R10461947

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APP-WTP PDC

RIVER PROTECTION PROJECT – WASTE TREATMENT PLANT

ENGINEERING SPECIFICATION

FOR

WET ELECTROSTATIC PRECIPITATORS

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

ADR No.	**Rev**
24590-LAW-ADR-M-02-022	0
24590-HLW-ADR-M-03-001	1

NOTE: Contents of this document are Dangerous Waste Permit affecting.

Quality Designator
QL
DOE Contract No. DE-AC27-01RV14136

REV	DATE	REASON FOR REVISION	BY	CHECK	REVIEW	QA	APEM/DEM
5	1/26/05	Incorporate SCN No. 24590-WTP-3PN-MKE0-00002, SCN No. 24590-WTP-3PN-MKE0-00003, SCN No. 24590-WTP-3PN-MKE0-00004, SDDR No. 24590-WTP-SDDR-PROC-04-00451, SDDR No. 24590-WTP-SDDR-PROC-04-00869, SDDR No. 24590-WTP-SDDR-PROC-04-01245, SDDR No. 24590-WTP-SDDR-PROC-00063, SDDR No. 24590-WTP-SDDR-PROC-05-00064. Changes to Appendix E	M.A Seal	W. Drosjack			
4	8/21/03	Revised HLW vessel configuration, modified functional testing requirements	K. Clarke	W. Drosjack	L.Donovan/J .Pullen	G. Warner	W. Eaton
3	4/18/03	Addressed comments from external review, strengthened functional testing requirements, modified vessel design changes made in Rev 2	K. Clarke	W. Drosjack	L.Donovan/J . Pullen	G. Warner	W. Eaton
2	1/14/03	Addressed design evolution/clarification for both LAW and HLW WESP vessels	K. Clarke	W. Drosjack	N/A	G. Warner	W. Eaton
1	11/19/02	Revised Cover Sheet	K. Clarke	D. Larson	N/A	G. Warner	W. Eaton/G. Duncan
0	11/11/02	Issued for Purchase	K. Clarke	D. Larson	N/A	G. Warner	C.Winkler/ G.Duncan

SPECIFICATION No.	**Rev**
24590-WTP-3PS-MKE0-T0001	5

Contents

1 Scope 1
1.1 Project Description and Location 1
1.2 Process Description 1
1.3 Acronyms 1
1.4 Definitions 1
1.5 Work in Scope 2
1.6 Work by Others 3
2 Applicable Documents 3
2.1 Referenced Codes and Industry Standards 3
2.2 Related Documents 3
2.3 Referenced Project Documents 4
3 Design Requirements 4
3.1 Performance Requirements 4
3.2 General Design Requirements 5
3.3 Vessel Design Requirements 5
3.4 Vessel Internal SSC Design Requirements 6
3.5 Design Requirements for Ease of Maintenance 7
3.6 Electrical Requirements 9
3.7 Control and Instrumentation Requirements 9
4 Materials 9
5 Fabrication 9
5.1 General 9
5.2 Welding Requirements 10
5.3 Nameplates and Markings 10
6 Tests And Inspections 10
6.1 Shop Testing 10
6.2 Site Performance Testing 11
7 Packaging, Shipping, Handling, And Storage Requirements 12
7.1 General 12
7.2 Vessels and other Equipment 12
8 Field Support 12
8.1 Training 12
8.2 Installation and Startup Support 12
9 Quality Assurance 13
10 Documentation and Submittals 13

10.1 General 13
10.2 Additional Submittals 13

Appendices

Appendix A General Design Data ..... A-i
Appendix B LAW WESP Design Data ..... B-i
Appendix C HLW WESP Design Data ..... C-i
Appendix D Engineering Information Data Sheet ..... D-i
Appendix E Figures ..... E-i

Please note that source, special nuclear, and byproduct materials, as defined in the Atomic Energy Act of 1954 (AEA) are regulated at the U. S. Department of Energy (DOE) facilities exclusively by DOE acting pursuant to its AEA authority. DOE asserts that pursuant to AEA, it has sole and exclusive responsibility and authority to regulate source, special nuclear, and byproduct materials at DOE-owned nuclear facilities. Information contained herein on radionuclides is provided for process description purposes only.

1 Scope

This specification covers the design, fabrication, documentation, testing, and delivery of wet electrostatic precipitators (WESPs) for hazardous waste vitrification (melter) offgas systems. The scope includes four (4) precipitator systems consisting of pressure vessels with internal precipitator components, power supplies and cable, system controls and instrumentation, and utility/service design. There are two precipitator system designs.

1.1 Project Description and Location

The Buyer has entered into a contract with the US Department of Energy for pretreatment and vitrification of waste stored in underground tanks at the Hanford Site in southeast Washington State. The contract specifies that the Department of Energy will retrieve and transfer low-activity and high-level (radioactive) waste to the River Protection Project - Waste Treatment Plant facilities designed, built, and commissioned by the Buyer for pretreatment and vitrification. The Buyer will return the vitrified waste products, intermediate waste products, and secondary wastes to the Department of Energy for interim storage and disposal.

1.2 Process Description

Vitrification of low-activity and high-level waste will be performed using joule-heated melters. Melter offgas will be generated by converting a slurry of radioactive waste and glass formers into molten glass. The vitrification process offgas will consist primarily of air and steam with acid gases and entrained particles. Under normal conditions, offgas leaving the melter will be mixed with air and steam and routed to a submerged bed scrubbing column. Within the submerged bed scrubber, the gas will be quenched while bubbling through packing submerged in water. Condensation will occur, most particles greater than 1μm will be removed, and some acids gases will be absorbed. The offgas will then be directed to the wet electrostatic precipitator for further particulate removal. The offgas system will operate under negative pressure.

The low-activity waste melter offgas systems are depicted on Refs. 2.3.B.1 through 2.3.B.3. The high-level waste melter offgas system is depicted on Refs. 2.3.B.4 through 2.3.B.9.

1.3 Acronyms

HLW	High-Level Waste
ICN	Integrated Control Network
LAW	Low-Activity Waste
PCS	Process Control System
RTD	Resistance-Temperature Device
SSC	System, Structure, and Component
WESP	Wet Electrostatic Precipitator

1.4 Definitions

Buyer	Bechtel National, Inc
Collecting Surface (also known as a collecting electrode)	Surface(s) on which negatively charged particles deposit or collect.
Discharge Electrode	Part that is installed in a high-voltage system to perform the function of charging gas particulate and/or creating an electrostatic field.
Insulator	Device used to physically support and electrically isolate the high-voltage WESP internals.

Owner	Department of Energy
Shall	Indicates a mandatory requirement in order to comply.
Supplier	Primary Seller of the deliverable items (including subcontractors).
Power Supply	Unit used to convert normal service voltage to a high-voltage/high-frequency dc supply.
WESP	The wet electrostatic precipitator, or precipitator, is a complete assembly of mechanical, electrical, control, and structural components for vitrification offgas particulate abatement.

1.5 Work in Scope

A Provide design, fabrication, documentation, and delivery of the following:
1 LAW WESPs complete with appurtenances, quantity per the material requisition.
2 HLW WESPs complete with appurtenances, quantity per the material requisition.

B Major WESP SSCs include:
1 Precipitator vessels with required nozzles.
2 Vessel structural support skirts, mounting rings and anchor chairs.
3 Collecting surfaces and supports.
4 Discharge electrodes and supports.
5 Offgas distribution plates or screens (as required).
6 Vessel internal flush/mist water piping and distribution manifolding (as required).
7 Air purge supply systems internal to the precipitator equipment (as required).
8 High-voltage insulator systems including housings, leads and bushings.
9 Power supplies including ancillary equipment (See Ref. 2.3.A.2).
10 All system controls and control execution requirements for Buyer's design and implementation into the ICN and PCS (see Ref. 2.3.A.2).

C Other work included:
1 Design and supply of high-voltage cable and terminations between power supplies and vessels.
2 Process and instrumentation design support for all required services/utilities from Buyer's supply headers.
3 Furnishing Buyer installation and testing parts:
a Six (6) sets of reusable gaskets for all manways/inspection ports, vessel heads and blinded openings on LAW vessels only: three sets for testing and shipment; and three sets unused, tagged, and shipped separately with the vessel.
b Three (3) sets of reusable gaskets for all HLW manways/inspection ports and blinded openings on HLW vessels only.
c One (1) gasket for each HLW vessel head.
d Ten percent fasteners for manways/inspection ports, vessel heads, and other blinds, for all vessels.
e One set of insulators for LAW WESPs.
f One set of insulators for HLW WESPs.
4 Shop testing as outlined in section 6.
5 Special Tools: Two (2) complete sets of all special equipment, tools, and/or other components required for installation and/or maintenance of the system. One set will be for LAW and one set will be for HLW.
6 Shim packs for HLW vessels only. See section 3.3.C.4 and Appendix E, Figure 3.
7 Under a separate contract, technical support for WESP system installation, startup and testing at the site.
8 Under a separate contract, technical support for training Owner's operating personnel, including training, operating, and maintenance manuals, and other applicable training material.

1.6 Work by Others

Buyer will be responsible for the following:

A Services, Utilities, and Controls:
1 All raceway, cabling, and connections to the WESP equipment outside of the Seller's scope of work, including the supply, routing and installation of high-voltage cable and fiber-optic communication cable, from the WESP controls to the ICN.
2 Supply of raceway from high-voltage cable between the power supply and vessel.
3 Routing and installation of raceway, high-voltage cable, and terminations between the power supply and vessel.
4 Supply, routing and installation of services and utilities (including instrumentation) to, and between, WESP system components, including water and air services, and level detection instrumentation.
5 Misting spray systems installed in offgas lines upstream of vessels.
6 Supply and routing of vessel drain discharge lines.
7 Connections from Seller's equipment to Buyer's grounding grid.
8 Motor control centers.
9 ICN communication system, including control platform and architecture.
10 PCS operating system.
11 Programming and configuration of the control's graphic display(s) and process flow diagrams into the PCS.

