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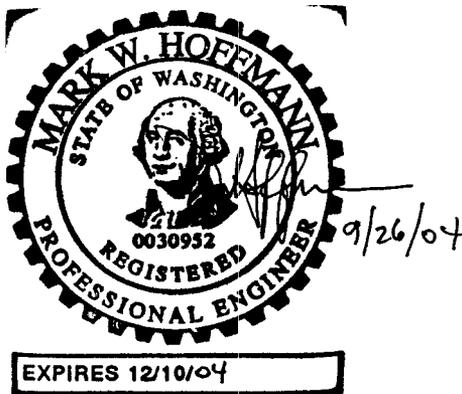


# RIVER PROTECTION PROJECT – WASTE TREATMENT PLANT

## ENGINEERING SPECIFICATION

FOR

### Silver Mordenite Column Design and Fabrication



This bound document contains a total of 51 pages.

Content applicable to ALARA?  Yes  No

ADR No. N/A Rev

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

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<b>SPECIFICATION No.</b> 24590-HLW-3PS-MBT0-TP001	<b>Rev</b> 2
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## 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. Information contained herein on radionuclides is provided for process description purposes only.

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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 (DOE) Hanford Site tank waste will be pretreated and immobilized into stable glass form via vitrification. The WTP Contractor will design, build, and startup the WTP pretreatment and vitrification facilities for the DOE Office of River Protection (ORP). The waste treatment facilities will pretreat and immobilize the low activity waste (LAW) and high level waste (HLW) currently stored in underground storage tanks at the Hanford Site.

The Hanford Site occupies an area of about 560 square miles and is located along the Columbia River, north of Richland, WA in the U.S.A. The WTP Facility will be constructed at the east end of the 200 East Area of the Hanford Site. The counties of Benton, Franklin, and Grant surround the Hanford Site.

## 1.2 Equipment, Material, and Services Required

This specification provides the requirements for the design, analysis, fabrication, project management, quality assurance, inspection, testing, qualification, and labeling of two (2) silver mordenite columns, a catwalk to connect the column platforms, associated filters, gaskets, fasteners, and special tools for use in the WTP HLW facility. This specification also provides the requirements for the creation, demonstration, design, fabrication, quality assurance, inspection, testing, qualification, and supply of silver mordenite, testing equipment, testing apparatus, testing materials, manuals, instructions, and procedures.

The scope of work for the Seller includes all work necessary to provide two (2) completely functional Silver Mordenite Columns specifically defined in this specification and its addenda and attachments. Work shall include, but is not limited to, the following:

- 1.2.1 Provide fully detailed designs, drawings, supporting calculations, supporting analyses, supporting models, procedures, and all labor, materials, fasteners, tooling, equipment, apparatus, instrumentation, shop drawings, and services necessary to manufacture, test, inspect, insulate, label, and package for shipment two (2) silver mordenite columns and catwalk to connect the column platforms in accordance with this specification and the attached data sheets that are in Section 2 of the Material Requisition (MR). Refer to Paragraph 3.1.6 for what shall be included as part of silver mordenite columns to be provided.
- 1.2.2 Provide Buyer with a breakdown (by paragraph) of the following codes, industry standards, and referenced documents to be applied to each aspect of the silver mordenite column detailed design, drawings, analysis, fabrication, quality assurance, inspection, testing, qualification, labeling, packaging, handling, and shipment for review prior to beginning the detailed design:
  - ASME AG-1-1997
  - ASME AG-1a-2000
  - ASME N509-1989

If an entire section or part of the above listed codes and standards applies, a breakdown by paragraph is not required. Only the part or section shall be listed.

- 1.2.3 Provide a three-dimensional (3-D) computational fluid dynamics (CFD) model and analysis of the silver mordenite columns.
- 1.2.4 Provide a thermal analysis of the silver mordenite columns, column support frame, support base material, and catwalk.
- 1.2.5 Provide an analysis from a silver mordenite expert (defined in 1.4.2) of the silver mordenite column design to determine expected adsorbent changeout frequency.
- 1.2.6 In addition to the field testing requirements set forth in ASME AG-1, Section TA, and/or ASME N509, Section 9, conduct the following acceptance tests in the shop, on each silver mordenite columns, with exception to the airflow distribution test (which shall be performed on a single column to verify design), prior to shipment:
- Visual Inspection
  - Structural Capability Test
  - Mounting Frame Pressure Leak Test
  - System Bypass Test
  - Differential Pressure Test
  - Airflow Distribution Test
- 1.2.7 Provide testing media for conducting shop acceptance tests if silver mordenite is not available in time. Issue manufacturer's information for testing media to the Buyer for review prior to purchase.
- 1.2.8 Provide challenge gas as defined in 1.4.2. As applicable per testing requirements, provide challenge gas injection and sampling ports/manifolds.
- 1.2.9 As applicable per testing requirements, provide all piping connections for challenge gas injection and sampling, pressure drop indication, pressure testing, leak testing, air flow distribution testing, and bypass testing required per this specification and its addenda and attachments.
- 1.2.10 Provide the services of a technical representative during installation and acceptance testing in the field. Provide all tooling, equipment, material, apparatus, instrumentation, and challenge gas necessary to conduct all field testing and inspections called for in this specification, applicable standards, applicable codes, and referenced documents. Provide travel, room, and board required.
- 1.2.11 Provide fully detailed designs, drawings, supporting calculations, procedures, and all labor, materials, fasteners, tooling, equipment, and services necessary to manufacture, test, inspect, and package for shipment two (2) sets (one for each column) of special tools to enable personnel to remove and install all fasteners, covers, lids, hold-downs, etc. necessary for removing and replacing silver mordenite column adsorbers and discharge roughing filters. Only manufacturer's information is required for tools readily available in the commercial market.

- 1.2.12 Provide a detailed bag-in/bag-out procedure for removal and replacement of the silver mordenite column adsorbers and discharge roughing filters. Seller may propose alternate method of replacement for Buyer review.
- 1.2.13 If full suite protection is required for bag-in/bag-out procedure, provide all personnel, equipment, apparatus, labor, Personnel Protection Equipment (PPE), materials, film, special tools, glovebags, bags, HEPA filters, etc. to simulate field conditions. Demonstrate, and videotape the bag-in/bag-out procedure using one of the fully assembled silver mordenite columns. Provide copies of the demonstration videotape, a glovebag (if required), one (1) unused bag, and any filters required for the demonstration.
- 1.2.14 Provide the services of a trainer to train Buyer maintenance personnel on the bag-in/bag-out procedure at the Buyer's offices in Richland, WA. Provide all materials, travel, room, and board required.
- 1.2.15 Select discharge roughing filters and gaskets for columns per the silver mordenite manufacturer's recommendation and this specification. Provide two (2) sets of discharge roughing filters and gaskets for each column in addition to all sets required for shop and field testing.
- 1.2.16 Provide material certified test reports, welding procedures, welder qualifications, insulation installation procedures, surface preparation and coating procedures, testing procedures, testing results, quality assurance procedures, quality control inspection results, and all other procedures and documentation required per this specification and its addenda and attachments.
- 1.2.17 Provide transportation, storage, and installation instructions for the silver mordenite column adsorbers per the silver mordenite manufacturer's recommendation and this specification.
- 1.2.18 Provide packaging and package the silver mordenite columns, column support frames, column catwalk, support frame shim packs, column adsorbers, roughing filters, gaskets, special tools, and silver mordenite for shipment to the WTP HLW facility site.
- 1.2.19 Provide all equipment, instrumentation, labor, and materials to test lifting points to be provided on the silver mordenite columns, column catwalk, column support frames, and adsorbers in the shop.
- 1.2.20 Provide Material Safety Data Sheets (MSDSs) for silver mordenite and all other materials used in the construction of the silver mordenite columns, column support frames, and shim packs.
- 1.2.21 Provide one (1) support frame for mounting each silver mordenite column to be provided (total two (2) support frames required). Provide fully detailed designs, drawings, supporting calculations, procedures, and all labor, material, fasteners, tooling, equipment, instrumentation apparatus, shop drawings, and services necessary to manufacture, test, inspect, prime, and prepare for shipment support frames in accordance with this specification.
- 1.2.22 Provide column support base insulation material required to insulate Buyer's concrete foundation in accordance with the requirements of this specification.

