP-3PS-MUMI-T0002, *Engineering Specification for Low Voltage Induction Motors*.

3.7.1.2 The Seller shall provide each pump with a totally enclosed fan-cooled, wash-down rated, chemical-type motor in accordance with the motor and vertical pump datasheet included with the MR.

3.7.1.3 Motor rated horsepower shall not be exceeded by any operating condition that can develop with the impellers.

3.7.1.4 Motors shall be rated for inverter duty for use with adjustable speed drives.

3.7.1.5 All motors shall be NEMA design C type (in accordance with NEMA MG-1). The motor shall be the weakest link in a high torque event such that the shaft, impeller blades, and so forth do not fail in any event.

3.7.2 Remote Service

3.7.2.1 Motor shall be Class H type and radiation resistant for levels stated in the Equipment Datasheet.

3.7.2.2 The Seller shall install all required conduit with proper wiring from the motor junction box to and including the Buyer supplied lower electrical connector. All electrical components shall be waterproof. Cable shall be radiation resistant for levels stated in the Equipment Datasheet.

3.7.2.3 Seller shall provide a remote motor stand on which the motor can be set for storage, decontamination, or maintenance. It is not necessary to handle the motor stand and motor together, just one at a time. The motor stand shall have no seismic category requirement.

3.8 Seismic Requirements

3.8.1 The remote vertical pump components and HFP piping, including the mounting plates, shall be designed to SC-II requirements in accordance with the methods and procedures in Specification 24590-WTP-3PS-SS90-T0001, *Seismic Qualification of Seismic Category I & II Equipment and Tanks*, attached to the MR. The Seller shall submit their seismic analysis documentation to the Buyer (Reference Section 10.2.4.1). The in-structure response spectra is provided in Appendix F. Jumper nozzle loads and pump-vessel bounding interface loads are located in Equipment Datasheet.

3.9 Accessibility and Maintenance

3.9.1 The Buyer's layout allows necessary access and space to facilitate maintenance during normal plant operation or scheduled shutdown.

3.9.2 The Seller's accessibility and maintenance recommendations for each piece of equipment shall be included in the Seller's operations manual submittal (Reference Section 10.2.5.2).

3.9.3 For the HLW pumps, frequency of inspection and maintenance intervals, beyond the 5-year no-maintenance period, shall be minimized in accordance with equipment Seller's recommendations.

3.9.4 Design configuration for accessibility and maintenance of the pumps shall be reviewed by Buyer at 50% design review.

4 Materials

4.1 General

Pump materials situated above and fastened to the mounting plate (see Figure 1 and Figure 2) shall be austenitic stainless steel type 316L, except for the discharge piping. Pump materials below and including the mounting plate, except for wetted pump components in contact with high velocity fluid, shall be 316L stainless steel (or approved equal) unless otherwise noted in this specification or the Equipment Datasheet. Stainless steel material shall be in accordance with requirements of this specification (including codes, standards, and specifications referenced within). Pump suction pipe, discharge pipe from the casing to the mounting plate,

and the HFP pipe from the mounting plate to the PUREX nozzle weld joint, shall be made from an appropriate erosion resistant material, such as Zeron 100.

Note: The Seller may use standard materials of construction, suitable for the radiation environment, for motor, bearings, and coupling components.

All other components (such as piping, nozzle assemblies, lifting assemblies, main shaft seals, nut retainer) shall be 316L stainless steel unless specified otherwise in this specification or the Equipment Datasheet.

The materials of construction for special components not named herein shall be subject to Buyer review.

4.1.1 The Seller shall identify, on assembly drawings, all materials (including plate, forging, pipe, bolting) by ASTM material designation, class and UNS number, and shall submit material certificates for the Buyer's review and approval (reference Section 10.2.8).

4.1.2 The wetted pump components (for example, suction bell, suction piping, casing, impeller, shaft bushing deflector, casing wear rings, discharge piping) shall be made of corrosion and erosion resistant materials. See the Equipment Datasheet for the reference material for these applications).

4.1.3 Gasket selection and configuration shall be based on specific application, performance requirements and environmental conditions.

4.1.4 Fastener interfaces shall be as shown on Figure 1 and Figure 2. Fasteners shall be accessible by the Buyer's impact wrench per requirements of Section 5.2.8 and 5.2.10 of 24590-WTP-3PS-M000-T0002, *General Specification for Mechanical Handling Equipment Design & Manufacture.* Seller shall design and fabricate pumps to ensure access is available for the remote impact wrench. The envelope dimensions of the impact wrenches are detailed on drawing 24590-WTP-M0-M10T-00012001. The HLW Melter Cave 1 and 2 impact wrenches will be used to remotely install and remove these pumps; the largest envelope dimensions for these wrenches must be used in impact wrench access design. The remote fasteners are per drawing 4, *WTP Remote Fasteners*. Buyer will provide the pump mounting flange bolt fasteners. Remote nuts are impact wrench torqued to 400 ft·lbs during makeup and up to 750 ft·lbs during breakout. All remote handling interfaces shall be subject to Buyer review prior to fabrication.

4.1.5 The starting materials for the structural and functional components shall be from new stock, not repaired or otherwise microstructurally changed from the as-received stock from the certified supplier.

4.1.6 The Seller shall coordinate with the Buyer to arrange delivery of the GFP, listed in Appendix D, as required for Seller's pumps. This shall be accomplished by identifying GFP need dates, on Seller's fabrication schedule.

4.1.7 All GFP shall be controlled in accordance with a Seller submitted Government Property Management Plan (GPMP) in accordance with the commercial terms of the purchase order.

4.2 Positive Material Identification

All pump casing, mounting plate, and HFP piping materials shall be identified in accordance with 24590-WTP-3PS-G000-T0002, *Engineering Specification for Positive Material Identification (PMI) for Shop Fabrication*. Components requiring PMI testing shall include the following: mounting plate assembly, discharge pipe assembly, prime pipe assembly, pump casing, packing box, and packing gland.

4.3 Prohibited Materials

4.3.1 Bronze, copper, lead, zinc, tin, antimony, cadmium, mercury, bismuth, or other low melting point metals, their alloys, or materials containing such metals as their basic constituents; sulfur; and halogens shall not be used in direct contact with stainless steel. This prohibition applies to tools, fixtures, paints, coatings and sealing compounds, and any other equipment or materials used by the Seller in handling, assembly, and storage of stainless steel parts or components.

4.3.2 Asbestos, Teflon, and aluminum shall not be used in any component of the vertical pumps.

4.4 Special Requirements

4.4.1 HFP piping handles process solutions outside the vessel boundary and shall have confirmatory testing to ensure the alloy is as listed on the certified material test report. This shall be accomplished using specification 24590-WTP-3PS-G000-T0002, *Engineering Specification for Positive Material Identification (PMI) for Shop Fabrication.*

4.4.2 Stress corrosion cracking, crevice corrosion, pitting corrosion and uniform corrosion can be minimized by the proper design and fabrication. Crevices, low points, and stress concentrations shall be eliminated wherever possible. Where crevices cannot be eliminated, a wider opening with flat bottoms shall be designed such that the volume can be readily flushed.

4.4.3 Stainless steel mill products shall be visually inspected (100 %) to determine surface quality and avoid using sections that have been damaged, bent, over pickled or exhibit contaminant spill stains.

4.5 Storage of Stainless and Corrosion Resistant Materials

4.5.1 The seller shall provide material control procedures for storage of stainless steels and corrosion resistant alloys (reference Section 10.2.2.13). The procedures shall include:

4.5.1.1 Identification and marking

4.5.1.2 Dirt, dust, and contamination control

4.5.1.3 Segregation of materials dedicated to the WTP fabrications

4.5.1.4 Dunnage control and prevention of contamination

4.5.1.5 Methods used to control welding consumables that include receipt, storage, issuance, baking/drying of flux and disposal.

5 Fabrication

5.1 General

5.1.1 All casting surfaces shall meet Level 1 visual examination acceptance standards as described in ASTM A802. Castings shall be free from cracks, tears, voids, or other defects indicative of substandard casting quality.

5.1.2 All vertical pumps shall be neatly finished and free of burrs and fins, and other harmful surface conditions.

5.1.3 For ease of decontamination, remote vertical pumps shall be designed to minimize crevices that can trap contaminants. All surfaces are to be polished smooth (RMS 125 finish other than impellers). See Section 3.5.7.8 for impeller requirements. Additionally, all non-machined plate, pipe surfaces, and welds shall be glass beaded to a 112 RA finish (equivalent to 125 RMS machined finish) or better. Actual surface finishes shall be verified with a Profilometer and recorded in the RA format. Material hold-up points internal to the pump shall be minimized.

5.2 Welding Procedures

5.2.1 All welding procedures and welder qualifications for pump components shall be in accordance with ASME BPVC Section IX. The Seller shall submit all welding procedures for vertical pumps for review prior to the start of any welding. (Section 10.2.2.1)

5.2.2 Deleted

5.2.3 The properties of duplex stainless steel can be appreciably affected by welding. Due to the importance of maintaining the balanced microstructure and avoiding the formation of undesirable sigma and intermetallic phases the weld procedures require additional testing for qualification. Significant intermetallic phases may lead to loss of toughness and corrosion resistance. Recommended filler material is a duplex UNS S32750 or similar. All dissimilar metal welds shall be made using a tungsten gas arc welding process using 100 % argon gas; both the welding gas and purge gas shall contain less than 25 ppm oxygen for optimum corrosion resistance of the finished weld. Weld procedures for duplex stainless steel (welding procedure specification and procedure qualification record) are to be supplemented by ferrite count or ferrite number tests and corrosion testing to ASTM standard G48. The ASTM G48 test is to be modified to include coupons exposed to nitric acid and sodium hydroxide to indicate that the welding method is satisfactory. G48 test temperature for super duplex stainless steels is 35 °C. Test reports shall be attached to the weld procedure and submitted to the Buyer. (Section 10.2.2.1)

5.2.4 All weld repairs, straightening, and machining processes shall be controlled and documented such that the Buyer representative can follow the process to shop procedures. All weld repairs shall be reviewed by the Buyer, planned, documented, and performed according to ASME BPVC Section IX. All weld repairs that result from nondestructive examination (NDE) evaluations shall be inspected a second time using the same technique. No more than two weld repairs are permitted for the same defect indication called out by the initial NDE inspection report. Any additional repairs shall be subject to additional Buyer review before implementation.