B Mechanical and Structural:
1 Equipment locations and dimensional constraints.
2 Structural supports, foundations, embeds, leveling channels and enclosures (to be coordinated with Seller).
3 Structural access platforms (to be coordinated with Seller).
4 Piping design and routing.
5 Bolts, nuts, gaskets at interfaces to Buyer-supplied equipment and structures.

C Other Work Provided by Buyer:
1 Job site material receiving, storage, and field installation of Seller's equipment.
2 Overhead maintenance crane(s).
3 Standard maintenance tool sets.
4 Site testing.

2 Applicable Documents

2.1 Referenced Codes and Industry Standards

National Fire Protection Association (NFPA) – NFPA 70 (1999), National Electrical Code, Article 250, Grounding

2.2 Related Documents

Other project specifications, standards, and standard details as listed or referenced in section 2 of the material requisition shall be used as applicable for the design and fabrication of the WESPs.

2.3 Referenced Project Documents

A Specifications:

1 24590-WTP-3PS-MV00-T0001, Engineering Specification for Pressure Vessel Design and Fabrication.

2 24590-WTP-3PS-EVR2-T0001, Engineering Specification for Wet Electrostatic Precipitator (WESP) Power Supply.

3 24590-WTP-3PS-G000-T0003, General Specification for Packaging, Shipping, Handling, and Storage Requirements.

4 24590-WTP-3PS-JQ07-T0001, Engineering Specification for Instrumentation for Package Systems.

5 24590-WTP-3PS-G000-T0001, General Specification for Supplier Quality Assurance Program Requirements.

6 24590-WTP-3PS-MV00-T0002, Engineering Specification for Seismic Qualification Criteria for Pressure Vessels.

7 24590-WTP-3PS-FB01-T0001, Engineering Specification for Structural Design Loads for Seismic Category III & IV Equipment and Tanks.

B Drawings:

1 24590-LAW-M6-LOP-00001, P&ID – LAW Primary Offgas Process System, Melter 1.

2 24590-LAW-M6-LOP-00002, P&ID – LAW Primary Offgas Process System, Melter 2.

3 24590-LAW-M6-LVP-00001, P&ID – LAW Secondary Offgas/Vessel Vent Process System, Melters Secondary Offgas.

4 24590-HLW-M6-HOP-00001, P&ID – HLW Melter Offgas System – Melter 1 – Primary Offgas Scrubber.

5 24590-HLW-M6-HOP-20001, P&ID – HLW Melter Offgas System – Melter 2 – Primary Offgas Scubber.

6 24590-HLW-M6-HOP-00002, P&ID – HLW Melter Offgas System – Melter 1 – Primary Offgas WESP.

7 24590-HLW-M6-HOP-20002, P&ID – HLW Melter Offgas System – Melter 2 – Primary Offgas WESP.

8 24590-HLW-M6-HOP-00003, P&ID – HLW Melter Offgas System – Melter 1 – Secondary Offgas Treatment Sheet 1 of 2.

9 24590-HLW-M6-HOP-20003, P&ID – HLW Melter Offgas System – Melter 2 – Secondary Offgas Treatment Sheet 1 of 2.

10 24590-WTP-MV-M59T-00026, Anchor Bolt Chair Details for Vertical Vessels

11 24590-WTP-PW-P30T-00001, WTP End Prep Detail for Field Butt Welds

3 Design Requirements

3.1 Performance Requirements

A The LAW and HLW vitrification facilities are expected to operate for approximately 40 years. Furnish WESPs for both facilities that comply with the following:

1 The general design criteria in Appendix A.

2 The operating conditions for LAW and HLW in Appendices B and C, respectively.

3 The performance/design requirements for LAW and HLW in Appendices B and C, respectively.

4 The availability requirements for LAW and HLW in Appendices B and C, respectively.

3.2 General Design Requirements

A Each WESP shall be stand-alone and have the capability to handle the design offgas flow from the melter and submerged bed scrubber, as well as purge air (if used) introduced at the WESP.

B Design WESP vessel and insulator housings to confine offgases and to undergo no structural or functional damage during temperature or pressure excursions.

C Seller shall consider the following during WESP design: For both LAW and HLW WESPs, the power supply and the precipitator vessel will be located in different rooms. See Ref. 2.3.A.2 for approximate cable lengths between proposed power supply locations and vessels.

D Provide completed data sheet in Appendix D.

E Seller shall ensure that SSCs common to each LAW WESP are identical in design and from the same supplier/manufacturer. Seller shall also ensure the same for the HLW vessel/precipitator design.

F All WESP internals for both LAW and HLW systems shall be commercial grade except for the vessels, and any other component or nozzle connection affecting the offgas confinement function of the vessels within Seller's scope. See section 9 of this specification for specific quality assurance requirements pertaining to vessels and vessel internals. Reference 2.3.A.2 for power supply requirements.

3.3 Vessel Design Requirements

A General:

1 The pressure vessels for all WESPs shall be designed and fabricated in accordance with Ref. 2.3A.1 and any additional requirements defined in this specification. Notify Buyer for resolution of any requirement conflicts.

2 Seismic Analysis: All vessels and power supplies shall be designed per Seismic Category (SC) III requirements. See Ref. 2.3.A.7 for SC-III definitions and design requirements. See Ref. 2.3.A.6 for general seismic qualification criteria.

3 Fatigue Analysis: See Appendix A for fatigue analysis requirements.

4 Other Loadings: See Appendices B and C for additional LAW and HLW vessel loadings, respectively.

B LAW Precipitator Vessels:

1 Vessels shall be floor mounted.

2 Vessels shall be designed to fit within the physical envelope defined in Figures 1 and 2 of Appendix E.

3 Vessel structural support shall consist of a skirt and foot plate with weep holes and access for visual inspection. Provide eight (8) anchor bolt "chairs" around the base of the skirt, equally spaced and straddling the vessel centerline. Details of the chairs to be used, Type 2a, are shown in Ref. 2.3.B.10.

4 Orient known required nozzles as shown in Figure 1 of Appendix E. Coordinate with Buyer to determine final nozzle elevations.

5 Vessels shall have flanged removable top heads to access internal components for maintenance. Heads may be flat, dished, or elliptical.

6 Design vessel head to minimize impact to adjacent insulators and associated housings during handling.

7 Design head/vessel mating interface to retain seal integrity after the head has been removed and replaced.

8 Design vessel head to be lifted and moved by a bridge crane with a standard C-hook.

9 Service penetrations through the top vessel heads are not permitted.

10 Connections to components that are not consumables or not removable shall be welded or otherwise made permanent.

C HLW Precipitator Vessels:

1 Vessel shall be floor mounted.

2 Vessels shall be designed to fit within the physical envelope defined in Figures 3 and 4 of Appendix E.

3 Vessel structural support shall consist of a skirt and foot plate with weep holes and access for visual inspection. Provide eight (8) anchor bolt "chairs" around the base of the skirt, equally spaced and

straddling the vessel centerline. Details of the chairs to be used, Types 2a thru 2f, are shown in Ref. 2.3.B.10. Coordinate with Buyer to finalize chair orientation and tolerances.

4 For each anchor bolt chair, provide a shim pack consisting of the following 10" square stainless steel plates:
   a 2 each 1/4" thick plates.
   b 1 each 1/8" thick plate.
   c 2 each 1/16" thick plates.

5 Orient known required nozzles as shown in Figure 4 of Appendix E. Coordinate with Buyer to determine final nozzle elevations.

6 Vessels shall have flanged removable top heads. Heads may be flat, dished, or elliptical

7 Design vessel head to minimize impact to adjacent insulators and associated housings during installation handling.

8 Design head/vessel mating interface to retain seal integrity after the head has been placed at installation in accordance with Seller's written instructions.

9 Design vessel head to be lifted and moved by a crane with a standard C-hook.

10 Service penetrations through the top vessel heads are not permitted.

11 Connections to components that are not consumables or not removable shall be welded or otherwise made permanent.

12 If a manway/inspection port is required for final alignment of electrodes before hot startup, design nozzle flange and blind flange plate to be seal welded by Buyer after completion of non-radioactive testing.

3.4 Vessel Internal SSC Design Requirements

A General:

1 Vessel internal SSC design shall account for thermal expansion, and simplify fabrication and maintenance requirements to the extent possible.

2 Design vessel internal SSCs to minimize the occurrence of dead gas pockets or areas where particulate or liquid might tend to accumulate.

3 Vessel internal SSCs not affecting the offgas confinement function of the vessels do not need to be seismically qualified.

4 LAW vessel internal SSCs shall be designed to be removable/replaceable if the Seller cannot guarantee zero maintenance for the life of the facility.

5 HLW vessels and their internal SSCs, excluding the insulators, will not be accessible after hot (radioactive) startup of the offgas systems. The internal SSCs will be designed for zero maintenance for the life of the facility.

B Insulators:

1 Insulators shall be ceramic, with a minimum alumina concentration of 97 percent.

2 Insulator enclosures and internal buses shall be designed with suitable internal surfaces and electrical clearances to prevent arcing.

C Collecting Surfaces:

1 Given the vessel envelope constraints, furnish the required collection surface area to meet the performance requirements in Appendices B and C.

2 Buyer prefers round pipes for ease of cleaning. Plate-type collection surfaces are not acceptable.

3 The design shall provide the means of maintaining the parallel alignment of adjacent collection surfaces after installation. Seller shall ensure that internal assemblies cannot be bent, buckled, or distorted prior to startup by following prescribed handling procedures.

4 The design shall prevent offgas from bypassing collection zones.

D Discharge Electrodes:

1 Furnish mechanically stable discharge electrodes of rigid construction or supported in a rigid frame. Use of weighted, hung, non-rigid discharge electrodes is not acceptable.

2 Discharge electrodes and collecting surfaces shall be plumb. The design and fabrication of discharge electrodes and collecting surfaces shall be such that the required alignment can be preserved after installation while permitting the necessary thermal expansion without warping.