- 1.2.23 Provide shim pack(s) for each point silver mordenite column support attached to Buyer's foundation embed plates. Each shim pack shall include one (1) 0.25" shim and two (2) 0.120", 0.060", 0.036", 0.010", and 0.005" shims. Provide drawings, and all labor, materials, tooling, equipment, and services necessary to manufacture, prime, inspect, and prepare for shipment shim packs.
- 1.2.24 Provide storage and installation instructions for silver mordenite column support frames.

### 1.3 Work by Others

Any item not specifically listed as being supplied by the Buyer shall be provided by the Seller. The Buyer shall supply the following:

- 1.3.1 Shipping to jobsite.
- 1.3.2 Unloading and storage of all material and equipment at jobsite.
- 1.3.3 Installation labor at jobsite.
- 1.3.4 Concrete foundation, embed plates, and anchor bolts.
- 1.3.5 Operator Training.
- 1.3.6 Piping external to the silver mordenite column.
- 1.3.7 Pressure drop indicators for pressure drop piping connections.
- 1.3.8 Insulation required at support frames, shims, and embeds.

### 1.4 Acronyms and Definitions

#### 1.4.1 Acronyms

3-D	Three-Dimensional
AGS	American Glovebox Society
AIHA	American Industrial Hygiene Association
ALARA	As Low As Reasonably Achievable
ANS	American Nuclear Society
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASNT	American Society for Nondestructive Testing
ASTM	American Society of Testing Materials
AWS	American Welding Society
CFD	Computational Fluid Dynamics

CFR	Code of Federal Regulations
DBE	Design Basis Event
DOE	US Department of Energy
ERDA	Energy Research and Development Administration
ERPG	Emergency Response Planning Guideline
ESF	Engineered Safety Feature
HEPA	High Efficiency Particulate Air
HLW	High Level Waste
HOP	Melter Offgas Treatment System
HVAC	Heating, Ventilation, and Air Conditioning
ITS	Important to Safety
LAW	Low Activity Waste
MR	Material Requisition
MSDS	Material Safety Data Sheet
NACE	National Association of Corrosion Engineers
NDE	Nondestructive Evaluation/Examination
NPH	Natural Phenomena Hazard
NPS	Nominal Pipe Size
OBE	Operating Basis Earthquake
ORP	DOE Office of River Protection
OSHA	Occupational Safety and Health Administration
PIP	Process Industry Practices
PMI	Positive Material Identification
PP	Personnel Protection
PPE	Personal Protection Equipment
ppmV	parts per million
psf	pounds per square foot (lb/ft <sup>2</sup> )
QA	Quality Assurance
QAM	Quality Assurance Manual
QL	Quality Level
QL-2	Quality Level 2
RFQ	Request for Quote
RRC	Risk Reduction Class
SDC	Safety Design Class
SDS	Safety Design Significant
SC	Seismic Category

SC-3	Seismic Category 3 or Seismic Category III
scfm	Standard Cubic Feet per Minute
SRD	Safety Requirements Document
SS	Stainless Steel
SSC	System, Structures, and Component
TBD	To Be Determined
UL	Underwriters Laboratories, Inc.
WAC	Washington Administrative Code
w.g.	Water Gage
WTP	Hanford Tank Waste Treatment and Immobilization Plant

#### 1.4.2 Definitions

*Adsorbent:* A solid having the ability to concentrate other substances on its surface. For this specification the adsorbent is silver mordenite (see silver mordenite definition).

*Adsorber:* A device or vessel containing adsorbent (e.g., an adsorber cell filled with adsorbent).

*Adsorber Cell:* A modular container for an adsorbent, with provision for sealing to a mounting frame, which can be used singly or in multiples to build up a system of any airflow capacity.

*Adsorber Bank:* Two or more adsorbers, in parallel, secured in a single mounting frame within the same housing. (e.g., Each silver mordenite column to be supplied per this specification is an adsorber bank containing 36 adsorbers.)

*ALARA:* As Low As Reasonably Achievable. ALARA documentation requirements apply to SSCs that have the potential to affect doses, contamination levels, or releases to the environment.

*Bag-in/Bag-out:* A method of introducing and removing items from a contaminated enclosure that prevents the spread of contamination.

*Buyer's Representative(s):* The Buyer's designee(s), who shall witness onsite operations at the seller and sub-seller sites and perform onsite inspections and surveillances.

*Bypass, Leakage:* A pathway through which contaminated air can escape treatment by the installed HEPA and/or adsorber banks. Examples are leaks in filters and filter mounting frames, defective or inefficient isolation dampers that result in the uncontrolled flow through adjacent plenums, and unsealed penetrations for electrical conduits, pipes, floor drains, etc.

*C3:* Contamination classification for plant areas that are ordinarily free of contamination, but have the potential of being contaminated.

*Challenge Gas:* A gas of known characteristics, under specified conditions, used for the purpose of testing. For in-shop and in-place/field testing of adsorbers required by this specification. The challenge gas to be used shall depend on what is recommended by the silver mordenite manufacturer. Challenge gas shall be an environmentally safe non-ozone depleting substance, if possible.

*Discharge Roughing Filter:* A micro-efficiency filter to be installed in the silver mordenite column housing downstream of the silver mordenite adsorbers for capture of abraded silver mordenite particles.

*Engineered Safety Feature (ESF):* A nuclear air treatment system, HVAC system, gas processing system, or a component that serves to control and limit the consequences of releases of energy and radioactivity in the event of occurrences as described in ANSI/ANS 51.1 and 52.1.

*Glovebag:* A temporary barrier to contain or prevent the spread of contamination generally during system maintenance or production. The area or component is surrounded by the portable glovebox boundary material, usually a flexible plastic film. Personnel perform work inside the glovebag through glovesleeves and gloves while remaining outside the containment area. Other access ports are provided to allow for equipment and service penetrations as necessary. Additional openings can be provided through the use of zippers, velcro closures, and bag-out ports.

*HEPA Filter:* A high efficiency particulate air filter having a fibrous medium with a particle removal efficiency of at least 99.97 % when tested with essentially monodispersed 0.3  $\mu\text{m}$  test aerosol particles.

*HEPA Filter Bank:* Two or more HEPA filters, in parallel, secured in a single mounting frame within the same housing.

*Important to Safety (ITS):* SSCs that serve to provide reasonable assurance that the facility can be operated without undue risk to the health and safety of the workers and the public. ITS encompasses the broad class of facility features addressed (not necessarily explicitly) in the top-level radiological, nuclear, and process safety standards and principles that contribute to the safe operation and protection of workers and the public during all phases and aspects of facility operations (i.e., normal operation as well as accident mitigation). ITS includes SSCs designated as Safety Design Class (SDC), Safety Design Significant (SDS), and Risk Reduction Class (RRC).