5.3 Structural Components

5.3.1 Stainless Structural Steel

Document 24590-WTP-3PS-SS00-T0002, *Engineering Specification for Welding of Structural Stainless Steel and Welding of Structural Carbon Steel to Structural Stainless Steel*, covers the welding requirements for stainless structural steel.

5.4 Chemical Requirements for Materials Used in Contact with Austenitic Stainless Steel and Nickel and Nickel Alloys

5.4.1 Materials and consumables used in the fabrication and handling of these pumps shall comply with 24590-WTP-3PS-NW00-T0002, *Chemical Requirements for Materials Used in Contact with Austenitic Stainless Steel and Nickel Based Alloys.*

5.5 Painting, Surface Preparation, and Cleaning

5.5.1 All steel surfaces, other than those materials listed in Section 5.5.6, shall be in accordance with the cleaning, surface preparation, and coating requirements of Appendix D, Item 4.20 System Code T in specification 24590-WTP-3PS-AFPS-T0001, *Engineering Specification for Shop Applied Special Protective Coatings for Steel Items and Equipment.*

5.5.2 Sharp welds and sharp corners shall be ground smooth and blended into the base materials. Each layer of welding shall be smooth and free of slag inclusions, porosity excessive undercut, cracks and lack of fusion prior to beginning the next layer. In addition, the final weld layer shall be sufficiently free of coarse ripples, non-uniform bead patterns, high crown, and deep ridges to permit required inspection.

5.5.3 The interior surfaces of attached piping and bearing housing shall be cleaned of all mill scale, grease, oil, dirt, cuttings, weld spatter, and other foreign matter.

5.5.4 Unpainted components shall not be sandblasted.

5.5.5 Cleaning agents used for austenitic stainless and nickel-based alloys shall not contain more than 50 ppm by weight of inorganic chlorides. Seller shall submit cleaning procedures for review (Reference Section 10.2.2.10).

5.5.6 Pump components of stainless steel, cobalt alloy, and nickel-based alloy construction shall not be painted. Commercial items provided by the Seller that are purchased prepainted (motor) need not be painted per 24590-WTP-3PS-AFPS-T0001.

5.5.7 Coatings from one manufacturer shall not be used over coatings from another, and to ensure compatibility, shall not be intermixed.

6 Tests and Inspections

6.1 General

A test and inspection plan shall be developed by the Seller and submitted to the Buyer for review and permission to proceed in accordance with Section 10.1. The plan shall identify all Seller's inspections, examinations, tests, and witness and hold points required during the pump fabrication process. When an operation requires a procedure, the procedure number shall be designated on the plan. The plan shall also identify the Buyer's hold/witness points identified in Section 5 of the appropriate MR. In addition, during review of the plan by the Buyer, the Buyer may add additional hold/witness points in the plan.

6.2 Hydrostatic Tests

6.2.1 Each pressure part of the pump including the priming and discharge piping shall be hydrostatically tested at 150 % of maximum allowable working pressure (MAWP). Hydrostatic tests shall be maintained for at least 30 minutes. Regions of the pump that are subject to suction pressure such as the mounting plate components and the packing box do not require to be rated for MAWP. These components shall by hydro tested at 25 psig.

6.2.2 Before a hydrostatic test procedure is implemented, the Seller shall submit it to the Buyer for review.

6.2.3 Water used in hydrostatic testing shall be of potable quality or better. At no time shall it contain over 50 ppm chlorides.

6.2.4 Systems shall be thoroughly drained and dried by wiping or blotting all accessible areas within 24 hours after testing, rinsing, or flushing operations. Water shall not be left in the system for more than 48 hours after testing, rinsing, or flushing operations. To minimize the potential of microbiologically induced corrosion, the Seller shall use only treated process water, potable water, or deionized (demineralized) water.

6.3 Performance Tests

6.3.1 A shop performance test with water shall be conducted on all pumps, in accordance with Hydraulic Institute (HI2.6) standards, at rated speed over the complete range of flow to maximum capacity to demonstrate fulfillment of efficiency and rating guarantees. Performance tests shall be run using the net positive suction head (NPSH) available to the pump at the site, including adjustments for all expected liquid levels in vessels and corrected to shop test conditions. The test shall utilize an adjustable speed drive (ASD) to maintain flow rate through the range of vessel liquid levels. ASD configuration and settings shall be submitted to Buyer. The minimum acceptable flow rate is stated on the Equipment Datasheet.

6.3.2 An NPSH at incipient cavitation test shall be performed in accordance with HI standards for each pump. At least three flow points shall be tested: design point, run out, and minimum flow. At each point, five or more readings shall be taken at increasingly lowered suction pressure until a 3 % drop in head is noted.

6.3.3 Water test results shall be plotted, showing head, efficiency, and brake horsepower vs. capacity. Water temperatures shall be recorded, and test results corrected to a design average

temperature. For pumps in slurry service, in addition to the water head curve, the Seller shall provide an estimated slurry head curve for comparison. The thickest slurry described in the Equipment Datasheet shall be used; specifically, the highest yield stress and highest viscosity.

6.3.4 Additional pump priming tests shall show the minimum pressure, flow, and total quantity of priming water required to prime the pump at the low liquid level described in the Equipment Datasheet. These tests shall be plotted showing the eductor primer flow rate vs. pressure at the primer nozzle for primer nozzle pressures between 30 and 80 psig.

6.3.5 Shop test results must verify that all pumps are capable of starting from the minimum liquid level without exceeding the maximum priming liquid volume as listed in the vertical pump data sheets.

6.3.6 Shop tests for each pump must verify all pumps operate within maximum allowable vibration limits specified in Section 3.5.7.10.

6.3.7 Witness tests shall be run after final trim has been calculated and applied to pumps. Final witness tests shall be run only with the Buyer's supplier quality representative (SQR) present. A satisfactory full-speed test shall be run at final impeller diameter before the Buyer's SQR is called in to observe the test. A preliminary curve and test data shall be submitted to the Buyer's SQR immediately after each test. The amount of acceptable plus tolerance on head, capacity, and horsepower shall be within the range of tolerances stated by the HI standards.

6.3.8 Seller shall provide an analysis verifying that the first lateral critical speed of all pump shafts and impellers is at least 20% above the maximum operating speed (Section 10.2.4.3). The Seller shall assume a rigid pump mounting foundation that contributes no more than 5 % of the total deflection of the structural elements.

6.3.9 During testing, each pump tested shall be fully supplied with electrical power by means of the electrical connectors per approved design.

Note: The Buyer will supply the upper female electrical connector to connect the Seller's wiring to the electrical lower holder. The Seller shall coordinate with the Buyer to arrange delivery of the upper female electrical connector, as required for testing of Seller's pumps. This shall be accomplished by identifying performance test need dates on Seller's fabrication schedule. The Seller is responsible for the interface between the upper female connector and the Seller's own power source during testing. The upper female connector component shall be returned to the Buyer after the final performance testing is completed.

6.3.10 After tentative acceptance by the Buyer's SQR, the pumps may be readied for shipment but shall not be released until acceptance by the Buyer of formal submission of curves and data, which will constitute the performance test report.

6.4 Final Dimensional Checks – Remote Vertical Pumps

6.4.1 The Seller shall verify the critical dimensions as given in Figure 1 and Figure 2, or as otherwise noted in this specification or material requisition. The measurements shall be in accordance with techniques described in Appendix E. (**Note**: The layout has not been finalized; therefore, the dimensions indicated are tentative.)

6.4.2 The Seller shall provide proof that the pump and pump appurtenances are dimensionally correct within the specified tolerances. This shall be accomplished by the completion of as-built dimensional record drawings. These drawings, with details of the critical dimensions added by the Seller, shall be submitted to the Buyer for review prior to shipment (Reference Section 10.2.1.13).

Note: In addition to pump and pump appurtenances above, as-built shim dimensions of each shim required for precision placement of the pump shaft thrust and radial bearings shall be recorded on the dimensional record drawings for each pump.

6.4.3 All final critical dimensional measurements, as detailed in Figure 1 and Figure 2 or as otherwise noted in this specification or MR, will be witnessed by the Buyer. No witness tests shall be performed without the Buyer's SQR present.

6.5 Main Coupling Engagement/Disengagement

Each splined coupling between the pump shaft and drive motor shaft shall be tested to ensure it functions properly. Specifically, each pump motor coupling shall be tested by means of a two-point lift applied at the motor lifting fixture to demonstrate that the motor can be satisfactorily engaged and disengaged from the coupling. The coupling shall be self-indexing and shall not require manual positioning for proper engagement. All main coupling engagement and disengagement tests will be witnessed by Buyer. No witness tests shall be performed without the Buyer's SQR present.

6.6 Plumb Lift Test

All pumps shall be tested for single point lift with Seller furnished lift beam connected to lifting lugs. Upper, lower and combined unit shall be tested. Variation from vertical shall be 1/4-inch maximum from plumb. All plumb lift tests will be witnessed by Buyer. No witness tests shall be performed without the Buyer's SQR present.

6.7 Test for Remote Handling Capabilities

Each component, as well as the complete assembly, must be tested for remote handling capabilities.

6.8 Load Lift Test

A load test for 1.5 times the normal dry load, shall be demonstrated on each unit in the Seller's shop, with Buyer to witness one of each type and review documentation on other tests. During the load test, the pump shall be lifted off the shop floor and held for at least 10 minutes. The pump shall be visually inspected for any deformation or stress cracking at the lifting lugs and at the lifting lugs attachments or reinforcements to the pump.

7 Preparation for Shipment

7.1 General

Vertical pumps shall be packaged, handled, and stored in accordance with 24590-WTP-3PS-G000-T0003, *Engineering Specification for Packaging, Handling and Storage Requirements*.