3 The high-voltage support system and rigid discharge electrode design shall prevent swaying or movement of the electrodes at the design flow rates shown in Appendices B and C.

E Offgas Distribution:

1 The inlet air distribution system shall be such that the offgas shall pass across each collecting surface uniformly.

2 If possible, it is preferred that the Seller use a design that does not use perforated plate(s) or screen(s).

F Cleaning/Flushing:

1 Seller shall provide water flushing systems to periodically wash solids from the collecting surfaces, discharge electrodes, and internal vessel surfaces to prevent solids buildup that would impair operation or collection efficiency. Provide top and bottom flushing systems in each HLW vessel as depicted in Ref. 2.3.B.6 and 7. Provide only a top flushing system in each LAW vessel. Recirculating systems are not acceptable.

2 Seller shall provide misting capabilities in the LAW vessels but not in the HLW vessels. Seller shall coordinate with Buyer to determine final misting requirements.

3 Periodic flushing, continuous misting spray nozzles, or other industry standard forms of washing are acceptable.

4 Water use for WESP operation/cleaning shall be minimized. Seller shall limit water consumption to 500 gallons per day for misting applications (if used) and 500 gallons per day for flushing.

5 Minimize WESP downtime during flushing. Misting applications shall not affect normal WESP operations.

6 Design consideration shall be given to minimizing blockages in nozzle discharge orifices and eliminating uncontrolled drips.

7 The spray headers shall not act as a ground for arcing.

8 The water quality and supply pressure will be as identified in Appendix A, unless otherwise recommended, and justified by the Seller.

9 Buyer may fill the vessel with decontamination solutions (HLW only) or hot or cold water for soaks/washes after hot startup, but only during offgas system shutdowns. Buyer intends to utilize the flush water systems to introduce the cleaning mediums. Seller shall consider and advise Buyer of design impacts to vessels and vessel internals.

G Purge Air:

1 Provide purge air around electrical components (such as the insulators) to reduce particulate buildup, salt scaling, and condensation, and to prevent arcing.

2 Specify temperature and flowrate requirements for the system. The air supply quality will be as identified in Appendix A, unless otherwise recommended, and justified by the Seller.

3 Minimize the amount of air used to the extent practical.

3.5 Design Requirements for Ease of Maintenance

A General:

1 The LAW and HLW vitrification facilities are expected to operate for 40 years. Seller shall consider this operational duration in the design of all components, including those to be removed/replaced and/or upgraded over the operational life of the facility.

2 Component design shall be modularized and/or designed to facilitate ease of component replacement, repair, or upgrade wherever practical. Submit a modularization plan for review and approval.

3 Seller shall ensure that component design accounts for the planned maintenance frequencies for LAW and HLW WESP SSCs defined in Appendices B and C, respectively.

4 WESP components designed to be removed/replaced, weighing more than 20 lb, shall be equipped with lifting attachments for use with a C-hook. Mount lifting attachments to minimize rotation/swinging during handling.

5 Seller shall ensure that WESP components designed to be removed/replaced will not damage adjacent SSCs when properly handled.

6 If required, provide two sets of specialty lifting devices (spreader bars, yokes, etc.) to interface with Buyer's crane and C-hook for WESP component handling: one set for LAW WESPs, and the other for HLW WESPs.

B Design WESP SSCs for the following access restrictions:

1 Electrical and Control Equipment: Access to electrical and system control equipment external to the vessel rooms, for both LAW and HLW WESPs, will be unrestricted.

2 HLW vessels:

a Vessels and internal components, excluding top insulator housing covers and the insulators themselves (via the top insulator housing covers), will not be accessible after hot startup. Access to the insulators will be possible only when the associated melter has been deactivated, or is not processing feed, and the offgas system flushed to bring radiation and contamination to safe levels.

b After vessel and vessel internals have been installed and the surrounding structure completed, intact removal and replacement of vessel internals will not be possible due to spatial constraints and radiation contamination.

c If additional alignment of vessel internals is required after installation and prior to hot startup, Seller must provide adequate access through suitably located manway/access ports in the vessel.

d Buyer will provide temporary access platforms around vessels during installation and cold (non-radioactive) startup, as required.

3 LAW vessels:

a After hot startup, vessel access (both internal and external) will be possible only when the associated melter has been deactivated, or is not processing feed, and the offgas system flushed to bring radiation and contamination to safe levels.

b Personnel accessing the vessels after hot startup will be in multilayered personal protective equipment and on supplied air systems.

c Buyer, in coordination with Seller, will provide structural platforms around the vessels to access insulator housings and head flange bolting.

d Buyer will provide access hatches through the floor, centered over each vessel, for removing/ replacing internal SSCs. The access hatches will be 11'-0" square.

e The corridor above the vessel rooms will be served by a bridge crane with a capacity of at least 20 tons. The crane, with C-hook, will be able to pick and place equipment in the vessel rooms through the access hatches. The corridor may be used to reassemble pressure vessel internals and other components if necessary.

C Other LAW Vessel Design Requirements:

1 LAW pressure vessel design shall consider personnel access requirements for replacing and aligning internal components after both cold and hot startup of the offgas systems. No personnel access via the manway/inspection ports will be permitted after hot startup. However, manual or remote operated tools may be inserted if required.

2 For LAW pressure vessel design, Seller shall consider ease of maintenance when determining vessel head bolting/fastener configuration. Coordinate with Buyer to finalize configurations.

3.6 Electrical Requirements

A Provide power supplies and associated high-voltage cable and terminations for each WESP accordance with Ref. 2.3.A.2. Depending on the final termination housing configuration, Buyer may provide load support via the building structure.

B Vessel Grounding: Furnish at least two (2) grounding connections on opposite sides of the vessel skirt, including pads with terminal lugs for #4/0 AWG ground wire, for interface with Buyer's grounding system in accordance with Ref. 2.1.A. All flanges shall be electrically bonded either by a welded or a bolted stainless steel jumper in a minimum of two locations.

3.7 Control and Instrumentation Requirements

A Controls:

1 Provide complete dedicated power and process controls (both hardware and software), for each WESP, in accordance with Ref. 2.3.A.2.

2 System controls shall include, but not be limited to, the following:

a Power supply with voltage control.
b Deleted
c Power supply cooling control (if required).
d Deleted
e Alarms and interlocks.

3 Control logic and application software for the WESP shall reside in Seller's control system.

4 Controls for the WESP shall be Seller-configured and programmed for Buyer's monitoring, auto-start, and stop, and any control signal interfaces from the Buyer's ICN PCS.

5 Buyer recognizes that Seller may have a standard control system with proprietary hardware and software. See Ref. 2.3.A.4 for integration of Seller's proprietary components with Buyer's ICN.

B Process and Instrumentation Design:

1 See Ref. 2.3.A.4 for packaged system instrumentation design requirements.

2 From Buyer's supply headers, coordinate with Buyer to provide complete designs of all process services and associated instrumentation for each WESP.

3 Process service and instrumentation design support shall include, but not be limited to:

a Purge air (as required).
b Water flushing/misting washing (as required).
c Cooling (as required).

4 Materials

See Appendix A for required/acceptable materials for WESP vessels, wetted internal components, nonwetted components, and structural steel. See Ref. 2.3.A.2 for power supply and control equipment requirements.

5 Fabrication

5.1 General

A Vessels: Fabrication of vessels and structural attachments shall conform with Ref. 2.3.A.1.

B Other WESP Components: Fabrication of WESP components other than vessels, nozzles, and welded structural components shall be per the Supplier's and/or industry standards for the intended service.

5.2 Welding Requirements

A Vessels: Welding requirements for vessels, nozzles, and structural attachments shall conform with Ref. 2.3.A.1.

B Other WESP components: Welding requirements for internal WESP components shall be per industry standards for the intended service.

C Nondestructive examination of vessels and structural attachments shall be in accordance with Ref. 2.3.A.1 with exceptions noted in Appendix A.

5.3 Nameplates and Markings

A Provide corrosion-resistant danger signs at all points of high voltage, reading: "DANGER - HIGH VOLTAGE".

B Provide additional nameplates and equipment tagging in accordance with the Purchase Order.

6 Tests And Inspections

6.1 Shop Testing

A Vessels, including nozzles, structural attachments, and any other component affecting the containment function of the WESP, shall be tested in accordance with the requirements of Ref. 2.3.A.1.

B Perform a hydrostatic test in accordance with Ref. 2.3.A.1.

C Power supplies and control equipment shall be tested in accordance with the requirements of Ref. 2.3.A.2.

D Load Tests: Lifting lugs on vessel internals shall be proof load tested at 125 percent (minimum) of the measured dry weight of the components. Also provide applicable test certification for lifting devices.

1 Deleted
2 Deleted
3 Deleted

E Prior to shipment, Seller shall assemble and operate each WESP to verify complete system functionality, including flush/mist water systems, purge air systems, insulators and electrodes, power supplies, electrical controls, and instrumentation. Seller shall be responsible for providing the following equipment and services:

1 High-voltage cable (with terminations) similar to the maximum designed length and configuration.
2 Source for flush/mist water purge. Water quality as referenced in Appendix A.
3 Source for purge air. Air quality as referenced in Appendix A.
4 Atomized spray mimicking the offgas. May be an air stream saturated with salt-laden water vapor. Flow rates as shown in Appendices B and C.
5 Test and control instrumentation as required.
6 Structural supports as required.

F Seller shall perform one (1) successful functional test on each WESP with no system malfunctions. The test shall include a four day run (96 hour test) using the saturated air stream (includes restart after flushing) and additional system checks conducted before or after the run. Each test shall be fully documented with photographs. During the test the Seller will perform the following:

1 Perform vessel flushing, utilizing no more than 500 gallons of water for each flush, once after 48 hours of operation and once after 96 hours of operation. Prior to and after the 48 hour flushing, an inspection shall be performed of the vessel internals (lower portions only after 48 hour flush), and documented with photographs. Successful operation will be determined by the Buyer, based on test data, visual

observation, and documented evidence of particulate build-up on the vessel internals. No water pooling deeper than 1/4" on internal surfaces is allowed. After the flushing cycle is complete document the time required to return to operation at normal voltage.