*Mounting Frame:* A structure against which adsorbers may be snugly mounted and supported in a position that permits the passage of air or gas and provides a surface to hold the sealing gasket, thereby avoiding a potential bypass or leakage path for the non-filtered air or gas.

*Paragraph:* When a paragraph of this specification, referenced documents, referenced codes, or referenced standards is referenced in this specification, the paragraph referenced and all subparagraphs and sub-subparagraphs of the paragraph referenced shall be considered inclusive.

*Quality Level 2 (QL-2):* SDS items. QL-2 shall also be used to identify other items and activities for which NQA-1 (1989) compliance is required.

*Rad:* A unit of energy absorbed from ionizing radiation, equal to 100 ergs per gram or 0.01 joules per kilogram of irradiated material.

Risk Reduction Class: RRC SSCs are ITS SSCs that are neither SDC nor SDS.

*R3:* Radiation classification for plant areas considered average. At early design stages, when insufficient information is available regarding worker occupancy, an initial target radiation level of 2.5 mRad/hr is to be used for the R3 classification.

*Safety Design Class (SDC)*: is an SSC whose safety function is to prevent a worker or the maximally exposed member of the public from receiving a radiological exposure that exceeds the accident exposure standards defined in the Safety Requirements Document (SRD). An SDC is also an SSC whose safety function is to prevent a worker or the maximally exposed member of the public from receiving a chemical exposure that exceeds the exposure standards defined in the SRD, or an SSC credited for the prevention of a criticality event.

*Safety Design Significant (SDS)*: SSCs needed to achieve compliance with the radiological or chemical exposure standards for the public and workers during normal operation; and SSCs that can, if they fail or malfunction, place frequent demands on or adversely affect the function of SDC SSCs.

*Seismic Category 3(III) Equipment (SC-3)*: (a) SDC and SDS SSCs that do not have a natural phenomena hazard (NPH) safety function. (b) SSCs that have a seismic safety function solely because they protect workers and members of the public from exposure to chemical hazards. (c) Risk Reduction Class (RRC) SSCs that provide primary confinement of significant inventories of radioactive materials, but in amounts less than quantities that require an SDC or SDS designation.

*Silver Mordenite*: Shall refer to C-Chem AG-900 (10 x 16 mesh, cylindrical pellets) hydrogen reduced silver mordenite. A form of silver zeolite (AgZ).

*Silver Mordenite Column*: An adsorber bank.

*Silver Mordenite Expert*: One who has extensive knowledge regarding the characteristics and application of silver mordenite for radioactive iodine adsorption. Must have a minimum of five (5) years experience.

*Special Tools*: Any tooling required to perform maintenance on the silver mordenite column or for silver mordenite adsorber and discharge roughing filter removal and replacement. Includes tools that must be specially designed and fabricated and tools that are readily available in the commercial market.

*Testing Media*: Media that could be used (if necessary) to conduct shop testing that requires adsorbent media to be installed in the silver mordenite columns. Media shall be identical in size and shape to C-Chem AG-900 (10 x 16 mesh, cylindrical pellets) hydrogen reduced silver mordenite and be able to adsorb challenge gas long enough to conduct required shop acceptance testing.

*Water Gage (w.g.)*: The units for air pressure typically expressed in inches of water column height (e.g., 60 inches w.g.). Equivalent to water column (w.c.).

## 1.5 Safety/Quality/Seismic Classifications

The quality level (QL) and seismic category (SC) of the silver mordenite columns are specified on the data sheets in Section 2 of the MR. The QL and SC for the column support frames shall be the same as the silver mordenite columns.

# 2 Applicable Documents

## 2.1 General

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

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. If a date or revision is not listed in section 2, the latest issue, including addenda, at the time of request for quote (RFQ) shall apply. The dates and revisions listed in section 2 shall apply to all subsequent references to codes and standards within this specification. When more than one code, standard, or referenced document covers the same topic, the requirements for all must be met with the most stringent governing.

## 2.2 Codes

- 2.2.1 ASME AG-1-1997, Code on Nuclear Air and Gas Treatment, Sections AA, FD, FF, FG, and TA
- 2.2.2 ASME AG-1a-2000, Addenda to ASME AG-1-1997 Code on Nuclear Air and Gas Treatment, Section HA
- 2.2.3 ASME B31.3-1996, Process Piping
- 2.2.4 ASME B30.20-1993, Below-The -Hook Lifting Devices
- 2.2.5 ASME Boiler and Pressure Vessel Code, Section VIII, Div. 1, Rules for Construction of Pressure Vessels
- 2.2.6 AWS D1.6, Structural Welding Code-Stainless Steel
- 2.2.7 WAC 296-24, General Safety and Health Standards

## 2.3 Industry Standards

- 2.3.1 AGS-G001 ©1998, Guideline for Gloveboxes, Second Edition
- 2.3.2 ASME N509-1989, Nuclear Power Plant Air-Cleaning Units and Components, Sections 1, 2, 3, 4 (Paragraphs 4.3, 4.4, 4.6.1 through 4.6.7.2, 4.12, 4.13(a)), 5 (Paragraphs 5.6.5.5 and 5.6.5.6), 7 (Paragraph 7.2), 8 (Paragraph 8.2), 9, Appendix C, and Appendix D
- 2.3.3 ASME N510-1989 (Rev. 1995), Testing of Nuclear Air Treatment Systems, Sections 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 13, 15, and Appendices
- 2.3.4 ASME NQA-1-1989, Quality Assurance Program Requirements for Nuclear Facilities
- 2.3.5 ASME Y14.100, Engineering Drawing Practices
- 2.3.6 ASTM A240/A240M, Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels
- 2.3.7 ASTM C533, Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation
- 2.3.8 ASTM C612, Standard Specification for Mineral Fiber Block and Board Thermal Insulation

- 2.3.9 ASTM C692, Standard Test Method for Evaluating the Influence of Thermal Insulations on External Stress Corrosion Cracking Tendency of Austenitic Stainless Steel
- 2.3.10 ASTM C795, Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel
- 2.3.11 ASTM C871, Standard Test Methods for Chemical Analysis of Thermal Insulation Materials for Leachable Chloride, Fluoride, Silicate, and Sodium Ions
- 2.3.12 ASTM C929, Standard Practice for Handling, Transporting, Shipping, Storage, Receiving, and Application of Thermal Insulation Materials for Use in Contact with Austenitic Stainless Steel
- 2.3.13 ASTM E84, Standard Test Method for Surface Burning Characteristics of Building Materials
- 2.3.14 ASTM F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs
- 2.3.15 ASTM F594, Standard Specification for Stainless Steel Nuts
- 2.3.16 ERDA 76-21, Nuclear Air Cleaning Handbook, Chapter 1 (All), Chapter 2 (Paragraphs 2.1 through 2.4.16), Chapter 3 (Paragraphs 3.1, 3.4.1, 3.4.2, 3.4.5, 3.4.6), Chapter 4 (Paragraphs 4.3 through 4.3.5, 4.5.9), Chapter 7 (All), Chapter 8 (All), Chapter 9 (Paragraph 9.4.1)
- 2.3.17 NACE Standard RP0198, The Control of Corrosion Under Thermal Insulation and Fireproofing Materials-A Systems Approach
- 2.3.18 PIP INIH1000, Hot Insulation Installation Details
- 2.3.19 PIP INSH2000, Installation of Hot Service Insulation Systems