7.2 Tagging

A stainless steel nameplate shall be fastened to each vertical pump showing the manufacturer's name, shop location, date of manufacture, serial number, equipment rating, equipment tag numbers, weight of assembly, and purchase order number. Equipment tag numbers are provided in the MR.

8 Quality Assurance

8.1 CM and Q Quality Designation – QA Requirements Specific to HLW Items or Service

8.1.1 The Seller shall have a quality assurance program (QAP).

8.1.2 The Seller shall have in place a QAP containing, at a minimum, all the elements marked as applicable in the Supplier quality assurance program requirements datasheets attached to the MR. The Seller shall submit their QA manual with their proposal.

8.1.3 The pumps shall be manufactured in accordance with the Seller's QAP that has been evaluated and accepted by the Buyer's procurement supplier quality department.

8.2 Seller Deviation

Seller shall identify and promptly document any deviation from requirements in the acquisition documents. Seller-proposed deviations from Acquisition Services documents shall be initiated by use of an SDDR form (listed in Section 2 of the MR and attached thereto). In addition, the Seller shall describe the recommended disposition based on appropriate analysis. Requests for deviations from sub-Sellers shall be submitted to the Buyer through the primary Seller.

9 Configuration Management

Equipment or components covered by this specification are identified with plant item numbers as shown in the motor and vertical pump datasheets, in accordance with Section 7.2, Tagging.

10 Documentation and Submittals

10.1 General

The Seller shall submit to the Buyer engineering and quality verification documents in the forms and quantities shown in Form G-321-E, *Engineering Document Requirements*, and Form G-321-V, *Quality Verification Document Requirements*, attached to Section 3 of the MR.

10.2 Submittals

The Seller shall submit the following:

10.2.1 Drawings

Drawings shall show the following information:

10.2.1.1 The outline dimensions of the vertical pumps, including outline and detail drawings for each major component and components with a significant function. These drawings shall reflect the "as-shipped" configuration of the equipment and instrumentation.

10.2.1.2 Details of construction.

10.2.1.3 Mounting dimensions and information required for the design of supports and foundations.

10.2.1.4 Operating weight and center of gravity of each vertical pump.

10.2.1.5 Dynamic loading on mounting flange.

10.2.1.6 The space required for the removal of components.

10.2.1.7 The weight of pump and motor fully assembled, motor assembly, pump assembly and individual pump systems: shaft, support columns, mounting plate, casing assembly, and prime/suction pipe.

10.2.1.8 The locations and identification of parts that are included in the parts list.

10.2.1.9 Wiring, schematic diagrams, and connection diagrams shall include wire gauges and fuse sizes applicable to the supplied units only.

10.2.1.10 The ASTM or equivalent designation for materials.

10.2.1.11 Any deviations from Section 5.5 requirements shall be submitted for Buyer approval.

10.2.1.12 Nameplate lists.

10.2.1.13 Dimensional record drawings per requirements of Section 6.4.2.

10.2.2 Procedures

Procedures shall include the following:

10.2.2.1 Welding procedures. The Seller shall submit all welding procedures for vertical pumps for review per 5.2.1

10.2.2.2 Procedures for repairs of rejected items or parts associated with the HFP piping.

10.2.2.3 Electrical component performance test procedures.

10.2.2.4 Seller's shipping preparation procedures, including initial startup and checkout procedures, instructions for final alignment checks and any other special instructions prior to initial startup in the facility.

10.2.2.5 Deleted

10.2.2.6 Special instruction for installing and maintaining any packing and seals for shafts, bearings, or similar items, include special instructions for extended storage (up to 8 years) or idle conditions prior to initial operation.

10.2.2.7 Procedure for all priming operations using an eductor or similar item, including special instructions and sequence for pump startup for all liquid level scenarios.

10.2.2.8 For in-place re-greasing (see Section 3.5.7.4), the Seller shall submit complete instructions of the remote re-lubrication requirements, including all materials needed, proper sequence, special remote crane operator instructions.

10.2.2.9 Seller shall submit a written tolerance control procedure to establish and verify horizontal and vertical centerlines, precise horizontal and vertical measurements, flatness, and datum planes for dimensional measurement of vertical pumps (Section 3.5.6.5).

10.2.2.10 Seller shall submit cleaning procedures for austenitic stainless and nickel-based alloys (section 5.5.5).

10.2.2.11 Hydrostatic test procedure per requirements of Section 6.2.2.

10.2.2.12 Plumb lift test procedure. (Section 6.6)

10.2.2.13 Material control procedure. (Section 4.5)

10.2.3 Inspection and Test Reports

10.2.3.1 Records of repairs and rejected items or parts, as needed.

10.2.3.2 Electrical component performance test reports.

10.2.3.3 Bench test mechanical performance reports. (Section 6.3)

10.2.3.4 Performance test reports, including priming, NPSH, ASD performance, preliminary curve and test data per Section 6.3.

10.2.3.5 Plumb lift test report. (Section 6.6)

10.2.3.6 Hydrostatic test report. (Section 6.2)

10.2.3.7 Surface finish report. (Sections 5.1.3 and 3.5.7.8)

10.2.4 Calculations

Calculations shall be submitted for the Buyer's review and permission to proceed, and shall be in accordance with 24590-WTP-3PS-G000-T0014, *Engineering Specification for Supplier Design Analysis*.

10.2.4.1 Seismic analysis (Section 3.8).

10.2.4.2 Lifting lug stress analysis. (Section 3.5.4)

10.2.4.3 Pump critical speed analysis (Section 6.3.8)

10.2.5 Manuals

Manuals and instructions shall be supplied per form G-321-E and shall include the following:

10.2.5.1 Erection and installation manuals that provide complete detailed procedures for installing and placing equipment in initial operation. The manuals shall include all erection and installation drawings. A minimum of one set of each manual type shall be provided.

10.2.5.2 Operation and maintenance manuals that provide complete detailed descriptions of components and accessories, including datasheets showing design, construction and performance data for equipment. Manuals shall include startup, shutdown, and idle procedures. Manuals shall include drawings required for operation, maintenance and repair, maintenance requirements, instructions, operational troubleshooting guides.

10.2.5.3 Instruction manuals shall cover every item purchased, including materials that the Seller has obtained from a subcontractor. The Seller shall obtain such manuals and lists, and submit them to the Buyer.

10.2.5.4 The Seller shall provide instructions regarding site storage, preparation, and protection of equipment after installation and prior to operation per 24590-WTP-3PS-G000-T0003, *Engineering Specification for Packaging, Handling and Storage Requirements*.

10.2.5.5 The Seller shall submit their QA manual per Section 8.1.2.

10.2.5.6 Seller deviations from the QA requirements of Section 8 shall be submitted to the Buyer per Section 8.2.

10.2.6 Certificates of Conformance

10.2.6.1 The Seller shall provide certificates of conformance demonstrating compliance with all applicable standards, specifications, and drawings in the fabrication of the pump and HFP piping as detailed in this specification.

10.2.6.2 The Seller shall certify that lifting lugs are suitable for the safe, balanced lifting and handling of the equipment per Section 3.5.4 of this specification.

10.2.7 Schedule

Lists and schedules shall include the following:

10.2.7.1 Schedule of engineering and fabrication

10.2.7.2 Parts list, and cost for parts and items subject to deterioration and replacement

10.2.7.3 List of recommended spare parts

10.2.8 Materials Certificates/Statistics

10.2.8.1 Material certificates of compliance shall be submitted for components of the CM pumps.

10.2.8.2 Material Test Reports shall be supplied for the HFP piping and weld materials used in interfacing the HFP pipe with PUREX nozzle and pipe supports.

10.2.9 Data

Data shall include the following:

10.2.9.1 Buyer's motor and vertical pump data sheets, completely filled out by the Seller, showing all information required to determine that the units are of the design and materials specified herein.

10.2.10 Design and Technology Selection Criteria

10.2.10.1 Bearing Grease Selection

If an alternative grease for bearings is recommended other than that specified (Section 3.5.7.5), all appropriate technical information shall be submitted for Buyer acceptance.

10.2.10.2 Deleted

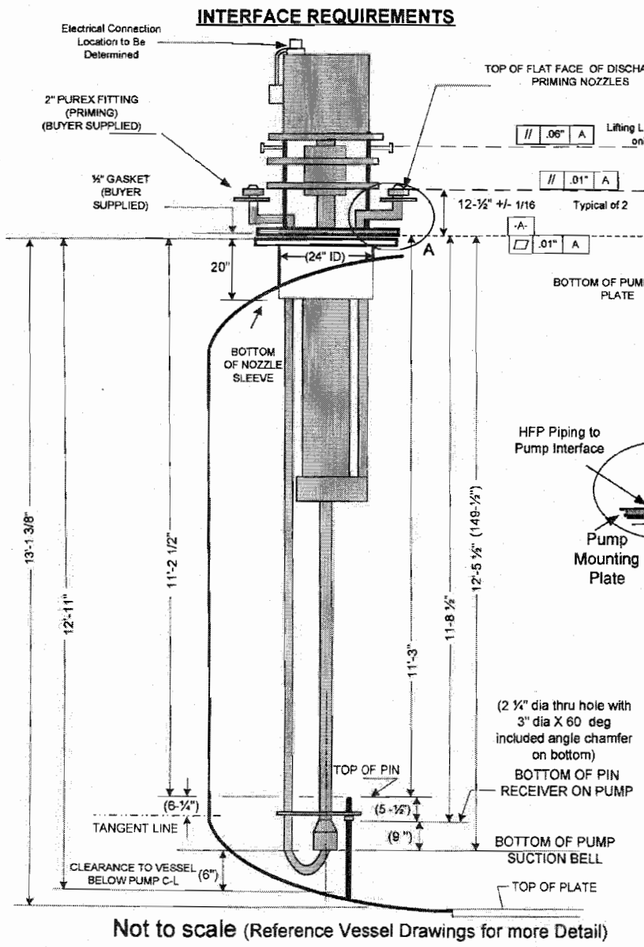
10.2.11 Material Safety Data Sheets

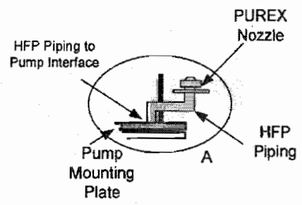
Material Safety Data Sheets shall be provided for all oils, greases, paints, preservatives, and all other chemicals and chemical products that are shipped with the vertical pumps.