2 For LAW WESPs, the internal misting nozzles may be operated during the 96 hour test..

3 Measure pressure differential relative to gas flow across vessel (between gas inlet and gas outlet) roughly every hour for the duration of the continuous run, excluding flush cycle and system restart.

4 Monitor spark rate for the duration of the 96 hour test. Successful operation shall be defined by no electrical shorting beyond the expected normal spark rate. In addition, determine the voltage at which abnormal/excessive sparking begins to occur.

5 Monitor power supply voltage, current, and power consumption for the duration of the 96 hour test.

6 Provide the Seller-determined flowrate of purge air to each insulator housing during the 96 hour test. After the 96 hour test, confirm that the insulators are free of any visible signs of particulate and water buildup.

7 Either before or after each 96 hour test, Seller shall operate the misting system (LAW only) and the flushing system(s) long enough to verify by visual means that water distribution is even over the cross-section of the vessel. For the misting system, verify coverage using not more than 25 gallons per hour. For the flushing system(s), verify coverage using not more than 100 gallons per minute.

8 Either before or after the 96 hour test, Seller shall confirm even gas distribution through approximately 20 to 30 collecting tubes for one LAW WESP and one HLW WESP, using a method to be agreed upon with the Buyer. Gas distribution shall be confirmed using nominal offgas flow for LAW as shown in Appendix B and maximum design offgas flows for HLW shown in Appendix C. Acceptable distribution must be proved via use of the WESP flow data and relationship to efficiencies shown in Appendix B and Appendix C and verified by Buyer. Any physical modifications to the internals required to successfully pass the tests shall also be completed on the similar untested vessel(s).

Provide two weeks advance notice to Buyer prior to conducting tests. After conclusion of each test, Seller shall disassemble, dry, and clean equipment in preparation for shipment.

G Buyer shall have access to all testing records. Furnish a copy of all certified test data and test results, whether witnessed or not.

6.2 Site Performance Testing

A Under a separate contract and prior to site testing, Seller shall conduct a thorough inspection with Buyer to ensure that each WESP has been installed in accordance with Seller's drawings and instructions. Notify Buyer of any deficiencies.

B Under a separate contract and prior to conducting installation inspections, advise Buyer on the specific inspections to be carried out, and the advance notice required for performing the inspections.

C Buyer will conduct performance testing on each installed melter offgas system (WESP included) to demonstrate operational and performance guarantees. All testing will be conducted before placing the systems into radioactive service.

D Testing will demonstrate operability of the WESP under various melter offgas operational conditions. The WESP must operate in compliance with Seller's performance guarantees and expected performance capabilities.

E All Seller-supplied systems and components will be utilized during testing.

F Buyer will notify Seller a minimum of one month prior to start of testing. Buyer will also inform Seller of test scope.

G Seller shall coordinate with Buyer to develop recommended WESP system test procedures to be used in conjunction with the test procedures for the overall offgas system.

H Seller shall provide a list of specialty equipment for component testing, tuning, checkout, and maintenance, based on Buyer's test scope.

I As required, Seller shall provide appropriate hardware, software, and support services to perform integration testing of the control portion of the WESP with the ICN.

J Data accumulated during testing shall be measured and recorded by Buyer, with Seller assistance as required.

K During testing, Seller shall document problems uncovered; assess root causes; and present findings, recommendations, and courses of action, which shall be reviewed in consultation with Buyer, prior to implementing any and all repairs/modifications. A complete written report shall be provided to Buyer.

L Remedial actions required to correct deficiencies uncovered in Seller's equipment during performance testing shall be made by Seller at his expense. Modifications shall be performed only after receipt of written approval by Buyer. Depending on the extent of the modifications, the performance testing will be repeated, and applicable costs involved with the repeat testing of the WESP shall be borne by Seller.

7 Packaging, Shipping, Handling, And Storage Requirements

7.1 General

General Requirements: Seller shall adhere to Ref. 2.3.A.3 for general packaging, shipping, handling, and storage requirements for all WESP components.

7.2 Vessels and other Equipment

A Vessels: In addition to the general requirements in Ref. 2.3.A.1, prepare vessels for shipment in accordance with Ref. 2.3.A.3.

B Clearly mark lifting points.

C Install shipping stops, bolts, ties, etc., in all devices prior to shipment.

D Match mark and package components to provide for rapid and accurate site installation.

E Seller shall ensure that the alignment and shape of discharge electrodes and collecting surfaces can be maintained and/or properly realigned prior to installation per Seller's handling instructions.

8 Field Support

8.1 Training

Under a separate contract, Seller shall provide operations and maintenance training to Owner's representatives at the site (five working days total), including provision of operating and maintenance manuals and other applicable training materials.

8.2 Installation and Startup Support

A Under a separate contract, Seller shall provide technically competent personnel, including representatives of sub-sellers, to advise and consult during installation, startup, testing, and commissioning.

B Seller shall provide the following to facilitate field installation in a timely and efficient manner:

1 Installation procedure describing sequence of installation and tolerances backed up by installation drawings showing lifting provisions for all heavy and/or bulky components necessary to properly handle them, including design and shop installation of lifting and tailing lugs as required.

2 Adjustment procedures for alignment of WESP internals prior to and during installation.

3 Components are to be delivered in the largest, most complete assemblies practical. Components will be clearly marked with weight, center of gravity, and rigging points identified. Components that contain special coatings or linings that could be damaged by welding or improper handling shall also be marked.

9 Quality Assurance

A Seller shall perform all work in this specification in accordance with a Buyer-approved quality assurance plan (see Ref. 2.3.A.5), and the supplier quality assurance data sheets included as part of the material requisition. Seller shall ensure that all software used and programs developed for use in design conform to the supplier quality assurance data sheets. Seller shall be responsible for flowdown of applicable quality assurance requirements to all sub-sellers.

10 Documentation and Submittals

10.1 General

A Seller shall comply with the requirements of Forms G-321-E and G-321-V of the material requisition. Furnish drawings, calculations, reports, specifications, procedures, test results, and all other required documents.

B All drawings and documents submitted for review shall be:

1 Checked and signed off by the Seller's qualified representative.

2 Identified by their own unique name and identification number.

3 In US customary units.

10.2 Additional Submittals

A In addition to examination and verification reports identified on Form G-321-V of the material requisition, Seller shall submit original radiographic film.

B Seller shall submit photographs depicting progress of vessel/vessel internals fabrication. Each photo shall include a sequence number, description, tag number, and date

C Seller shall furnish pricing and availability for all spare parts.

Appendix A

General Design Data

Appendix A
General Design Data

The following information applies to both LAW and HLW WESPs.

General Location Information

Site Elevation:	662-684 ft	Location of Project:	S.E. Washington State

Available Services

	Instrument/Plant Service Air
Dew Point:	-40°F at 100 psig. Plant service air is instrument air supplied through carbon steel pipe.
Supply Pressure:	90 to 150 psig
Quality:	ANSI/ISA S7.0.01-1996

	Demineralized Water	Process Water
Supply Temp:	60-80°F	60-80°F
Supply Pressure:	60-90 psig	60-90 psig
Quality:	demineralized, filtered <2μm; 40 ppm chlorides, 10 ppm sulfates, 340 ppm tds, 300 ppm tss, 170 ppm total hardness max	raw river water filtered <2μm

Available Power Supplies

For Instrumentation:	120 Vac, 1ϕ, 60 Hz, 480 3ϕ, 60 Hz
For Power Supplies	See Ref. 2.3.A.2

Vessel Materials

Vessel:	6% Mo alloy (e.g. AL-6XN)	Non-Contact (offgas and fluids) Metal Components:	304 or 316 ss (note 1)
Wetted Metal Components:	6% Mo alloy (e.g. AL-6XN)	External Structural Steel:	304 or 316 ss (note 1)

Other Vessel Design Requirements

Surface Corrosion Allowance:	0.04" (minimum internal)	Code Stamp:	required for all vessels
Vessel Fatigue Analysis:	not required	National Board Registration:	required for all vessels
Other Vessel Loadings:	1. For HLW vessels only, full decontamination solution soak with max specific gravity of 1.07. Do not consider this loading in seismic analyses.		
	2. Live loads generated by water flushing. Include these loads in seismic analyses.		
Nondestructive Examinations:	UT and RT (and PT as applicable) per Ref. 2.3.A.1		

Notes:

1. Stainless steel material SS304 and SS316 shall have a maximum carbon content of 0.03%. Nonwelded specialty items are excluded from this requirement.
2. For Project use only – This document has considered/applied the requirements of section 14.10 of the project design basis, Document No. 24590-WTP-DB-ENG-01-001.
3. Active vessel utility and service connections shall be welded stub-end with the following exceptions which shall be gasketed with ANSI B16.5 150# flanges. Flush /mist water connections on LAW vessels. Purge air connections on all vessels (only if connections are integral to the housings that must be removed for servicing the insulators).
4. Manways shall be blinded with ANSI B16.5 150# flanges. Clad flange not permitted.
5. Gaskets may be EPDM or equivalent, except for the HLW vessel head flange, which shall be a spiral-wound graphite-filled 6% Mo alloy gasket with inner and outer support rings of the same material.
6. Bolts for noncontact (offgas and water) applications shall be ASTM A193 Grade B8 or equivalent. Bolting material for contact applications shall be SB 574, N 10276.
7. For all vessels, Buyer supplied drain and offgas piping is schedule 10S. All other Buyer supplied piping is schedule 40S. Seller shall taper welded stub-end utility and service nozzles as required to match Buyer supplied piping schedule class.