## **2.4 Reference Documents/Drawings**

- 2.4.1 24590-WTP-DC-ST-01-001, Structural Design Criteria
- 2.4.2 24590-WTP-3PS-G000-T0001, General Specification for Supplier Quality Assurance Program Requirements
- 2.4.3 24590-WTP-3PS-G000-TP002, Specification for Positive Material Identification (PMI)
- 2.4.4 24590-WTP-3PS-G000-T0003, General Specification for Packaging, Handling and Storage Requirements
- 2.4.5 24590-WTP-3PS-NWP0-T0001, Engineering Specification for General Welding and NDE Requirements for Supplier Fabricated Piping
- 2.4.6 24590-WTP-3PS-P000-T0001, Engineering Specification for Piping Material Classes
- 2.4.7 24590-WTP-3PS-SS00-T0001, Engineering Specification for Welding of Carbon Structural Steel
- 2.4.8 24590-WTP-3PS-SS00-T0002, Specification for Welding of Structural Stainless Steel and Welding of Structural Carbon Steel to Structural Stainless Steel

- 2.4.9 24590-WTP-3PS-FB01-T0001, Engineering Specification for Structural Design Loads for Seismic Category III and IV Equipment and Tanks
- 2.4.10 24590-WTP-3PS-AFPS-T0001, Engineering Specification for Shop Applied Special Protective Coatings for Steel Items and Equipment

## 3 Design Requirements

### 3.1 General Requirements

- 3.1.1 The silver mordenite columns, catwalk between the columns, and column support frames shall be designed per this specification, the applicable documents listed in section 2 of this specification, and the attached data sheets that are in Section 2 of the MR.
- 3.1.2 The detailed design of the silver mordenite columns, catwalk between the columns, and column supports shall be performed by personnel who have, at a minimum, past experience in the design, fabrication, and testing of silver zeolite adsorber banks or HEPA filter banks to meet the requirements set forth in ASME AG-1, ASME AG-1a, and NQA-1. Qualifications for personnel conducting the detailed design of the silver mordenite columns shall be provided to the Buyer for review.
- 3.1.3 All calculations, modeling, analyses, drawings, and documentation shall be performed and/or completed using U.S. customary units.
- 3.1.4 The design of the two (2) silver mordenite columns to be provided shall be identical except for platform layout details and catwalk layout details (see Figure 3). See Figures 1 and 3 for column outlet termination points.
- 3.1.5 The CFD model and analysis, thermal analysis, silver mordenite column design analysis, and seismic analysis to be provided per this specification must verify that the final detailed design of the silver mordenite columns and column support frames meet the requirements set forth in this specification and its addenda and attachments.

- 3.1.6 Each silver mordenite column shall include all items shown or implied in Figure 1 including, but not limited to, the following:
- housing with inlet, outlet, mounting frame, mounting channel base with anchorage provisions, platform supports, discharge roughing filter receiver, piping connections and manifolds for testing and sampling, piping connections for pressure drop indication, insulation supports and hold-downs, column lifting lugs, adsorber hold-downs, adsorber cover hold-downs, internal baffles, and mixing vanes (if mixing vanes required)
  - adsorbers
  - adsorber covers
  - discharge roughing filter with access cover
  - gaskets for sealing adsorbers to mounting frame, adsorber covers, and discharge roughing filter cover
  - insulation with jacketing
  - platform with grating and guardrails
  - catwalk platform with grating and guardrails
  - tool box

One (1) of the silver mordenite columns shall also include an access ladder.

- 3.1.7 The silver mordenite columns shall be designed in a bank configuration with 36 silver mordenite adsorbers per column mounted to a mounting frame within a housing (refer to Figure 1). The inlet and outlet shall be at opposite ends with the melter offgas entering into an upper plenum (inlet plenum), flowing in parallel through the adsorbers to a lower plenum (outlet plenum), passing through a replaceable discharge roughing filter, and finally exiting.
- 3.1.8 Each silver mordenite column shall be designed for uniform offgas distribution so that the offgas velocity readings through each adsorber are within  $\pm 20\%$  of the calculated average when operating at  $\pm 10\%$  of the silver mordenite column's design flowrate.
- 3.1.9 As applicable per testing requirements, all testing and sampling piping, connections, ports, and manifolds shall be permanently attached to the silver mordenite columns and easily accessible for shop and field testing. The Seller shall work closely with the Buyer to determine best locations for testing and sampling piping, connections, ports, and manifolds.
- 3.1.10 The silver mordenite columns shall be designed for use with the bag-in/bag-out procedure to be developed by the Seller to facilitate adsorber and discharge roughing filter removal and replacement operations from the silver mordenite column's platform. The Seller shall work closely with the Buyer on developing the bag-in/bag-out procedure.
- 3.1.11 A platform with guardrails shall be permanently attached to the top of each silver mordenite column to enable access to the top of the columns for adsorber removal. The silver mordenite column platforms shall be joined by a catwalk using mechanical fasteners after installation (refer to Figure 1 and Figure 3). There shall be a three (3) foot wide opening, with a safety gate or chain installed, in the guardrail of one (1) of the column platforms to facilitate adsorber removal to grade. A ladder, with a safety gate or chain installed in column guardrail opening, shall be permanently affixed to the northwest corner of the northern silver mordenite column to facilitate access to the platforms.

## 3.2 Basic Function

- 3.2.1 The silver mordenite columns are part of the HLW HOP system to remove gaseous radioactive iodine (I-129) from the melter offgas stream. The columns will also remove other gaseous halogens, such as fluorine and chlorine.
- 3.2.2 Melter offgas is generated from the vitrification of HLW slurry feed by a joule-heated ceramic melter. The offgas consists primarily of:
- Air from inleakage into the melter, instrumentation, purges, and melter bubbler operation (if used)
  - Water evaporated from the melter feed
  - Acid gases (i.e., CO<sub>2</sub>, NO<sub>x</sub>, SO<sub>x</sub>, etc.) generated from anion decomposition
  - Aerosols from dried melter feed and melter cold-cap reaction solids, and
  - Semivolatile chemicals generated from the molten glass pool

## 3.3 Performance

- 3.3.1 The silver mordenite columns shall be designed and fabricated to meet the mechanical and process requirements on the attached data sheets in Section 2 of the MR and the design requirements given in this specification.
- 3.3.2 The silver mordenite columns, catwalk, and support frame shall be designed for a minimum service life of 40 years.
- 3.3.3 The silver mordenite columns shall have a minimum adsorbent life expectancy (before requiring changeout due to halogen breakthrough) of five (5) years when operating 8,760 hours per year.
- 3.3.4 Pressure boundary leakage shall be no greater than 0.2 % of rated flowrate at a minimum leakage test pressure equal to 150 % of maximum operating pressure.
- 3.3.5 The adsorber bypass leakage shall be no greater than 0.1 % of rated flow at 99.9 % efficiency.
- 3.3.6 Each silver mordenite column shall have uniform offgas flow distribution such that velocity readings through each adsorber within the column (36 total) do not exceed  $\pm 20$  % of the calculated average when operating within  $\pm 10$  % of design flowrate.
- 3.3.7 At maximum design temperature, the insulation jacket temperature and all uninsulated portions of the silver mordenite columns, column support frames, embed plates, and shims, with potential for personnel exposure, shall not exceed 140 °F.
- 3.3.8 The Seller shall select a column base support insulating material that shall prevent the Buyer's concrete foundation from exposure to temperatures exceeding 100 °F.
- 3.3.9 Temperature of embed plate to concrete interface shall not exceed 150 °F (refer to Figure 5) with the average temperature of the concrete area under the columns not exceeding 100 °F.