10.2.12 Accessibility and Maintenance Requirements

The Seller's recommended accessibility and maintenance requirements for each piece of equipment shall be included in the Seller's submittal per Section 3.9.

Figure 1 HLW Remote Vessel Mounted Vertical Transfer Pumps





Notes:
1. REMOTE ASPECTS OF JUMPER CONNECTION, CRANE INSTALLATION/REMOVAL, ACME NUT FASTENING, AND ADJACENT TANK MOUNTED COMPONENTS, REQUIRE STRICT ADHERENCE TO DIMENSIONAL TOLERANCES SHOWN
2. ALL DIMENSIONS ARE APPROXIMATE. SELLER SHALL VERIFY DIMENSIONS WITH BUYER PRIOR TO FABRICATION
3. THE LIFTING LUG LOCATIONS WILL NEED TO ALTERED TO ACCOMMODATE PUMP DRIVE CONFIGURATION
4. ALL DIMENSIONS ARE IN INCHES
5. TOTAL VERTICAL HEIGHT FROM LIFTING HOOK TOP OF SADDLE TO BOTTOM OF PUMP ASSEMBLY NOT TO EXCEED 17'-7¾" DUE TO REMOVAL SPACE LIMITATIONS
6. IF DIMENSIONS ON THIS FIGURE CONFLICT WITH THE VESSEL DRAWINGS, THE VESSEL DRAWINGS ARE TO GOVERN
7.THE PUMP AND HFP PIPING MUST BE SELF DRAINING.
8. THE FITTINGS ON THE PIPE CONNECTED TO THE PUREX NOZZLE AND THE PUMP BASE MUST BE SCHEDULE 80 45 DEGREE FITTINGS AND DESIGNED TO 24590-WTP-PS02-T0002
9. THE INNER SURFACE OF THE HFP PIPING SHALL BE ELECTRO POLISHED

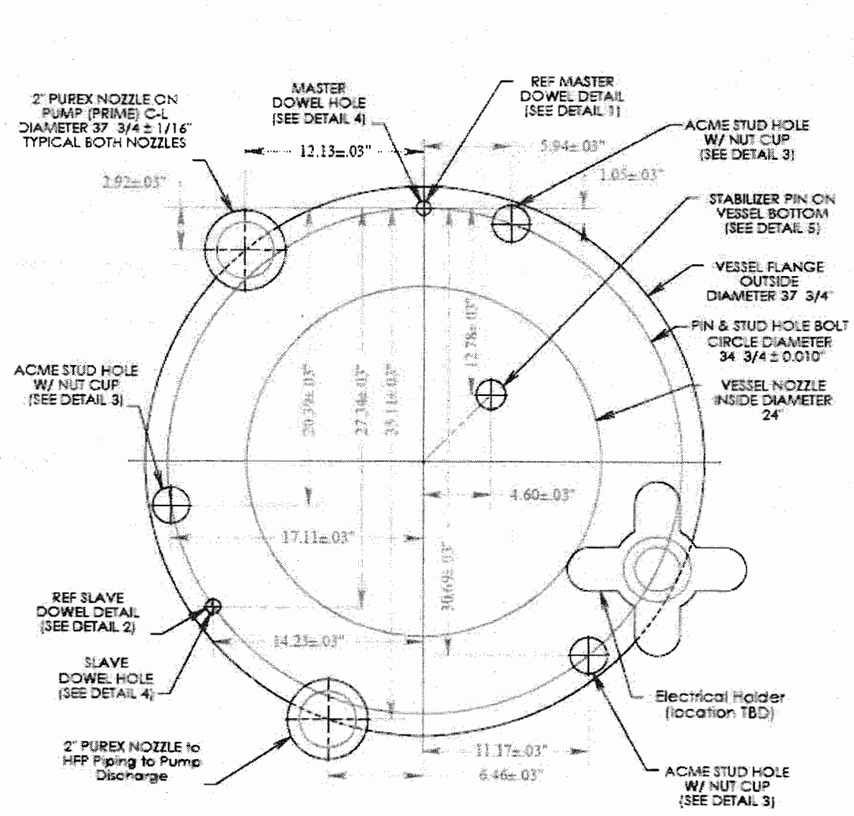
TOLERANCES ON ALL DIMENSIONS, UNLESS OTHERWISE NOTED, TO BE	DECIMALS	
ANGLES ±0° 30'	.X	± .1
FRACTIONS ± 1/8"	.XX	± .05
SURFACE FINISH 125	.XXX	± .010

Figure 2 Top View of Pump and Pump Stabilizer Pin

NOTES:

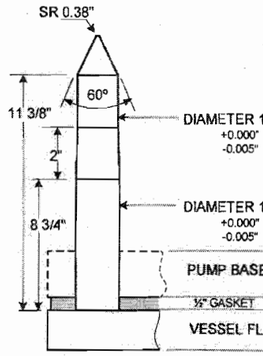
1. THE ELECTRICAL CONNECTORS AND PROCESS CONNECTORS WILL BE SUPPLIED BY THE BUYER. TOLERANCES ARE FIXED; HOWEVER, LOCATIONS FOR THESE CONNECTORS MAY BE SUBJECT TO REALIGNMENT. CONDUIT IS INSTALLED BETWEEN THE CONNECTORS AND THE MOTOR JUNCTION BOX BY SELLER.
2. ALL DIMENSIONS ARE APPROXIMATE SELLER SHALL VERIFY DIMENSIONS WITH BUYER PRIOR TO FABRICATION.
3. ACME NUT CUP TO BE SUPPLIED BY SELLER ADDITIONAL NUT RETAINERS REQUIRED FOR MOTOR REMOVAL NOT PICTURED FOR CLARITY
4. TOLERANCES SHALL BE CONTROLLED SUCH THAT THE MAXIMUM DEVIATION FROM THE MASTER DOWEL PIN TO CENTER OF DISCHARGE CONNECTOR & ELECTRICAL CONNECTOR IS < 0.010".
5. IF DIMENSIONS IN THIS FIGURE CONFLICT WITH THE VESSEL DRAWINGS, THE VESSEL DRAWINGS ARE TO GOVERN.

Attachment 2A [Top view of pump interfaces]

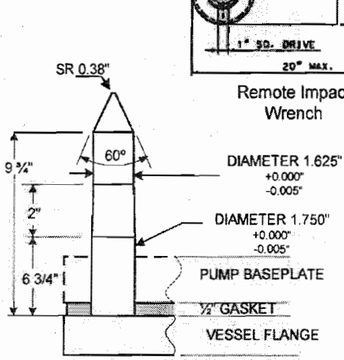


NOT TO SCALE

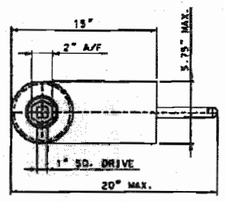
TOLERANCES ON ALL DIMENSIONS, UNLESS OTHERWISE NOTED, TO BE	DECIMALS	
ANGLES ±0° 30'	.X	± .1
FRACTIONS ± 1/8"	.XX	± .05
SURFACE FINISH 125	.XXX	± .010



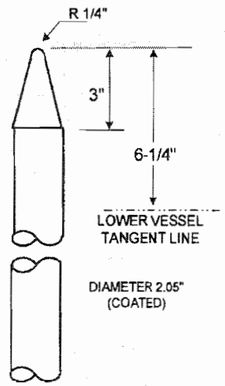
MASTER PIN
DETAIL 1



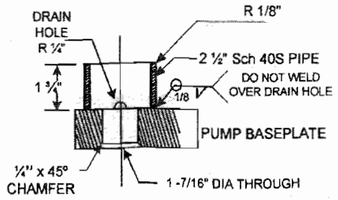
SLAVE PIN
DETAIL 2



Remote Impact Wrench



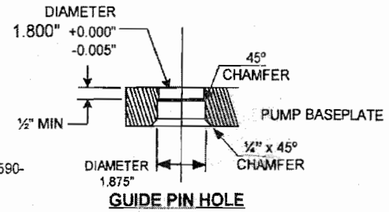
STABILIZING PIN
DETAIL 5



NUT CUP
DETAIL 3

FOR TOLERANCES SEE 24590-WTP-M0-50-00016

NOT TO SCALE



GUIDE PIN HOLE
DETAIL 4

Appendix A

Pump Operation Summary

Appendix A
Pump Operation Summary

#	Pump ID#	Pump Description	Pump Frequency [hours between batches]	Pump Duration [See Note 1) [minutes]
1	HFP-PMP-00005A	Melter 1 Feed Preparation Vessel Pump	57	100 (transfer) / recirc.
2	HFP-PMP-00005B	Melter 1 Feed Preparation Vessel Pump	57	100 (transfer) / recirc.
3	HFP-PMP-00007	Melter 1 Feed Vessel Pump	57	100 (transfer) / recirc.
4	HFP-PMP-00018A	Melter 2 Feed Preparation Vessel Pump	57	100 (transfer) / recirc.
5	HFP-PMP00018B	Melter 2 Feed Preparation Vessel Pump	57	100 (transfer) / recirc.
6	HFP-PMP-00017	Melter 2 Feed Vessel Pump	57	100 (transfer) / recirc.

Note 1: Finite times shown in this column are for batch transfers only. All pumps shown as recirc. should be designed for continuous service. All other pumps should be designed for intermittent service in addition to transfer durations shown (nom. 30 min. per day)

Appendix B

Deleted

Appendix C

Connectors

Appendix C
Connectors

1.0 General

Certain connectors shown will be supplied by the Buyer, as described in this specification and in Appendix D, and the Seller shall be responsible for incorporating the proper interfaces and locations into their final designs. The final selection of connector size and type is subject to change and shall be approved by the Buyer prior to fabrication of the pumps.