Appendix B

LAW WESP Design Data

Appendix B
LAW WESP Design Data

Conditions in Equipment Rooms:	For Pressure Vessels	For Power Supply and Control Equipment	Access Corridors (above Rooms for Pressure Vessels)
Temperature:	max: 113°F, min: 59°F (radiant heat sources may raise temp to 150°F)	max: 95°F, min: 50°F	max: 95°F, min: 50°F
Pressure:	-1 to –1.4 in w.c.	-0.1 to –1 in w.c.	-0.1 to –1 in w.c.
Relative Humiditv:	30% - 100%	30% - 60%	30% - 60%
Contamination Level:	(C5) surface contamination ≥100,000 dpm/100cm^2	(C2) surface contamination <1,000 dpm/100cm^2	(C3) surface contamination 100,000≥x≥1,000 dpm/ 100cm^2, may elevate to C5 when hatch is open
Radiation Level:	R5: high - 100 mrem/hr (decontaminated for personnel access)	R2: 0.25 mrem/hr	R3: 2.5 mrem/hr
Personnel Access:	access not normally permitted (plastic suits and supplied air)	unrestricted area – normal work clothes	contaminated area –(protective clothing, gloves, respirator)
Electrical Hazard Class:	non hazardous	non hazardous	non hazardous

WESP Vessel Configuration

Offgas Nozzle Orient (In): side mounted
Offgas Nozzle Orient (Out): side mounted
Vessel Orientation: vertical
Offgas Flow Path thru Vessel: bottom to top

Inlet Process Conditions

Offgas Flow Rate:	Nominal:	1400 acfm	Design Range:	1000-2000 acfm
Offgas Temp:	Nominal:	121 °F +/- 15 °F	Design Range:	45-170 °F (minimal cycling)
Offgas Pressure:	Nominal:	-45 inches w.c.	Design Range:	+1 atm to -1 atm
Offgas Humidity:	Nominal:	100 %	Design Range:	0 – 100% (with minor solution entrainment - see note 2)
Particulates:	Inlet Conc:	10 to 300 mg/m^3		
Size:	Range:	by mass - 50% smaller than 0.50 μm, 80% smaller than 1.0 μm, 90% smaller than 2.0 μm		

Performance Requirements

Solids Removal: 99.5 % overall, 99 % for ~0.3μm particles based on 1400 acfm

Equipment Service Life:
- Pressure vessel and attached nozzles and structural components: 40 years
- Pressure vessel and permanent internal precipitator components: 40 years
- Pressure vessel consumable internal precipitator components (including insulators): minimum of 7 years. Consider ease of replacement in design.
- Power supply and control equipment: minimum of 7 years. Consider ease of upgradeability.
- Instrumentation systems: design for 40 years. Consider ease of upgradeability in design.
- Power, control communications cabling: design for 40 years. Consider ease of upgradeability.

Availability: 97% rolling average over each 7 year period between melter changout.

Planned Maintenance Freq: Equipment in Pressure Vessel Rooms: Approximately every 5-7 years. Equipment outside Pressure Vessel Rooms: Regular scheduled maintenance will be performed

Notes:

1. Low end of offgas flow rate design range occurs after melter has stopped feeding. The offgas from two idled melters can be combined to permit one offgas system to be isolated, flushed, and accessible for maintenance.
2. It is anticipated that offgas humidity will not fall below 75 percent, based on upstream scrubber operation.

Predicted LAW Offgas Analysis at Inlet – Bounding Conditions for All Feed Types

	% by Volume	g/m3	mol/l
Cations			
Al^{3+}	0.0%	1.54E-04	5.71E-09
Ag^{+}	0.0%	3.88E-07	3.60E-12
B^{3+}	0.0%	7.18E-05	6.64E-09
Ba^{2+}	0.0%	3.28E-08	2.39E-13
Bi^{3+}	0.0%	5.46E-07	2.61E-12
Ca^{2+}	0.0%	4.98E-04	1.24E-08
Cd^{2+}	0.0%	6.59E-06	5.86E-11
Cr^{3+}	0.0%	7.88E-04	1.52E-08
Cs^{+}	0.0%	4.54E-10	3.42E-15
Fe^{3+}	0.0%	1.80E-05	3.22E-10
H^{+}	0.0%	3.37E-10	3.34E-13
Hg^{2+}	0.0%	8.27E-04	4.12E-09
K^{+}	0.0%	6.60E-03	1.69E-07
La^{3+}	0.0%	1.47E-08	1.06E-13
Li^{+}	0.0%	3.23E-08	4.65E-12
Mg^{2+}	0.0%	9.44E-05	3.89E-09
Mn^{4+}	0.0%	4.91E-07	8.94E-12
Mo^{6+}	0.0%	5.30E-06	5.52E-11
Na^{+}	0.0%	1.72E-03	7.50E-08
Ni^{2+}	0.0%	5.30E-06	9.02E-11
Pb^{2+}	0.0%	1.19E-05	5.76E-11
Se^{4+}	0.0%	1.88E-05	2.38E-10
Si^{4+}	0.0%	3.86E-03	1.37E-07
Sr^{2+}	0.0%	3.65E-09	4.17E-14
Ti^{4+}	0.0%	2.79E-03	5.84E-08
U^{4+}	0.0%	1.91E-08	8.02E-14
Zn^{2+}	0.0%	9.88E-05	1.51E-09
Zr^{4+}	0.0%	5.77E-07	6.33E-12
Anions			
Cl^{-}	0.0%	3.01E-04	8.50E-09
$H_2BO_3^{-}$	0.0%	1.54E-09	2.53E-14
HBO_3^{2-}	0.0%	1.46E-16	2.44E-21
BO_3^{3-}	0.0%	1.23E-24	2.09E-29
F^{-}	0.0%	5.21E-05	2.74E-09
I^{-}	0.0%	5.90E-11	4.65E-16
IO_3^{-}	0.0%	1.06E-220	6.07E-226
NH_4^{+}	0.0%	4.42E-05	2.45E-09
NO_3^{-}	0.0%	6.17E-08	9.95E-13
O^{2-}	0.0%	9.24E-03	5.78E-07
$OH^{-}(aq)$	0.0%	1.25E-13	7.37E-18
$H_2PO_4^{-}$	0.0%	3.53E-07	3.64E-12
HPO_4^{2-}	0.0%	7.14E-11	7.44E-16
PO_4^{3-}	0.0%	2.71E-15	2.85E-20
$HSiO_3^{-}$	0.0%	4.33E-10	5.62E-15
SiO_3^{2-}	0.0%	2.29E-16	3.01E-21
HSO_3^{-}	0.0%	1.73E-04	2.13E-09
SO_3^{2-}	0.0%	6.67E-08	8.33E-13
Organics			
Non-Volatile	0.0%	3.40E-03	1.16E-08
SVOC	0.0%	1.08E-02	8.43E-08
VOC	0.0%	3.16E-05	2.46E-10

Sucrose	0.0%	2.78E-02	8.12E-08
Water			
H_2O	13.8%	8.16E+01	4.53E-03
Aerosols	0.0%	7.32E-02	4.06E-06
Gases			
Ar	0.8%	1.00E+01	2.51E-04
CO	0.0%	2.78E-01	9.91E-06
CO_2	2.6%	3.73E+01	8.47E-04
HCl	0.0%	3.22E-03	8.82E-08
HF	0.0%	5.19E-03	2.59E-07
I_2	0.0%	4.31E-05	1.70E-10
N_2	64.4%	5.94E+02	2.12E-02
NH_3	0.0%	1.21E-02	7.10E-07
NO	0.7%	6.53E+00	2.18E-04
NO_2	0.5%	8.31E+00	1.81E-04
NaCl(s)	0.0%	4.04E-02	6.91E-07
NaF(s)	0.0%	2.98E-02	7.09E-07
NaI(s)	0.0%	1.78E-08	1.19E-13
O_2	17.3%	1.82E+02	5.69E-03
P_2O_5(s)	0.0%	2.64E-05	1.86E-10
SO_2	0.0%	2.86E-02	4.47E-07
Total	100.0%	9.21E+02	3.29E-02

LAW Radionuclides – Maximum Dosages	**Bq/m^3**	**mol/l**
^{3}H	1.12E+05	1.05E-13
^{14}C	1.24E+05	5.34E-11
^{60}Co	2.41E+00	9.62E-19
^{90}Sr	3.02E+02	6.65E-16
^{90}Y	3.02E+02	1.67E-19
^{99}Tc	2.37E+04	3.82E-10
^{126}Sn	4.89E-02	3.70E-16
^{129}I	2.51E+03	3.22E-09
^{129}I(s)	8.78E-01	1.13E-12
^{134}Cs	4.72E-02	7.37E-21
^{137}Cs	2.72E+03	6.23E-15
^{137m}Ba	2.57E+03	9.44E-22
^{152}Eu	2.71E-01	2.76E-19
^{154}Eu	6.11E+01	3.97E-17
^{155}Eu	6.23E+00	2.22E-18
^{233}U	2.57E-03	3.09E-17
^{235}U	1.05E-03	5.59E-14
^{237}Np	5.34E-02	8.65E-15
^{238}Pu	7.18E-02	4.76E-19
^{239}Pu	3.86E-01	7.03E-16
^{240}Pu	9.85E-02	4.87E-17
^{241}Pu	5.90E+00	6.42E-18
^{241}Am	1.63E+01	5.34E-16
^{243}Cm	1.91E-01	4.13E-19
^{244}Cm	2.49E+00	3.41E-18
Total	2.68E+05	3.66E-09

Appendix C

HLW WESP Design Data

Appendix C
HLW WESP Design Data

Conditions in Equipment Rooms:	For Pressure Vessels	For Insulator Enclosures	For Power Supply and Control Equipment
Temperature:	max: 113°F, min: 59°F (radiant heat sources may raise temp to 150°F)	max: 95°F, min: 50°F	max: 95°F, min: 50°F
Pressure:	-1 to –1.4 in w.c.	-0.1 to –1 in w.c.	-0.1 to –1 in w.c.
Relative Humidity:	30% - 100%	30% - 60%	30% - 60%
Contamination Level:	(C5) surface contamination ≥100,000 dpm/100cm^2	(C5) surface contamination ≥100,000 dpm/100cm^2 (surrounding room is C2)	(C2) surface contamination <1,000 dpm/100cm^2
Radiation Level:	R5: high - greater than 100 mrem/hr.	R5: high – up to 100 mrem/hr (surrounding room is R3)	R2: 0.25 mrem/hr
Personnel Access:	no access allowed	decontaminated for access (protective clothing, gloves, respirator)	unrestricted area – normal work clothes
Electrical Hazard Class:	non hazardous	non hazardous	non hazardous