### 3.4 Design Conditions

- 3.4.1 Refer to the silver mordenite column data sheets in Section 2 of the MR.
- 3.4.2 The silver mordenite columns shall be designed so that the overall housing length (excluding insulation) does not exceed 19'-9 1/4", the overall width (including insulation) does not exceed 15'-3 1/8", and the overall height does not exceed 7'-0" when measuring from the bottom of the column to the top of the column's platform grating (refer to Figure 1). Only the outlet can extend above the grating. The height of the outlets above the grating shall be the minimum required to enable replacement of the discharge roughing filters from the column platforms. **Every effort shall be made by the designer performing the detailed design to minimize the overall dimensions of the silver mordenite column while still meeting the requirements of this specification and its addenda and attachments.**
- 3.4.3 Each silver mordenite column platform may be extended up to 3.75 inch past the outlet end of the column housing to enable platforms to be connected once the columns are installed at the Buyer's facility (refer to Figure 3). This is to accommodate up to 7.5 inch of insulation between the columns.
- 3.4.4 The silver mordenite columns shall be considered non-ESF as defined in ASME AG-1, Article AA-1000.
- 3.4.5 The silver mordenite columns shall meet Level C service limits as defined in ASME AG-1, Paragraph AA-4214.
- 3.4.6 The following silver mordenite column nominal inlet conditions shall apply:
- Flowrate: 1,200 scfm (may fluctuate from 1,100 scfm to 1,400 scfm)
  - Temperature:  $\cong 330$  °F
  - Pressure: (-)0.97 psig
  - Halogens:  $\cong 0.02$  lb/d (may fluctuate between 0.02 and 0.1 lb/d)
  - NO<sub>x</sub>:  $\cong 0.35$  lb/h
  - Primary Offgas Components:
    - N<sub>2</sub> → 69.7 % by volume
    - O<sub>2</sub> → 18.7 % by volume
    - H<sub>2</sub>O → 10.3 % by volume
    - CO<sub>2</sub> → 0.37 % by volume
    - Ar → 0.83 % by volume

3.4.7 The following silver mordenite column process requirements shall apply for design:

- Halogen Adsorption Efficiency: 99.9 %
- Iodine Adsorption Efficiency: 99.9%
- Design Flowrate: 1500 scfm
- Maximum Superficial Velocity: 0.8 ft/s
- Maximum Design Temperature: 330 °F
- Minimum Adsorbent Life Expectancy: 5 y
- Hours of Operation: 8760 h/y
- Maximum Pressure Drop: 10 inch w.g.
- Maximum Operating Pressure: ± 1.5 psig
- Maximum Design Pressure ± 3.0 psig

3.4.8 Silver mordenite column support frames shall be designed so that the overall length does not exceed 19'-9 1/4" (excluding insulation), and the overall width does not exceed 15'-3 1/8" (excluding insulation).

3.4.9 Approximately 1/2 inches of shim plates will be stacked at embed locations for leveling support frames (refer to Figure 5). Once leveled, the following will be completed to anchor column support frames to Buyer's foundation:

- Shim plates will be field welding together
- Support frames will be field welded to shim plates
- Shim plates will be field welded to embed plates

3.4.10 Drawings showing embed plate details and silver mordenite column embed plates locations are included in Section 2 of the MR. Embed plates for silver mordenite columns are located between column lines 7 & 9 and C & G on drawings. Embed plates are type "C".

3.4.11 No portion of the silver mordenite column support frames, or shims for leveling support frames, shall come in contact with Buyer's foundation.

### 3.5 Environmental Conditions

3.5.1 The silver mordenite columns and column support frames will be installed indoors in an R2/C2 area maintained between 59 °F and 95 °F dry-bulb temperature during normal operation. Radiation exposure is targeted to be 0.25 mRad/hr.

3.5.2 Prior to installation, the silver mordenite columns and column support frames may be stored outdoors at ambient temperature extremes ranging from (-)30 F dry-bulb to 117 F dry-bulb and with a relative humidity of 0-100 %.

### 3.6 Loadings

- 3.6.1 The silver mordenite columns, catwalk, and column support frames shall be self-supporting, capable of carrying the static loads of components, and capable of handling the stresses imposed during shipment, installation, operation, and an earthquake.
- 3.6.2 Loads to be considered for the structural design of the silver mordenite columns shall be in accordance with applicable codes, standards, and reference documents listed in section 2 of this specification. As a minimum, loadings and stresses to be imposed shall meet Level C service limits as described in ASME AG-1, Paragraph AA-4214 and shall be in accordance with Buyer specification 24590-WTP-3PS-FB01-T0001, *Engineering Specification for Structural Design Loads for Seismic Category III and IV Equipment and Tanks*. Loadings and stresses imposed for design of the column housings shall also be in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, Div. 1.
- 3.6.3 Loads to be used for the structural design of the silver mordenite column support frames shall be in accordance with Buyer specification 24590-WTP-3PS-FB01-T0001, *Engineering Specification for Structural Design Loads for Seismic Category III and IV Equipment and Tanks*.

### 3.7 Housing and Mounting Frame Requirements

- 3.7.1 The silver mordenite column housings and associated mounting frames shall be designed per ASME AG-1a, Section HA, ASME AG-1, Section FG, and all other applicable codes and standards listed in section 2 of this specification. The housing pressure boundary for each silver mordenite column shall also be designed generally in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, Div. 1.
- 3.7.2 Each silver mordenite column housing and associated mounting frame shall be designed so that the adsorbers are automatically centered and aligned when inserted to ensure proper gasket seating and sealing. The design shall ensure that the gasket and sealing surface is not damaged during insertion and removal operations.
- 3.7.3 Housings shall have adsorber access covers for each adsorber to facilitate removal and replacement of the adsorbers from the silver mordenite column platform.
- 3.7.4 Each housing shall have platform supports and be able to withstand maximum platform loadings without damage. Refer to subsection 3.10 for platform loadings.
- 3.7.5 One (1) of the housings shall have ladder supports designed to withstand maximum ladder loadings without damage. Refer to subsection 3.10 for ladder loadings.
- 3.7.6 Each housing shall have two (2) 3/4 inch flanged piping connections for installation of pressure drop indication across the discharge roughing filter. Seller shall work with Buyer to determine exact location and configuration of piping connections.
- 3.7.7 Housings shall have discharge roughing filter access covers to facilitate removal and replacement of the discharge roughing filters.

- 3.7.8 Fasteners, hold-downs, etc. for securing the adsorbers to the mounting frame and the adsorber access covers to the housing shall be accessible from the platforms on the top of the silver mordenite columns. The only additional operation required for adsorber removal after the access covers are removed shall be to connect the crane hook to the adsorber lifting lug.
- 3.7.9 Internal baffles, turning vanes, and cross-venting holes shall be provided in the inlet plenum, as required, to achieve balanced flow through the adsorbers.
- 3.7.10 The housing outlet shall terminate facing in the upward direction.
- 3.7.11 Each housing shall be insulated on the sides, top, bottom, and ends, and have insulation supports, hold-downs, and fasteners. Piping and testing connections shall also be insulated. Insulation design and installation shall be per applicable codes and standards listed in section 2 of this specification. The thermal code shall be PP.
- 3.7.12 Adequate insulation flexibility shall be provided in the silver mordenite column housing insulation to allow longitudinal and circumferential expansion and contraction of the silver mordenite column insulation, housing, and housing attachments for temperatures ranging from ambient to maximum design temperature.
- 3.7.13 Insulation shall be designed to provide a continuous waterproof, weather, and environmental barrier.