2.0 Connector Selection

2.1 Remote Process Connectors – HLW (HFP)

The remote process (discharge) and priming (eductor) connectors will be supplied by the Buyer. (Drawings of the Connectors are DOE ECI and are included in the MR.)

2.2 Remote Electrical Connectors – HLW

The remote electrical connector, or electrical lower holder, will be supplied by the Buyer. (A drawing of the electrical connector is included in the MR).

2.3 Grease-fittings shall be male Staubli RBE11 valved plugs supplied by the Seller.

Appendix D

Items Supplied by Buyer (GFP)

Appendix D
Items Supplied by Buyer (GFP)

Item No.	Description	Quantity
1	Remote electrical connectors with all required internal components. Reference Drawings provided in MR.	6
2	Mating to remote Electrical connector assembly, with all required internal components to be installed by Seller, with 30 feet of shielded 8 AWG wire (required for testing, to be assembled by Seller)	1 for each remote Electrical Lower Holder
3	*Discharge Nozzle – Reference ECI PUREX Male Connector,* 24590-WTP-M61-P23T PT7	6
4	*Prime Nozzle – Reference ECI PUREX Male Connector,* 24590-WTP-M61-P23T PT7	6
5	Deleted	
6	Deleted	
7	Hook profile, hook thickness and lift beam clearance dimensions for Seller to fabricate Lifting Beams (required for plumb lift test)	1 set for lifting lug configuration
8	Vertical Connector Assemblies (required for hydraulic testing)	2 total (1 for discharge, 1 for eductor)

Appendix E

Final Dimensional Measurements of Pumps by Seller

Appendix E
Final Dimensional Measurements of Pumps by Seller

1.0 Purpose

The Seller shall perform dimensional measurements for all vertical pumps, all nozzles, and all appurtenances at the Seller's shop. All as-built dimensions obtained thereby shall be recorded as required in Section 6.4.1 of Specification 24590-WTP-3PS-MPC0-T0009. The Seller shall give the Buyer opportunity to witness all final dimensional measurements and review all dimensional records prior to shipment.

2.0 Scope

Items Included – Seller shall furnish the following:

- Level precision floor surface or surfaces
- Instrument supports, platforms, ladders, stairs, and guardrails
- Overhead crane access, if required
- Vertical pump support stand
- Lifting beams seller provided
- Optical instruments and scales

3.0 Requirements – Shop Facilities

3.1 The Seller shall provide a measurement area for final dimensional verification. This will require approximately 30 feet of headroom to the bottom of the crane hook. A vertical pump stand with a level, flat surface matching the tolerances of the pump support plates is required for mounting pumps during dimensional check. Clear space of at least 7 feet shall be available surrounding the remote vertical pump.

3.2 The measurement area shall be temperature controlled above 70 °F. The same temperature within 5 °F shall be maintained during the dimensional measurement by the Seller.

3.3 After final Seller dimensional checks and as-built dimensional records are completed as specified in Section 6.4.1 of Specification 24590-WTP-3PS-MPC0-T0009, and prior to preparation for shipment, each remote vertical pump assembly shall be reviewed by the Buyer against this dimensional record.

3.4 The Seller shall make final dimensional measurements using their own equipment, such as calibrated jig transits, tilting levels, and calibrated and certified scales. Scales shall be graduated to 0.01 inch. The optical instruments shall be equipped with micrometers graduated to

0.001 inch. The Seller may alternatively choose to use electronic theodolites calibrated to 0.001 inch.

3.5 The vertical pump support-plate face shall be profiled at 15 ° intervals and plotted for record. All connector nozzles shall be checked at a minimum of four points for parallelism with vertical pump support-plate face.

3.6 The Seller shall allow adequate time to perform final dimensional measurement of each pump in the presence of the Buyer's representative to witness/observe the Seller's inspection activity. The Seller shall also provide appropriate notification to the Buyer for each witnessed inspection activity. The Seller has sole responsibility for quality control inspections of their products.

3.7 There shall be no visual interference (such as arc welding or equipment movement) with the optical measurements performed by the Seller.

3.8 The Seller shall provide rigid supports for optical transits and levels. These supports shall be freestanding and not touching the remote vertical pumps. Substantial platforms, ladders, stairs, and handrails shall be provided, all meeting OSHA requirements. The instrument supports shall be set up a minimum of 7 feet away from the vertical pump stand and at least 3 feet higher.

3.9 The Seller shall submit the following drawings for the Buyer's review:

a The measurement enclosure area
b The vertical pump stand
c The optical instrument supports
d Substantial platforms, ladders, and handrails
e The crane interface

3.10 The Seller shall furnish one balanced lifting beam, or one for each lifting lug configuration as necessary, for the plumb lift testing of the vertical pumps.

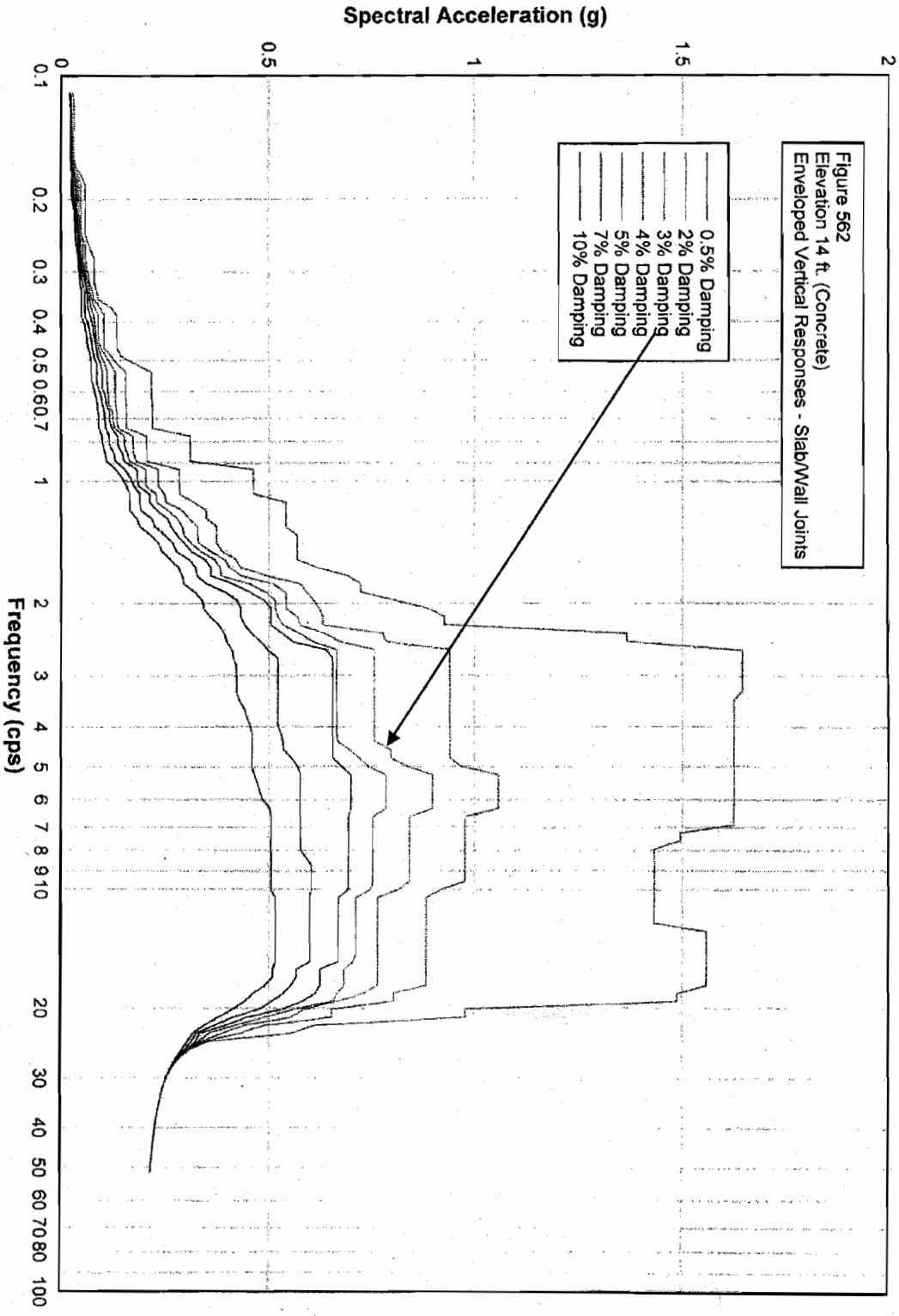
3.11 The Seller shall provide adequate lighting to facilitate the optical dimensional measurements. Lighting should generally be 100-foot candle average where measurements will be made.