WESP Vessel Configuration

Offgas Nozzle Orient (In):	side mounted	Offgas Nozzle Orient (Out):	side mounted
Vessel Orientation:	vertical	Offgas Flow Path thru Vessel:	bottom to top

Inlet Process Conditions

Offgas Flow Rate:	Nominal:	1200 acfm	Design Range:	1000-2000 acfm
Offgas Temp:	Nominal:	121 °F +/- 15 °F	Design Range:	45-170 °F (minimal cycling)
Offgas Pressure:	Nominal:	-45 inches w.c. (inlet)	Design Range:	+1 atm to –1 atm
Offgas Humidity:	Nominal:	100 %	Design Range:	0 – 100% (with minor solution entrainment – see note 1)
Particulates:	Inlet Conc:	10 to 300 mg/m^3		
Size:	Range:	by mass - 50% smaller than 0.50 μm, 80% smaller than 1.0 μm, 90% smaller than 2.0 μm		

Performance Requirements

Solids Removal:	99% overall, 97.5% for ~0.35μm particles based on 2000 acfm
Equipment Service Life:	Pressure vessels and attached nozzles and structural components: 40 years.
	Pressure vessel internal precipitator components: 40 years, or longest possible life up to 40 yrs.
	Power supply and control equipment: minimum of 7 years. Consider ease of upgradeability.
	Instrumentation systems: design for 40 years. Consider ease of upgradeability in design.
	Power, control, communications cabling: design for 40 years. Consider ease of upgradeability.
Availability:	97% rolling average over each 7 year period between melter changeouts.
Planned Maintenance Freq:	Equipment in pressure vessel rooms: none.
	Equipment in insulator enclosure: none
	Power supply and control equipment: regular scheduled maintenance will be performed.
	Instrumentation equipment: inside the pressure vessel room -- none, other instrumentation outside C5 areas will have regular scheduled maintenance.

Notes:

1. It is anticipated that offgas humidity will not fall below 75 percent, based on upstream scrubber operation.

Predicted HLW Offgas Analysis at Inlet – Bounding Conditions for All Feed Types

	% by Volume	g/m3	mol/l
Cations			
Al^{3+}	0.0%	1.54E-06	5.72E-11
Ag^{+}	0.0%	3.37E-07	3.13E-12
B^{3+}	0.0%	3.73E-06	3.45E-10
Ba^{2+}	0.0%	6.55E-06	4.77E-11
Bi^{3+}	0.0%	5.54E-05	2.65E-10
Ca^{2+}	0.0%	7.63E-07	1.90E-11
Cd^{2+}	0.0%	1.76E-03	1.57E-08
Cr^{3+}	0.0%	2.68E-04	5.16E-09
Cs^{+}	0.0%	2.51E-04	1.89E-09
Fe^{3+}	0.0%	1.10E-05	1.98E-10
H^{+}	0.0%	1.41E-06	1.40E-09
Hg^{2+}	0.0%	3.27E-02	1.63E-07
K^{+}	0.0%	4.27E-03	1.09E-07
La^{3+}	0.0%	8.57E-06	6.17E-11
Li^{+}	0.0%	2.25E-04	3.24E-08
Mg^{2+}	0.0%	4.55E-07	1.87E-11
Mn^{4+}	0.0%	1.43E-06	2.61E-11
Mo^{6+}	0.0%	8.24E-05	8.58E-10
Na^{+}	0.0%	2.98E-03	1.30E-07
Ni^{2+}	0.0%	1.85E-06	3.15E-11
Pb^{2+}	0.0%	2.94E-05	1.42E-10
Se^{4+}	0.0%	2.07E-03	2.62E-08
Si^{4+}	0.0%	8.17E-06	2.91E-10
Sr^{2+}	0.0%	6.89E-08	7.86E-13
Ti^{4+}	0.0%	2.28E-05	4.76E-10
U^{4+}	0.0%	2.43E-06	1.02E-11
Zn^{2+}	0.0%	4.23E-06	6.47E-11
Zr^{4+}	0.0%	3.17E-06	3.47E-11
Anions			
Cl^{-}	0.0%	1.01E-05	2.85E-10
$H_2BO_3^{-}$	0.0%	9.28E-11	1.52E-15
HBO_3^{2-}	0.0%	2.25E-19	3.76E-24
BO_3^{3-}	0.0%	4.85E-29	8.24E-34
F^{-}	0.0%	4.28E-05	2.25E-09
I^{-}	0.0%	2.18E-11	1.72E-16
NO_3^{-}	0.0%	5.60E-07	9.04E-12
O^{2-}	0.0%	1.42E-03	8.88E-08
O_2^{2-}	0.0%	0.00E+00	0.00E+00
$OH^{-}(aq)$	0.0%	1.61E-15	9.49E-20
$HSiO_3^{-}$	0.0%	3.45E-11	4.48E-16
SiO_3^{2-}	0.0%	4.67E-19	6.14E-24
	% by Volume	**g/m3**	**mol/l**
Organics			
none			
Water			
H_2O	22.1%	1.28E+02	7.09E-03
Aerosols	0.1%	4.21E-01	2.34E-05
Gases			

Ar	0.7%	9.14E+00	2.29E-04
CO	0.0%	8.66E-02	3.09E-06
CO_2	0.8%	1.19E+01	2.70E-04
HCl	0.0%	7.39E-05	2.03E-09
HF	0.0%	1.19E-02	5.95E-07
I_2	0.0%	1.35E-05	5.32E-11
N_2	59.8%	5.37E+02	1.92E-02
NH_3	0.0%	1.45E-01	8.49E-06
NO	0.3%	3.35E+00	1.12E-04
NO_2	0.1%	7.71E-01	1.68E-05
NaCl(s)	0.0%	1.16E-03	1.99E-08
NaF(s)	0.0%	8.07E-03	1.92E-07
NaI(s)	0.0%	4.95E-09	3.30E-14
O_2	16.0%	1.64E+02	5.13E-03
P_2O_5(s)	0.0%	1.44E-05	1.01E-10
SO_2	0.0%	2.00E-02	3.12E-07
Total	100.0%	8.55E+02	3.21E-02

HLW Radionuclides – Maximum Dosages	**Bq/m^3**	**mol/l**
^{3}H	2.45E+05	2.28E-13
^{14}C	1.99E+04	8.58E-12
^{60}Co	4.21E+03	1.68E-15
^{90}Sr	3.12E+04	6.87E-14
^{90}Y	3.12E+04	1.73E-17
^{99}Tc	1.08E+07	1.74E-07
^{126}Sn	6.76E-01	5.11E-15
^{129}I	7.87E+02	1.01E-09
^{129}I(s)	2.44E-01	3.14E-13
^{134}Cs	1.11E+00	1.73E-19
^{137}Cs	2.72E+07	6.24E-11
^{137m}Ba	2.58E+07	9.45E-18
^{152}Eu	2.18E+00	2.22E-18
^{154}Eu	2.30E+02	1.50E-16
^{155}Eu	1.31E+02	4.68E-17
^{233}U	4.04E-03	4.86E-17
^{235}U	1.13E-03	6.00E-14
^{237}Np	3.36E-01	5.43E-14
^{238}Pu	1.59E+00	1.05E-17
^{239}Pu	1.40E+01	2.55E-14
^{240}Pu	7.51E-01	3.71E-16
^{241}Pu	9.97E+01	1.09E-16
^{241}Am	4.08E+02	1.33E-14
^{243}Cm	6.07E-01	1.31E-18
^{244}Cm	1.30E+01	1.78E-17
Total	6.42E+07	1.75E-07