### **3.8 Support Frame Requirements**

- 3.8.1 Column support frames shall be designed in accordance with applicable sections of Buyer specification 24590-WTP-DC-ST-01-001, *Structural Design Criteria*.
- 3.8.2 Column support frame shall contain the base support material used to insulate the Buyer's concrete foundation.
- 3.8.3 Column support frame and insulation base material must meet the thermal requirements of this specification and the seismic requirements of Buyer specification 24590-WTP-3PS-FB01-T0001, *Engineering Specification for Structural Design Loads for Seismic Category III and IV Equipment and Tanks*.

### **3.9 Adsorber Requirements**

- 3.9.1 The silver mordenite column adsorbers shall be designed per ASME AG-1, Sections FD and FF, and all other applicable codes and standards listed in section 2 of this specification.
- 3.9.2 The design of the adsorber cells for the silver mordenite columns shall be completed by a silver mordenite expert (defined in 1.4.2) with experience in silver mordenite adsorber design. Seller shall provide personnel qualifications to the Buyer for review prior to beginning adsorber design.
- 3.9.3 Each adsorber shall be able to fit into a standard 55-gallon drum (excluding lifting lug). A standard 55 gallon drum has an internal diameter of 22 1/2 inch and a height of 33 1/4 inch.

- 3.9.4 Each adsorber shall hold at least 5.75 ft<sup>3</sup> of silver mordenite and have a cartridge bed length of 31.75 inch.
- 3.9.5 Each adsorber shall have a configuration per Figure 2, and be removable through the top of the silver mordenite columns via a bag-in/bag-out operation.
- 3.9.6 The lifting lugs for the adsorber cells shall be securely attached during silver mordenite column operation, but shall be removable if necessary.
- 3.9.7 The lifting lugs for the adsorber cells shall be sized and configured so that personnel are not required to break the plane of the adsorber access openings in the silver mordenite column housings to connect the crane hook for adsorber removal operations. Seller may propose a method other than using a crane hook with a lifting lug to the Buyer for meeting this criteria (e.g., a grab, grapple, etc.). Alternate methods must be compatible with Buyer's crane and be submitted for Buyer's review prior to implementing into the detailed design.
- 3.9.8 Adsorbers shall be designed so that gasket material remains completely attached to the adsorber during removal operations.

### **3.10 Platform and Catwalk Requirements**

- 3.10.1 The silver mordenite column platforms and catwalk shall be designed to meet the requirements set forth in WAC 296-24, General Safety and Health Standards, Buyer specification 24590-WTP-DC-ST-01-001, *Structural Design Criteria*, and all other applicable codes and standards listed in section 2 of this specification.
- 3.10.2 The silver mordenite column platforms shall be designed to provide a removal route for each column adsorber individually. Platform shall have a grid of removable grating sections to accomplish this (one section per adsorber).
- 3.10.3 The silver mordenite column platforms and catwalk between the columns shall include guardrails. The guardrails shall be made out of piping.
- 3.10.4 The guardrails shall be designed per WAC 296-24-750 and to handle additional loading imposed by a fully loaded toolbox (refer to 3.15) without failure during normal operation.
- 3.10.5 The minimum combined floor dead load and 100 psf live load for the column platforms and catwalk shall be 150 psf.
- 3.10.6 The fixed ladder to be installed on one of the silver mordenite columns shall meet the requirements set forth in WAC 296-24-810. Use a concentrated live load of 300 pounds for the ladder design.
- 3.10.7 The silver mordenite column platforms and catwalk must be able to be attached without welding after the columns are placed in the HLW facility.
- 3.10.8 All openings in guardrails of each silver mordenite column platform shall have a safety gate or chain designed per the requirements of WAC 296-24-750.

### 3.11 Piping and Manifold Requirements

All piping (excluding guardrails), piping connections (includes column inlet and outlet), ports, and manifolds shall be per the requirements set forth in Buyer specification 24590-WTP-3PS-P000-T0001, *Engineering Specification for Piping Material Classes*, for piping material service class S11V.

### 3.12 Lifting Requirements

- 3.12.1 Lifting lugs shall be installed on each silver mordenite column, catwalk, and column support frame for balanced lifting and handling. Seller shall identify the weight and center of gravity of each column, the catwalk, and column support frame and submit a report for Buyer review.
- 3.12.2 Installation of each silver mordenite column and column support frame shall be completed separately by a single crane operation.
- 3.12.3 All lifting attachments shall have either a safety factor of three (3), based on material yield strength, or five (5), based on the material ultimate strength, whichever is more conservative meeting the requirements of ASME B30.20.
- 3.12.4 The lifting lugs and any supplied lifting equipment (i.e. spreader beam, structural lifting devices, etc.) shall be designed in accordance with the requirements of ASME B30.20 and permit lifting the silver mordenite columns, the catwalk, and column support frames without distortion or damage to the components.
- 3.12.5 The silver mordenite column, catwalk, and column support frame lifting lugs must be accessible from the top without removal of insulation, covers, and guardrails.
- 3.12.6 The lifting lugs must accept standard lifting equipment. Chain blocks or braiding shall not be permitted. Shackles must be Crosby or equivalent meeting Federal Specification RR-C-271D.
- 3.12.7 Sampling and testing connections and ports shall not be used for lifting.
- 3.12.8 All lifting points on silver mordenite columns and column adsorbers, catwalk, and column support frames shall be proof tested in-situ. Test and examination certificates shall be in accordance with the requirements of ASME B30.20 and shall be provided to the Buyer for review.

### 3.13 Discharge Roughing Filter Requirements

The discharge roughing filters for the silver mordenite columns shall be rated for at least 330°F and have a minimum capacity of two (2) times the design flowrate.

### 3.14 Bag-in/Bag-out Procedure Requirements

- 3.14.1 Seller shall provide a detailed bag-in/bag-out procedure for removal and replacement of the silver mordenite column adsorbers and discharge roughing filters using PPE, bags, a glovebag (if required), special tools, and a standard one-half ton overhead traveling crane. Refer to Figure 3 and Figure 4 for room and crane clearance limitations.