Appendix F

In-Structure Response Spectra

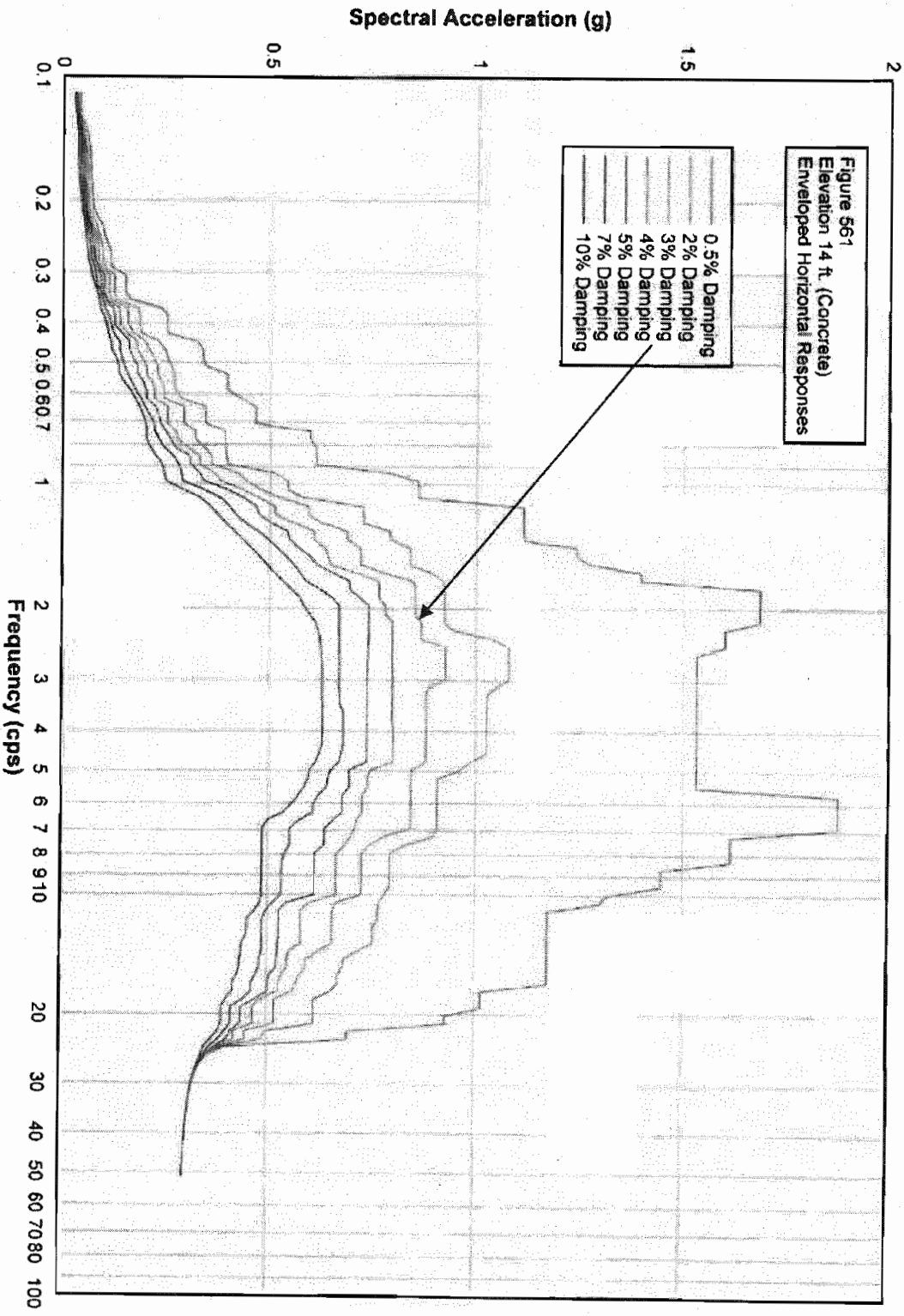
Appendix F
In-Structure Response Spectra

In-structure response spectra at the vessel support points in three orthogonal directions, as authorized in CCN 158072, are given in figures 561 and 562 on the following pages. Peak accelerations from the 3% damping curves in these response spectra (identified with arrows) will be used as seismic accelerations at vessel nozzles for the Transfer Pumps. Appropriate factors shall be used with these values in accordance with specification 24590-WTP-3PS-SS90-T0001. In addition, to account for response spectra amplification through the vessel, an extra factor of 1.5 shall be integrated into the seismic acceleration values for seismic analysis of the Transfer Pumps.



RPP-WTP HLW Vitrification Facility ISRS

Calc No.: 24590-HLW-S0C-S15T-00057, Rev. A



RPP-WTP HLW Vitrification Facility ISRS
Calc No.: 24590-HLW-S0C-S15T-00057, Rev. A

Appendix G

AISC M016 SRD Tailoring

Appendix G
AISC M016 SRD Tailoring

Appendix G-1 24590-WTP-SRD-ESH-001-02, Rev 5i, Appendix C.9

9.0 AISC M016, Manual of Steel Construction, Allowable Stress Design (ASD)

Revision: 9th Edition
Sponsoring Organization: American Institute of Steel Construction

WTP Specific Tailoring

The following tailoring of M016 is required for use by the WTP contractor as an implementing standard for design of structural steel for Seismic Category III and IV SSCs.

No specific section

The design of structural steel utilizes the requirements of the *Specification for Structural Steel Buildings Allowable Stress Design and Plastic Design, June 1, 1989 with Commentary* as found in Part 5 of the AISC M016, *Manual of Steel Construction*. The current reference for this specification is:

AISC S335-89, *Specification for Structural Steel Buildings Allowable Stress Design and Plastic Design June 1, 1989 with Commentary*.

Justification: At the time the AISC M016 Manual was first published, AISC had not assigned a publication number for the specification in Part 5. Beginning in March 2002, AISC implemented a new publication numbering system. Under this system, every AISC standard and publication was assigned a reference number. The *Specification for Structural Steel Buildings Allowable Stress Design and Plastic Design, June 1, 1989* found in Part 5 of M016 can now be referenced as AISC S335-89.

No specific section

Load combinations for design of structural steel members utilize those identified in UBC 97, Section 1612.3.

Justification: These load combinations represent the commercial requirements for allowable stress design of structural steel. Use of these load combinations will ensure compliance with the commercial design in accordance with the UBC.

No specific section

Seismic detailing requirements shall be in accordance with UBC 97, Chapter 22, Division V, Section 2214, for moderate seismic risk structures.

Justification: The requirements contained in this section contain accepted industry practice for design of important commercial steel structures. Use of this section will ensure compliance with the commercial design in accordance with the UBC.

Appendix H

ASME B31.3 SRD Tailoring

Appendix H
ASME B31.3 SRD Tailoring

Figure H-1 24590-WTP-SRD-ESH-001-02, Rev 5r, Appendix C.26

26.0 ASME B31.3-1996, Process Piping

Revision: 1996
Sponsoring Organization: ASME

WTP Specific Tailoring

The following tailoring of ASME B31.3, *Process Piping*, is required for use by the WTP contractor as an Implementing Standard for: (1) the fabrication and installation of those portions of the C5V ductwork that are being embedded in concrete, (2) the use of ASME B16.9 welding tees in accordance with ASME B31.3-2002, (3) use of vacuum box leak testing, (4) the ASME B31.3-1998, paragraph 345.2.3(c), allowance for not leak testing closure welds outside of a closed cell (black cell) and/or hard-to-reach area, (5) the test pressure that is used for piping systems subjected and designed to HPAV events, and (6) design for HPAV Detonation/Deflagration loads and associated thermal gradients.

- The tailored sections of ASME B31.3 applicable to embedded ductwork will only be utilized to the extent that it will cover the fabrication, installation, and inspection (and associated testing) of Category D fluid service piping being used as C5 ductwork. Air testing requirements for this ductwork will be compliant with ASME AG-1. Below is a description of those portions of ASME B31.3 that apply to fabrication, installation, and inspection of Category D fluid service piping and the sections of the SRD that they will apply to.
- The tailored sections of ASME B31.3 applicable to welding tees will only be used for ASME B16.9 welding tees. As long as the stress intensification factors from ASME B31.3-2002 are used in the stress analysis for the welding tees, welding tees fabricated to either the 1996 or the 2002 edition of ASME B31.3 can be used. Below is a description of those portions of ASME B31.3, Appendix D, Table D300, that apply to welding tees and the section of the SRD to which they will apply.
- The tailored paragraphs of ASME B31.3 applicable to vacuum box leak testing, in lieu of hydrostatic or pneumatic leak testing, will only be used to leak test full penetration circumferential piping field butt welds inside a closed cell (black cell) and/or hard-to-reach area as defined in Appendix M, out to the first isolation component outside the closed cell (black cell) and/or hard-to reach area. Further, if the 100 % volumetric inspection using ultrasonic examination per ASME B31.3 paragraph 344.6, is conducted for welds to be vacuum box tested, then the ultrasonic examination shall be conducted using a method that creates and maintains a reproducible computerized image(s) of the entire weld in the axial and radial direction.
- The tailored paragraphs of ASME B31.3 adopting the provisions of ASME B31.3 (c) - 1998 Addendum paragraph 345.2.3(c) are applicable to all ASME B31.3 piping in all facilities except for closure welds in closed cells (black cell) and/or hard-to-reach areas.

Figure H-1 24590-WTP-SRD-ESH-001-02, Rev 5r, Appendix C.26 (Continued)

Piping providing a confinement function in accordance with SRD 4.4-3 will comply with the following sections of ASME B31.3-1996, *Process Piping*. These sections of ASME B31.3 are applicable for embedded ductwork.

Chapter 3, Materials
Chapter 5, Fabrication
Table 341.3.2, Visual acceptance criteria for Category D fluid service piping

Justification: Due to wall thickness requirements of duct embedded in concrete, piping materials are required. ASME B31.3 will apply to materials, fabrication, and inspection standards as appropriate. Testing requirements for nuclear air treatment systems will be consistent with ASME AG-1.

Piping providing a confinement function in accordance with SRD 5.1-2 will comply with the following sections of ASME B31.3-1996, *Process Piping*. These sections of ASME B31.3 are applicable for embedded ductwork.

Chapter 3, Materials
Chapter 5, Fabrication
Table 341.3.2, Visual acceptance criteria for Category D fluid service piping

Justification: Due to wall thickness requirements of duct embedded in concrete, piping materials are required. ASME B31.3 will apply to materials, fabrication, and inspection standards as appropriate. Testing requirements for nuclear air treatment systems will be consistent with ASME AG-1.

Piping providing a confinement function in accordance with SRD 4.2-2 will comply with ASME B31.3-1996, *Process Piping*, with the following modification:

In Table D300, the description of welding tee per ASME B16.9 shall be revised so it is consistent with that shown in Table D300 of ASME B31.3-2002:

		Stress Intensification Factor [Notes (2), (3)]			
Description	**Flexibility Factor k**	**Out-of-Plane, i_o**	**In-Plane i_i**	**Flexibility Characteristic, h**	**Sketch**
Welded tee per ASME B16.9 [Notes (2), (4), (6), (11), (13)]	1	$\frac{0.9}{h^{2/3}}$	$3/4\ i_o + 1/4$	$3.1\frac{\bar{T}}{r_2}$	Same as ASME B31.3-1996

This means that for welding tees per ASME B16.9, note 11 in Table D300 is also changed to:
(11) If $r_x \geq 1/8D_b$ and $T_c \geq 1.5T_{ave}$, a flexibility characteristic of 4.4 T_{ave}/r_2 may be used.