Appendix D

Engineering Information Data Sheet

Appendix D
Vendor Data Sheet

Vendor to Complete and Submit

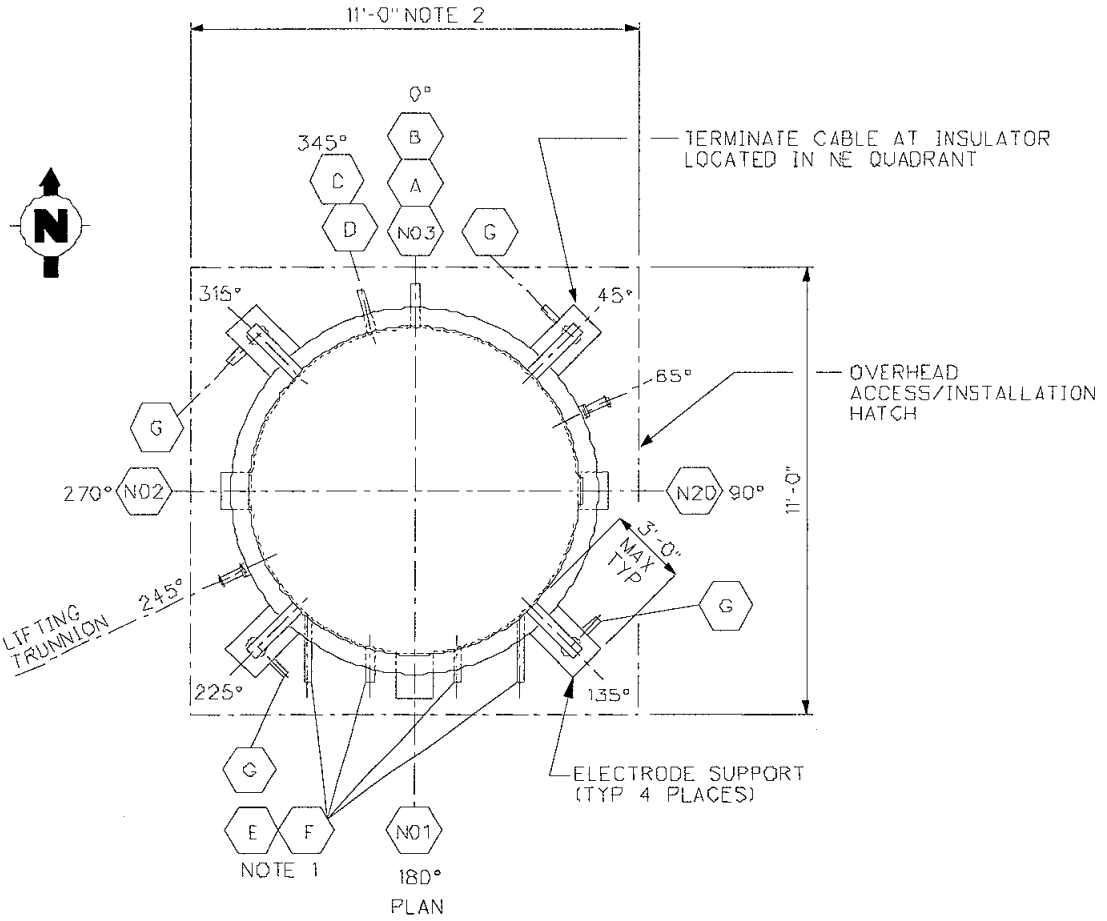
Item		LAW/HLW	Item	LAW/HLW
Performance Data:				
Velocity Thru Inlet (fps)	Nom Flow:	/	Design Flow:	/
Velocity Thru Outlet (fps)	Nom Flow:	/	Design Flow:	/
Migration Velocity (fps)	Nom Flow:	/	Design Flow:	/
Residence Time (sec)	Nom Flow:	/	Design Flow:	/
dP through WESP (psi)	Nom Flow:	/	Design Flow:	/
Vessel and Insulator Housings				
Vessel Height (TL to TL) (ft):		/	Total Height:	/
Vessel Inside Diameter (in):		/	Vessel O.D. w/Connections (in):	/
Vessel Shell Plate Thickness (in):		/	Head Plate Thickness (in):	/
Bottom Head Configuration:		/	Top Head Configuration:	/
Insulator Housing Height (ft):		/	Insulator Housing ID (in):	/
Insulator Shell Plate Thickness (in):		/	Head Plate Thickness (in):	/
Collecting Electrodes				
Quantity:		/	Shape:	/
Effective Length (ft):		/	Actual Length (ft):	/
Inside Diameter (in):		/	Thickness (in):	/
Specific Collection Area (SCA) ft^2/1000 acfm gas		/	Collecting Surface (ft^2):	/
Total Area (ft^2) – total flat projected area for "A" in Deutch-Anderson equation:				/
Discharge Electrodes				
Quantity:		/	Type/Configuration:	/
Effective Length (ft):		/	Actual Length (ft):	/
Diameter (in):		/	Output Current Density:	/
Space between Electrodes, CL to CL (in):		/	Connection to Frame:	/
Power Supplies				
Type:		/	Supplier:	/
Insulating Oil Type:		/	Oil Quantity:	/
Power Input (guaranteed), kW:		/	Power Output, kW:	/
Output Waveform		/	Power Factor:	/
Voltage Input, V:		/	Current Input, A:	/
Voltage Output, V:		/	Current Output, A:	/
% Voltage Harmonics		/	% Current Harmonics:	/
Secondary Current Form Factor:		/	Nom Current Rating (mA):	/
Transformer Turns Ratio:		/		
Support Insulators				
Material:		/	Quantity:	/
Operating Temperature (F):		/	Diameter:	/
Purge Airflow (scfm):		/	Purge Air Duty:	/
Voltage Class:		/	Creep Distance:	/
Flush Water/ Mist Systems				
Flush Water Nozzle Quantity:		/	Flush Water Nozzle Size:	/
Estimated Flushing Frequency (times/month):		/	Flush Water Flow (gpm):	/
Misting Water Nozzle Quantity:		/	Misting Water Nozzle Size:	/
Misting Frequency		/	Misting Flow (gpm):	/
Weights				
Empty Vessel (w/internals, supports):		/	Internals Only:	/
Total Vessel Operating Weight:		/	Total Vessel Test Wt:	/
Control Panel (if separate from power sup):		/	Power Supply:	/

Appendix E

Figures

Appendix E
Figures

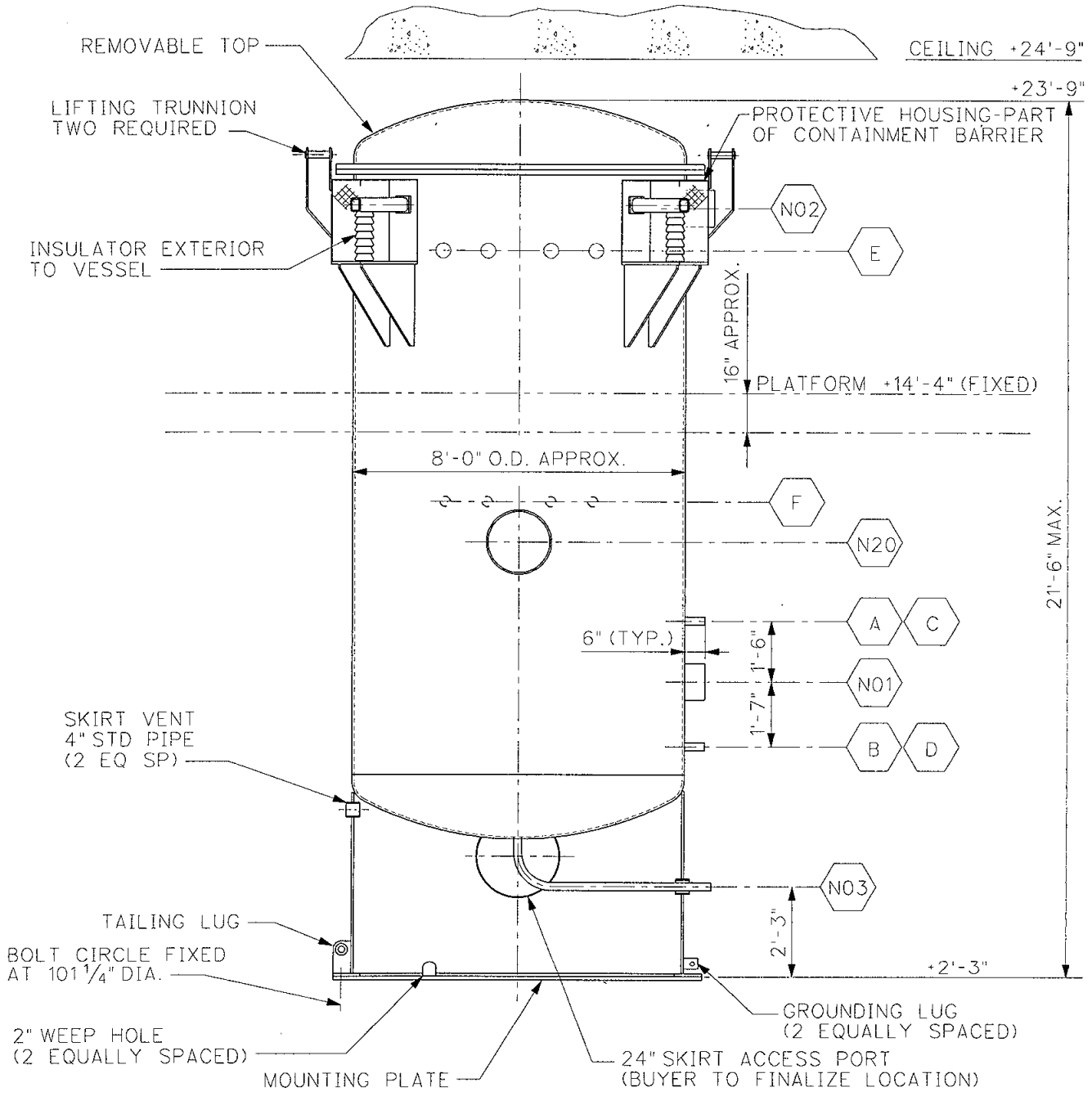
NOZZLE	SIZE	SERVICE/REMARKS
N01	10"	OFFGAS INLET
N02	10"	OFFGAS OUTLET
N03	3"	DRAIN
A	3"	LEVEL TRANSMITTER
B	1"	LEVEL TRANSMITTER
C	3"	LEVEL TRANSMITTER
D	1"	LEVEL TRANSMITTER
E	BY SELLER	FLUSH WATER NOZZLES-QTY & LOCATION BY SELLER
F	BY SELLER	MISTING SPRAY NOZZLES-QTY & LOCATION BY SELLER
N20	BY SELLER	MANWAY INSPECTION PORT-NOTE 3
G	1"	PURGE AIR TO INSULATOR ENCLOSURES



Notes:

1. Locate flush and misting nozzles as required between 135° and 225°. For same-service nozzles to be located on the same horizontal plane, configure to be easily connected to a common header.
2. Buyer will provide 11'-0" square opening centered over the vessel in the floor above for access/installation. Seller shall allow a minimum of 3" clearance on all sides. High voltage cable termination and termination housing is excluded from envelope limits.
3. Manway/inspection port, if required, shall be 24".
4. Coordinate final location and size of purge air nozzles with Buyer. Purge air connection may be located above or below insulator mounting flange depending on final insulator configuration and cable termination requirements. Additional purge air nozzle required for high voltage cable enclosure, coordinate with Buyer.