- 3.14.2 Seller shall work with Buyer to determine PPE requirements to be included in the procedure for personnel conducting adsorber and roughing filter removal and replacement.
- 3.14.3 The bag-in/bag-out procedure shall be based on conducting adsorber and discharge roughing filter replacement when the silver mordenite columns are not in operation. The temperature of the silver mordenite columns shall be no greater than 100 °F.
- 3.14.4 If a glovebag is required to perform the bag-in/ bag-out procedure, it shall conform to AGS-G001, and ERDA 76-21, Paragraph 2.2.1 and Chapter 7. Seller shall work with Buyer to determine whether or not a glovebag will be necessary.
- 3.14.5 Drawings of bags and glovebag (if glovebag is required) to be used shall be included in the bag-in/bag-out procedure. Drawings shall show configuration with dimensions and identify any equipment, filters, and/or apparatus to be an integral part of the bags and glovebag. Drawings shall also identify material, manufacturer, and/or model numbers of all bag and glovebag components.
- 3.14.6 The bag-in/bag-out procedure shall be written to ensure that, after adsorber or discharge roughing filter access cover removal and bag installation, adsorber or filter confinement is not broken at any time.
- 3.14.7 Only one (1) adsorber access cover shall be removed at any time when performing the bag-in/bag-out procedure.
- 3.14.8 After any one (1) of the adsorber access covers or the discharge roughing filter access cover is removed, a vacuum will be drawn on the silver mordenite column to ensure that approximately 5 scfm of air will be drawn into the silver mordenite column adsorber or discharge roughing filter opening.
- 3.14.9 Personnel shall not need to break the plane of the adsorber or discharge roughing filter access openings in the silver mordenite columns at any time to perform the bag-in/bag-out procedure.
- 3.14.10 The bag-in/bag-out procedure shall be able to be safely completed with crane clearance and lifting constraints shown in Figure 4.
- 3.14.11 At no time during completion of the bag-in/bag-out procedure shall personnel performing the procedure need to extend any part of their bodies below the adsorbers when the adsorbers are attached to the crane.

### **3.15 Special Tool Requirements**

- 3.15.1 Special tools shall be designed for use with the bag-in/bag-out procedure to be proposed by the Seller.
- 3.15.2 Special tools shall be fabricated using stainless steel.
- 3.15.3 All special tooling shall be designed to handle at least four (4) times the expected load without yielding.

### 3.16 Toolbox Requirements

- 3.16.1 Toolboxes for special tools shall be affixed to the top rail of the platform guardrails per the configuration shown in Figure 1 and Figure 3.
- 3.16.2 Toolboxes shall have hinged lids with positive latching mechanisms. Padlocks shall be able to be installed on latching mechanisms.
- 3.16.3 Toolbox shall be designed to hold at least 4 times the intended load and have 50 % more capacity than required to house all special tools.

### 3.17 CFD Model and Analysis Requirements

- 3.17.1 The 3-D CFD model, required per section 1 of this specification, shall demonstrate the effects of internal structures and components on offgas flow distribution through the adsorbers in the silver mordenite columns.
- 3.17.2 The 3-D CFD model shall include the following components of the silver mordenite columns:
- housing including inlet (with transition fittings or piping to inlet plenum), outlet (including transition fittings or piping from outlet plenum), inlet plenum, mounting frame, outlet plenum, discharge roughing filter, manifolds for testing and sampling, and any required internal baffles, mixing vanes, and/or cross-venting holes
  - adsorbers with hold-downs
  - adsorber covers
  - discharge roughing filter
- 3.17.3 The 3-D graphical results from the CFD model shall include:
- analysis of changes to the silver mordenite columns to enhance offgas flow effectiveness
  - analysis of the effect of including additional baffles, mixing vanes, and/or cross-venting holes as required to study local offgas flow effects to achieve uniform offgas flow distribution through the adsorbers
  - analysis of changes to the silver mordenite column to minimize the overall dimensions
- 3.17.4 The 3-D graphical results from the CFD model shall demonstrate uniform offgas flow distribution through the adsorbers so that the offgas velocity readings through each adsorber in the silver mordenite columns are within  $\pm 20\%$  of the calculated average when operating at  $\pm 10\%$  of the silver mordenite column's design flowrate.
- 3.17.5 Provide pressure drop to velocity relationship per foot of silver mordenite bed length as part of the CFD analysis.

3.17.6 The Seller shall provide the documented results from the 3-D CFD analysis in report form to the Buyer. The CFD report shall provide a complete offgas flow analysis and shall include 3-D graphical results of the model and any calculations performed. The reports shall, at a minimum, include:

- definition of analysis objective
- identification of equipment for analysis
- general description of equipment supplemented by drawings and sketches
- functional requirements per this specification and its addenda and attachments
- purpose of analysis
- definition of design criteria and inputs with corresponding sources
- results of literature searches and other applicable background data
- applicable codes, standards, and reference documents per section 2 of this specification broken down by chapter, section, and paragraph, as applicable
- analysis methodology
- description of computer(s) used to conduct analysis
- description of software/computer programs used for modeling and any calculations required, including program name, program revision, description of program capabilities and limitations, justification for choice of program, and evidence and description of program validation method
- assumptions (indicate those that must be verified as the design proceeds)
- analyses conducted with results
- summary of analysis results
- conclusions
- location for Buyer review signatures

All assumptions shall be plainly identified and data presented (including their uncertainty) with precise logic. Actual accomplishments of the work shall be clearly stated.

3.17.7 The final CFD report shall convey information to several disciplines, many of whom may be less familiar with the general subject than the authors. Care shall be taken to use simple statements and expressions and to make statements as concise as possible. If highly technical terms are necessary, they shall be adequately explained and defined.

### **3.18 Thermal Analysis Requirements**

3.18.1 Method of thermal analysis shall be proposed by the Seller.

3.18.2 The thermal analysis shall include the effects of stresses resulting from potential variations in temperatures due to startup, normal operation, shutdowns, and thermal cycling of the silver mordenite columns. The analysis shall consider that the column platforms shall be connected together with mechanical fasteners during normal operation.

- 3.18.3 The thermal analysis shall determine the thickness and extent of insulation required on the sides, ends, and top of silver mordenite columns, column support frames, embed plates, and shims, to ensure that the insulation jacket temperature and all exterior uninsulated portions of the silver mordenite columns, with potential for personnel exposure, do not exceed 140 °F at maximum design temperature and that the total heat loss is limited to 12 Kw per unit.
- 3.18.4 The thermal analysis shall determine the thickness and extent of insulation required on the bottom of the silver mordenite columns so that the temperature of embed plate to concrete interfaces do not exceed 150 °F and the temperature of support base to concrete interface do not exceed 100 °F (refer to Figure 5). Thermal analysis shall confirm Seller's column support insulation material meets requirements of this specification, addenda, and attachments.
- 3.18.5 The thermal analysis shall determine the maximum allowable inlet and outlet nozzle loadings and displacements in all directions at maximum design temperature.
- 3.18.6 The base temperature for construction shall be assumed to be 70 °F. Refer to the attached data sheets that are in Section 2 of the MR for maximum design temperature, operational temperature extremes, and thermal cycling data.
- 3.18.7 The thermal analysis shall include the following components of the silver mordenite columns:
- housing with inlet, outlet, mounting frame, mounting channel base with anchorage, platform supports, discharge roughing filter receiver, piping connections and manifolds for testing and sampling, insulation supports and hold-downs, adsorber hold-downs, adsorber cover hold-downs, internal baffles, and mixing vanes (if mixing vanes required)
  - adsorbers
  - catwalk
  - adsorber covers
  - discharge roughing filter with access cover
  - gaskets for sealing adsorbers to mounting frame, adsorber covers, and discharge roughing filter cover
  - insulation with jacketing
  - platform with grating and guardrails
- 3.18.8 The thermal analysis shall include column support frame, shims, embed plates, Buyer's foundation, and any insulation required on support frame, shims, and embed plates.
- 3.18.9 The thermal analysis results shall demonstrate that the silver mordenite columns, catwalk, and support frame are adequate for a 40 year service life. For design purposes, use a thermal cycle frequency of 13 cycles every 3 years for the life of the plant (40 years).