Figure H-1 24590-WTP-SRD-ESH-001-02, Rev 5r, Appendix C.26 (Continued)

Justification: The use of a lower flexibility characteristic for welding tees per ASME B.16.9 in accordance with ASME B31.3-2002 will increase both the out-of-plane and in-plane stress intensification factors. The increased stress intensification factors will reduce the allowable out-of-plane and in-plane moments that can be applied to the welding tee and keep the calculated stress below the stresses allowable by ASME B31.3-1996.

Safety piping within the scope of SRD 4.2-2 shall comply with ASME B31.3-1996, Chapter V, Paragraph 345, using the following approach for vacuum box leak testing. Vacuum box leak testing, in lieu of hydrostatic or pneumatic leak testing, may be used to leak test full penetration circumferential piping, field butt welds inside a closed cell (black cell) and/or hard-to-reach area as defined in Appendix M, out to the first isolation component outside the closed cell (black cell) and/or hard-to-reach area, only under the following conditions:

Vacuum Box Leak Test Method - The vacuum box leak test shall be in accordance with a Bubble Test - Vacuum Box Technique method specified in ASME BPV Code, Section V, Article 10, Appendix II, subject to the requirements listed below:

(a) Sensitivity of the test shall be demonstrated to be not less than 1E-3 atm-ml/sec at 15 psig.
(b) The test pressure shall be a partial vacuum of at least 7 psi below atmosphere, applied to the outside of the weld.
(c) The required partial vacuum shall be maintained for at least 20 sec examination time.

In addition, the following limitations and restrictions shall apply to the application of vacuum box leak testing in lieu of a hydrostatic or a pneumatic leak test:

- Vacuum box leak testing will only be used to leak test circumferential piping field welds inside a closed cell (black cell) and/or hard-to-reach area (as defined in SRD Appendix M). This includes any welds in extensions of piping systems contained or originating in accessible areas between the closed cell (black cell) and/or hard-to-reach area boundary and the first isolation valve or device beyond the closed cell (black cell) and/or hard-to-reach area boundary;
- It shall only be used for piping field welds where required to avoid damage to components, ensure the safety to construction workers, perform leak tests of field welds where physical limitations prevent hydrostatic or pneumatic leak testing as prescribed in ASME B31.3-1996 paragraph 345.4 and paragraph 345.5 respectively;
- Pipe welds that are to be vacuum box leak tested will be assessed for suitability. The number of welds to be vacuum box leak tested shall be limited to a maximum of three welds between termination points (two termination or closure welds and one intermediate weld) on a given pipe system except where physical limitations prevent examination by hydrostatic or pneumatic leak testing. DOE will be informed of such exceptions, and may at its discretion and within 48 hours of being informed, respond to BNI on the suitability of the use of vacuum box leak testing for such instances. Termination points may be tanks, vessels, valves, etc. (Specifically excluded from the definition of termination points are junctions where the piping changes design class). This could be either the last two closure welds in a closed cell (black cell) and/or hard-to-reach area or the last closure weld in the closed cell (black cell) and/or hard-to-reach area and the last closure weld outside the closed cell (black cell) and/or hard-to-reach area. In addition, vacuum box leak testing would be

Figure H-1 24590-WTP-SRD-ESH-001-02, Rev 5r, Appendix C.26 (Continued)

permitted for the connection welds between construction modules if this is limited to one module-to-module weld per piping run within the cells. This is in addition to termination welds on the piping run. A module is defined as a pre-leak-tested subassembly containing multiple pipe spools;

- Vacuum box leak testing shall be limited to full penetration girth butt welds, on straight pipe or between straight pipe and pipe components of the same nominal pipe size and same wall thickness on both sides of the weld at the weld location. The following configurations are candidates for vacuum box testing:
  (a) Straight pipe to straight pipe connection butt welds
  (b) Straight pipe to 90□ elbow connection butt welds
  (c) Straight pipe to 45□ elbow connection butt welds
  (d) Straight pipe to concentric reducer connection butt welds
  (e) Straight pipe to eccentric reducer connection butt welds
  (f) Straight pipe to butt welding tee connection butt welds
  (g) Straight pipe to butt welding reduced outlet tee connection butt welds
  (h) Straight pipe to valve nozzle connection butt welds
  (i) Straight pipe to tank or vessel nozzle connection welds
  (j) Straight pipe to safe-end of a weldolet connection butt welds - full penetration butt welded connection only
  (k) Straight pipe to pipe cap connection butt welds
  Prior to the application of vacuum box testing using any of the candidate configurations on piping butt welds at the WTP, the Contractor must successfully demonstrate to the DOE, for the candidate configuration, that (1) all portions of the weld to be inspected are visible and can be inspected in accordance with the ASME Boiler and Pressure and Vessel Code, Section V, Article 10, Appendix II - 1995; (2) the vacuum box can adequately maintain a partial vacuum of 7 psid; and (3) vacuum box leak testing can be accomplished in the time limits and other requirements established by this procedure. The DOE shall be advised at least 7 days in advance of any demonstration to qualify a new weld configuration so that they can witness the demonstration. The Contractor shall document any demonstration relied upon to justify the use of vacuum box leak testing on a new configuration. Further, vacuum box leak testing shall be conducted with a vacuum box that completely encapsulates the weld, at the test location;
- All welds shall be 100 % volumetrically inspected in accordance with ASME B31.3-1996, paragraphs 344.5 or 344.6. If the 100 % volumetric inspection is conducted using ultrasonic examination per ASME B31.3-1996 paragraph 344.6, then the ultrasonic examination shall be conducted using a method that creates and maintains a reproducible computerized image(s) of the entire weld in the axial and radial direction;
- It shall be limited to welds made using the Orbital welding machines. The only exception is that vacuum leak box testing may be used on manual welds if the 100 % volumetric inspection was conducted by radiography per ASME B31.3-1996 paragraph 344.5;
- The piping systems and or components on both sides of the weld to be vacuum box leak tested shall have been subjected to a hydrostatic leak test in accordance with ASME B31.3-1996 paragraph 345.4, a pneumatic test in accordance with ASME B31.3-1996 paragraph 345.5, a combination pneumatic-hydrostatic leak test in accordance with ASME B31.3-1996 paragraph 345.6, or in the case of components, leak tested in accordance with the Code or Standard applicable to the design of the component;

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- At a minimum, a flexibility analysis in accordance with ASME B31.3-1996 paragraphs 319.4.2 (a) and (b) shall be required on any piping systems that contain welds that are to be vacuum leak box tested. In addition, a comprehensive flexibility analysis in accordance with ASME B31.3-1996 paragraphs 319.4.2 (c) and (d) shall be performed on any piping systems that contain welds that are to be vacuum box leak tested when the piping systems have a design temperature greater than or equal to 150 °F;
- For manual welds, the requirements of ASME B31.3-1996 paragraph 344.7.1 (a) through (g) shall be invoked on any weld to be vacuum box leak tested with the exception that the requirement of subparagraph 344.7.1 (e) "... aided by liquid penetrant or magnetic particle examination when specified in the engineering design" shall not be required. For welds made using Orbital welding machines, the requirements of ASME B31.3-1996 paragraph 344.7.1 (a), (b), (c), (d), and (g) shall be invoked. The requirements of 344.7.1 (e) and (f) shall not be required. The implementation of these requirements shall be documented in the weld inspection report;
- Pipe welds and the associated line numbers that are to be vacuum leak box tested shall be identified in advance of the testing. This identification shall be documented in the controlled document Weld List, which must include this information prior to the initiation of any vacuum box leak testing associated with those welds and line numbers. It is understood that the controlled document Weld List may need to be revised and updated periodically through the construction phase of the WTP Project; and
- The following special requirements shall be placed on the training programs used to certify the technicians that will be conducting the vacuum box leak tests:

  1. The BNI Construction Manager shall pre-approve the technician qualifying examination(s) for vacuum box leak testing;
  2. The BNI Construction Manager shall pre-approve the qualifications of each Level III technician preparing or giving the examinations for vacuum box leak testing;
  3. DOE ORP at their discretion shall reserve the right to observe any and/or all practical leak test examinations and review of the results of any and/or all written vacuum box leak test examinations;
  4. The minimum topical content of each Level II examination shall be specified by BNI, and approved by DOE;
  5. The 80 % correct criteria for passing the examination shall apply to each part of the three part examinations that are to be given;
  6. BNI shall provide reasonable assurance that they will take adequate measures to assure the integrity of written examination is maintained; and
  7. There shall be several versions of each examination in use to assure Level II knowledge and ability concerning vacuum box leak testing is confirmed.

Justification: The requirement for the vacuum box leak test sensitivity is consistent with the ASME B31.3 requirement for a sensitive leak test as given in ASME B31.3-1996 paragraph 345.8 and for at least 7 psi vacuum and an examination time of at least 20 seconds. The limitations in using vacuum box leak testing better define when this method can be used. DOE ORP may further change the definition and application of these special vacuum box leak testing criteria based on the Contractor's experience with their use, or the Contractor's request for a change.