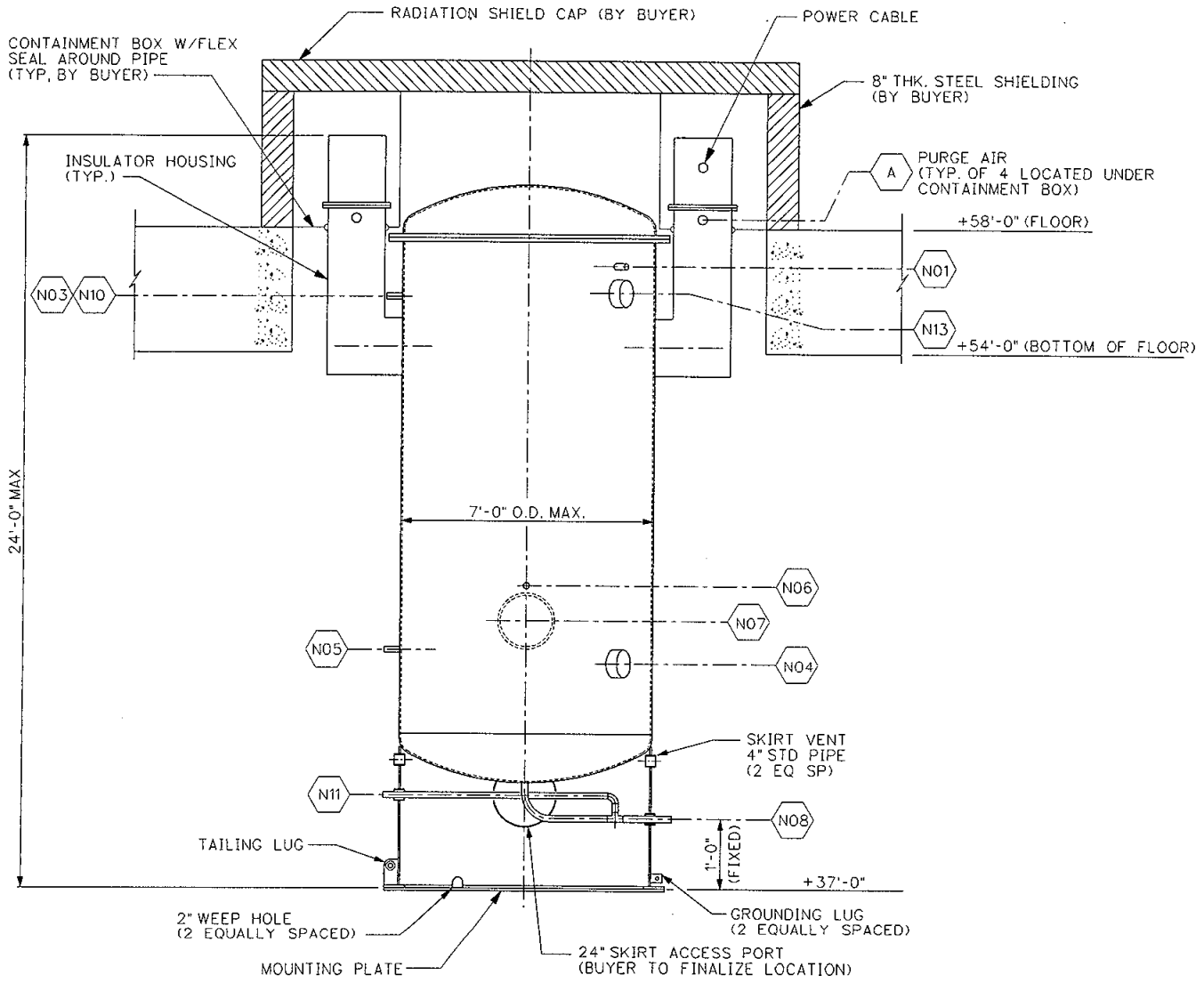
Figure 1- Conceptual Design for LAW WESP Vessel Plan and Nozzle Schedule
(Typical for all LAW WESPs, not to scale)



Notes:

1. Application and orientation of misting spray nozzles (nozzles marked "F") are on hold pending Seller confirmation of requirement. Buyer intends to introduce misting in the offgas line upstream of the vessel.
2. Anchor bolt chairs shall be at 0°, 45, 90, 135, 180, 225, 270, and 315. Seller shall locate tailing lugs, weep holes, grounding lugs, etc., to miss the chairs.
3. Maximum envelope height excludes high voltage cable termination and termination housing, as well as electrical bus extensions (if required). Top of termination housing will not exceed elevation 25'-6".

Figure 2 – Conceptual Design for LAW WESP Vessel, Elevation
(Typical for all LAW WESPs not to scale)

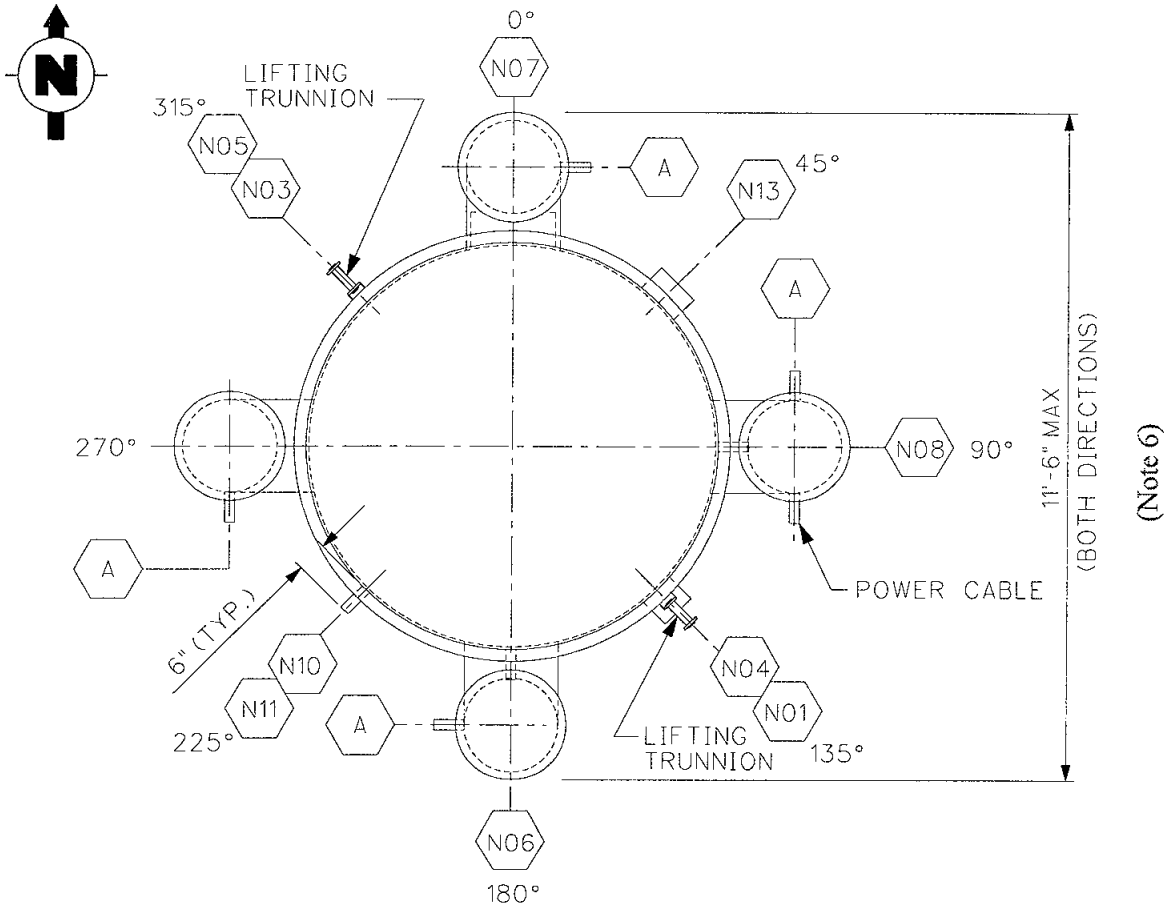


Notes:

1. Coordinate with Buyer to retain access for electrode alignment, as required, prior to hot startup.
2. The radiation shield cap shown is depicted as being steel plate but it may be concrete instead. The cap may be installed immediately after final electrode alignment is complete.
3. Provide stainless steel shim packs as required.
4. Purge air connections to be located within the containment boxes surrounding the insulator housing caps. Purge air connection may be located above or below insulator mounting flange depending on final insulator configuration and cable termination requirements. High voltage cable connection enclosure requires additional purge air connections for inlet and outlet (1" diameter). Coordinate final location and size of purge air nozzles with Buyer.

Figure 3 – Conceptual Design for HLW WESP Vessel, Elevation
(Typical for all HLW WESPs, not to scale)

NOZZLE	SIZE	SERVICE/REMARKS
N01	2"	FLUSH WATER NOZZLE
N02	N/A	NOT USED
N03	1"	PRESSURE DIFFERENTIAL TRANSMITTER
N04	8"	OFFGAS INLET
N05	1"	PRESSURE DIFFERENTIAL TRANSMITTER
N06	2"	FLUSH WATER NOZZLE
N07	BY SELLER (NOTE 1)	MANWAY/ INSPECTION PORT
N08	6"	DRAIN
N09	N/A	NOT USED
N10	1"	LEVEL TRANSMITTER
N11	1"	LEVEL TRANSMITER
N13	10"	OFFGAS OUTLET
A	1" (NOTE 2)	PURGE AIR TO INSULATOR ENCLOSURES



Notes:

1. Manway/inspection port, if required, shall be no larger than 24".
2. Final size and location of purge air nozzles to be coordinated with Buyer via drawing review cycle. One additional purge air inlet and outlet is necessary for the High Voltage Cable Enclosure along with the four required for the insulator enclosures.
3. Terminate cable at insulator in southeast quadrant. Cable will be routed south.
4. Final location of lifting trunnions by Seller.
5. High voltage cable termination and termination housing is excluded from envelope limits.
6. Envelope specified is for conceptual purposes. Coordinate with Buyer if exceeded.

Figure 4 – Conceptual Design for HLW WESP Vessel, Nozzle Plan and Schedule
(Typical for all HLW WESPs, not to scale)