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Piping system closure welds outside of a closed cell (black cell) and/or hard-to-reach area as defined in SRD Appendix M, shall comply with the requirements of ASME B31.3-1998, subparagraph 345.2.3(c). When ASME B31.3-1998, subparagraph 345.2.3(c) is invoked the following restrictions shall apply:

- It shall not be invoked on any closure welds on piping systems in a closed cell (black cell) and/or hard-to-reach area as defined in SRD Appendix M. This includes any welds in extensions of piping systems contained or originating in a closed cell (black cell) and/or hard-to-reach area, between the closed cell (black cell) and/or hard-to-reach area boundary and the first isolation valve, or device beyond the closed cell (black cell) and/or hard-to-reach area boundary;
- It shall only be invoked on full penetration butt welds in straight pipe, full penetration butt welds at the safe-end of an equipment nozzle, or full penetration butt welds at the safe-end of branch connections. [The safe-end is defined as the piping to equipment nozzle connecting weld or the branch connection to branch piping connecting welds.];
- The requirements of ASME B31.3(c) - 1998, subparagraph 345.2.3 (c) shall be met;
- The piping systems and or components on both sides of the closure weld shall have been subjected to a hydrostatic leak test in accordance with ASME B31.3-1996 paragraph 345.4, a pneumatic leak test in accordance with ASME B31.3-1996 paragraph 345.5, a combination pneumatic-hydrostatic leak test in accordance with ASME B31.3-1996 paragraph 345.6, or in the case of components leak tested in accordance with the Code or Standard applicable to the design of the component;
- For manual welds, the requirements of ASME B31.3-1996 paragraph 344.7.1 (a) through (g) shall be invoked with the exception that the requirement of subparagraph 344.7.1 (e) "...aided by liquid penetrant or magnetic particle examination when specified in the engineering design" shall not be required. For welds made using the Orbital welding machines, the requirements of ASME B31.3 - 1996 paragraph 344.7.1 (a), (b), (c), (d), and (g) shall be invoked. The implementation of these requirements shall be documented in the weld inspection report;
- Piping welds and the associated line numbers for which the closure weld classification is invoked shall be documented in a controlled document Weld List;
- Piping components may include mechanical elements other than piping; and
- In addition, BNI shall incorporate these requirements into the appropriate specification. DOE-ORP may further change the definition and application on the use of closure welds based on the Contractor's experience with their use or the Contractor's request for a change.

Justification: This change does not change the safety function of any pressure boundary components. The requirement to leak test pressure boundary field welds is primarily to ensure the reliability of the welds in addition to the reliability provided by the other required examinations. The exception allowed by ASME B31.3-1998, paragraph 345.2.3 that the final weld connecting piping systems or components which have been successfully tested in accordance with paragraph 345 need not be leak tested provided the weld is examined in-process in accordance with paragraph 344.7 (a), (b), (c), (d), and (g) and passes with 100 % radiographic examination in accordance with paragraph 344.5 or 100 % ultrasonic examination in accordance with paragraph 344.6 provides adequate assurance that the weld is reliable and leak tight. The change continues to provide adequate safety since it requires that all piping closure welds that are not leak tested are in-process examined and 100 % volumetrically examined which exceeds the requirements of ASME B31.3-1996 for closure welds that are leak tested. The inability to hydrostatically or pneumatically leak test these closure welds does not affect the soundness of the welds.

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Design for Hydrogen Detonation/Deflagration Loads and Thermal Gradients

This section provides design criteria to determine the acceptable responses of piping systems and components to occasional loads that may result from HPAV events. Piping routes that fail to meet these criteria require preventive controls. The development of such criteria is permitted by B31.3 and is, therefore, not a deviation from it.
A best-estimate design tool may be used to determine the number of cycles for defined classes of HPAV events that differ in applicable structural design considerations for their accommodation subject to the following constraints to ensure consistency with safety analysis expectations:

1. The route specific factors that affect the potential for significant quantities of combustible gases to accumulate must be considered, including the maximum expected waste characteristics (i.e., combustible gas generation rate, temperature, viscosity), the proposed configuration of the route, and the related human and equipment failure rates.
2. An ignition probability of one is to be assumed at each maximum bubble size unless a technical basis for a lower probability is submitted to DOE-ORP and receives their concurrence.
3. The design tool shall not be used to exclude limiting events such as PRC-DDT that can occur for credible gas configuration conditions.
4. A defined class of events may be designated as structurally insignificant provided the included events are shown not to affect compliance with these Appendix C, B31.3 tailoring provisions.
5. Documentation of the model must be provided including the process for its application, the defined event classes, the parameters chosen, and the results.

For HPAV events, analysis will use 100/sec strain-rate dependent stress-strain curves for austenitic stainless steels (SS 304, 304L, 316 and 316L), which are used in the construction of WTP piping systems. Strain rate dependent properties will be developed based on a literature survey of academic, National Laboratory and industry information, covering the range of experimental test data to which the material in question will be subjected in service. Specifically, the experimental data requirements shall provide:

(a) A lower-bound estimate for strength over the strain rate and temperature regime of interest,
(b) Variation of yield strength with strain-rate and temperature,
(c) Variation of the rate of strain-hardening with strain-rate,
(d) Determination of a loading path-dependence to both the quasi-static (QS) and rate-dependent yield behavior,
(e) A loading path-dependence to both the quasi-static (QS) and rate-dependent strain-hardening behavior, and
(f) Development of an equation (or mathematical model) that describes the strength properties over the regime of interest.
(g) Scaled to the ASME Boiler and Pressure Vessel Code, Section VIII, Division 2, static, room temperature true stress-true strain curve.

Events Affecting Piping Located in Black Cells or Designated as Hard-To-Reach

Deflagrations events must meet the criteria of ASME B31.3-1996, *Process Piping*, and B31.3 Code Case 178, with appropriate consideration of deflagration pressure, sustained loads, and thermal gradients.

In evaluating Code Pressure Boundary for detonation events (including deflagration to detonation [DDT]

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transitions and reflected DDTs [PRC-DDT]), the straight pipe equivalent through-wall average strain will be limited to 0.2 % plastic strain using the 100/sec strain-rate dependent stress-strain curves, finite element time-history analysis, and end-of-life wall thickness.

For bends fabricated from straight pipe, the equivalent through-wall average strain will be limited to 0.2 % plastic strain using the 100/sec strain-rate dependent stress-strain curves, finite element timehistory analysis, and end-of-life wall thickness.

Fittings (tees, elbows, reducers) manufactured in accordance with B31.3 Paragraph 303 and the standards listed in B31.3 Table 326.1 are considered to be as strong as the matching pipe, due to the burst test requirements of the standards. BNI will verify that burst test methods (in lieu of calculation methods) have been used to validate representative fitting designs.

Fatigue damage from high frequency oscillations, bar waves, thermal gradients, pressure changes, and traveling detonation waves must be evaluated.

B31.3 302.3.5 limits the sum of longitudinal stresses due to pressure, weight, and other sustained loads to S_h, the basic Code allowable at maximum temperature. Combining only longitudinal stresses, as is done in B31.3 paragraph 302.3.6, does not consider the possible combination of hoop and longitudinal (axial) effects. For highly dynamic pressures during a traveling wave detonation event, the axial and hoop effects due to pressure are not necessarily both tensile, so a departure from the normal B31.3 methods (sum of longitudinal stresses) must be made to allow for the possible combination of hoop and axial effects. Therefore, for traveling wave detonation events, the combination of hoop and axial effects must be considered without exceeding the 100/sec strain-rate dependent yield; the dynamic interaction ratio added to the dead weight interaction ratio shall not exceed 1. Since DDT and PRC-DDT events are point events, the requirement to combine hoop and axial effects does not apply.

Events Affecting Piping Not Located in Black Cells or Designated as Hard-To-Reach

Except as noted below, all HPAV requirements in the BC/HTR apply. The criteria below are limited to affected piping systems and components located in the HLW Process Cells, or in the Pretreatment facility Hot Cell and C3 area bulges that serve as extensions of the Hot Cell.

For HPAV events that are anticipated to result in a PRC-DDT, detonation, or DDT, the maximum pressure that produces a straight pipe (or 3D bend, whichever is limiting) equivalent through-wall average strain of 0.2 % plastic strain, as determined above for the BC/HTR, will be permitted to be 1.5 times higher. This results in a plastic through-wall average strain estimated to be less than 2.5 %.

Other Components

Stresses in the nozzle/vessel intersection or in the dipped line due to the traveling detonation wave loading will be combined with stresses due to normal loads (PJM operation, if applicable, thermal expansion, internal pressure, weight) and the primary results limited to 1.2 times the normal condition allowable stress for that type of stress, as permitted by the ASME Boiler and Pressure Vessel Code, Sections VIII-1 and VIII-2, for occasional loads.

Stresses in pipe supports inside BC/HTR areas under combined weight, thermal expansion, and

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detonation loading will be limited to B31.3 allowable stress (if a catalog support) or the AISC allowable stress (if a structural shape), for occasional loads.

Stresses in pipe supports outside BC/HTR areas under combined weight, thermal expansion, and detonation loading will be limited to 1.6 times the B31.3 or AISC normal condition allowable stress. The basis for the 1.6 is AISC N690, Table Q1.5.7.1 for extreme and higher loading.

In-line instrumentation, such as pressure transducers, will be shown to be acceptable up to DDT loading by limiting the maximum pressure to the maximum rated pressure of the instrumentation pressure boundary. Since these items are replaceable, i.e., there are none in Black Cells, their possible failure to function after a PRC-DDT is acceptable.

Components such as jumper connectors, valves, jet pump pairs, etc., whose function cannot be demonstrated by analysis alone may be qualified by a combination of analysis and test as follows:

1. Analyses per the criteria above as applicable for the component boundary.

2. Demonstrate other significant design aspects such as leak tightness of jumper connectors or valve operability, closure function and stem leakage by performing a bounding impulsive load test. Provide test acceptance criteria similar to those that would be used for the same functions in a seismic test.

Justification: ASME B31.3 does not address detonation pressure loading, but does permit the designer to perform detailed analysis for unusual situations, as indicated in Paragraphs 300(c)(3) and 304.7.2. The purpose of the criteria described above is to implement that provision.

Exception to B31.3 Paragraph 302.2.4

Piping subjected to HPAV events, as defined in Appendix A, Section 5.4, and designed to withstand those events without controls will be leak tested at a pressure equal to the system design pressure (from the Mechanical line list) multiplied by the applicable factors in Section 345 of ASME B31.3-1996, *Process Piping*. The HPAV pressure will be permitted to exceed the test pressure, which is an exception to Paragraph 302.2.4.

Justification: ASME B31.3 does not address highly impulsive pressure loading, and does permit the designer to perform detailed analysis for unusual situations, as indicated in Paragraph 304.7.2 for Unlisted Components. The design rules developed in Report 24590-WTP-RPT-ENG-07-011, Revision 2, ensure that the piping system will maintain pressure boundary under all conditions.

Appendix I

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