3.18.10 The Seller shall provide the documented results of the thermal analysis in report form to the Buyer. The thermal analysis report shall provide a complete thermal analysis of the silver mordenite columns, catwalk, and support frame and shall include 3-D graphical results of models and all calculations performed, as applicable to the analysis approach chosen. The report shall, at a minimum, include:

- definition of analysis objective
- identification of equipment for analysis
- general description of equipment supplemented by drawings and sketches
- functional requirements per this specification and its addenda and attachments
- purpose of analysis
- definition of design criteria and inputs with corresponding sources
- results of literature searches and other applicable background data
- applicable codes, standards, and reference documents per section 2 of this specification broken down by chapter, section, and paragraph, as applicable
- analysis methodology
- description of computer(s) used to conduct analysis
- description of any software/computer programs used for modeling and any calculations required, including program name, program revision, description of program capabilities and limitations, justification for choice of program, and evidence and description of program validation method
- assumptions (indicate those that must be verified as the design proceeds)
- analyses conducted with results
- summary of analysis results
- conclusions
- location for Buyer review signatures

All assumptions shall be plainly identified and data presented (including their uncertainty) with precise logic. Actual accomplishments of the work shall be clearly stated.

3.18.11 The final thermal analysis report shall convey information to several disciplines, many of whom may be less familiar with the general subject than the authors. Care shall be taken to use simple statements and expressions and to make statements as concise as possible. If highly technical terms are necessary, they shall be adequately explained and defined.

### **3.19 Silver Mordenite Column Design Analysis Requirements**

3.19.1 The design analysis of the silver mordenite columns shall be conducted by a silver mordenite expert (defined in 1.4.2) to determine the expected adsorbent changeout frequency for the final silver mordenite column design. Seller shall provide personnel qualifications to the Buyer for review prior to beginning adsorber design.

3.19.2 Analysis shall be conducted considering operation of the silver mordenite columns at design conditions.

- 3.19.3 Analysis shall determine expected adsorbent changeout frequency for the following two (2) halogen loading conditions:
- 0.02 lb/d
  - 0.1 lb/d
- 3.19.4 Assume that the offgas flow through the adsorbers in the silver mordenite columns may vary up to  $\pm 20\%$  from the average with the system operating at  $\pm 10\%$  of design flowrate.
- 3.19.5 The Seller shall provide the documented results of the silver mordenite column analysis with any graphical results, as applicable, in report form to the Buyer prior to fabricating the columns. The report shall, at a minimum, include:
- definition of analysis objective
  - identification of equipment for analysis
  - general description of equipment supplemented by drawings and sketches
  - functional requirements per this specification and its addenda and attachments
  - purpose of analysis
  - definition of design criteria and inputs with corresponding sources
  - results of literature searches and other applicable background data
  - applicable codes, standards, and reference documents per section 2 of this specification broken down by chapter, section, and paragraph, as applicable
  - analysis methodology
  - description of computer(s) used to conduct analysis
  - description of any software/computer programs used for modeling and any calculations required, including program name, program revision, description of program capabilities and limitations, justification for choice of program, and evidence and description of program validation method
  - assumptions (indicate those that must be verified as the design proceeds)
  - analyses conducted with results
  - summary of analysis results
  - conclusions
  - location for Buyer review signatures
- 3.19.6 All assumptions shall be plainly identified and data presented (including their uncertainty) with precise logic. Actual accomplishments of the work shall be clearly stated.
- 3.19.7 The final silver mordenite column design analysis report shall convey information to several disciplines, many of whom may be less familiar with the general subject than the authors. Care shall be taken to use simple statements and expressions and to make statements as concise as possible. If highly technical terms are necessary, they shall be adequately explained and defined.

### 3.20 Accessibility and Maintenance

Accessibility and maintenance requirements shall be per this specification and its addenda and attachments.

## 4 Materials

### 4.1 Construction

- 4.1.1 Materials used in the construction of the silver mordenite columns shall conform to the requirements of ASME AG-1, Article AA-3000, ASME AG-1a, Article HA-3000, and this specification. Material property and performance data for any materials not covered in ASME AG-1, ASME AG-1a or this specification shall be submitted to the Buyer for review prior to incorporation into the design of the silver mordenite columns. Performance data shall indicate that material is acceptable for environmental and specific service conditions.
- 4.1.2 All materials used in the construction of the silver mordenite columns shall be resistant to radiation levels indicated in subsection 3.5 of this specification and be able to operate under environmental and design conditions described in ASME N509, paragraph 4.4 and this specification.
- 4.1.3 Seller shall maintain a record of ASTM numbers, material test reports, and manufacturer material certifications for all materials used for construction of the silver mordenite columns, catwalk, support frame, and base support insulation. Seller shall provide copies to the Buyer.
- 4.1.4 All materials used in the manufacture of the silver mordenite columns, column support frames, and shims shall be new and unused. Where specific criteria are not provided, material selection shall be determined by the Seller and have properties and composition suitable for the specific service conditions and consistent with this specification and its addenda and attachments.
- 4.1.5 Dissimilar metal couples shall be avoided. Materials classified in different groups are considered dissimilar and incompatible due to corrosion potential.
- 4.1.6 The silver mordenite columns shall be made of the materials listed in the silver mordenite column data sheets in Section 2 of the MR. Adsorber cells, adsorber covers, and access roughing filter covers shall be constructed of 316 L stainless steel. The column platforms, catwalk, and toolboxes shall be made of 304 L stainless steel. All fasteners, hold-downs, and adsorber covers shall be 316 L or 304 L stainless steel.
- 4.1.7 The discharge roughing filter frame shall be composed entirely of 316 L stainless steel.

- 4.1.8 The insulation to be installed on the silver mordenite columns shall be calcium silicate jacketed with 304 stainless steel. Column support base insulation material shall be per Seller to meet concrete temperature requirement. The calcium silicate shall meet the requirements of ASTM C533, Type I, and shall be marked continuously to designate that no asbestos is present. The insulation thickness to be installed shall be as determined in the thermal analysis. The stainless steel jacketing shall be 0.024 inch thick flat and smooth sheet, and conform to ASTM A240. The jacketing shall be furnished in the annealed or soft condition with a regular 2B mill finish and have a factory applied moisture barrier.
- 4.1.9 Insulating materials shall be uniform in thickness when installed and without irregular surfaces, voids, gaps, or depressions greater than 1/8 inch. Use sectional, segmental, cut block, or preformed insulation and jackets as much as possible to enhance the uniformity. The Seller may use mineral wool blanket insulation on irregular surfaces and around intricate shapes. Column support base insulation material shall be per Seller to meet concrete temperature requirement.
- 4.1.10 Mineral wool insulation materials shall have less than 30 % cumulative shot as determined by ASTM C612, Annex A1. The density shall not be less than eight (8) pounds per cubic foot with a thermal conductivity of 0.40 Btu-inch square foot per °F at a mean temperature of 200 °F.
- 4.1.11 Cements, mastics, and adhesives used shall be suitable for the maximum design temperature of the silver mordenite columns. The mixing of cements, mastics, etc., shall be done with deionized water.
- 4.1.12 The following insulation holding materials are permissible:
- 18-gage wire
  - 0.025 inch × 3/4 inch wide straps (0.025 inch × 1/2 inch wide straps for 2 inch and smaller pipe)
  - 1 inch hexagonal mesh netting (0.025 inch three-twist stainless steel 18-8 wire)
  - wing seals
- 4.1.13 All calcium silicate and other insulating materials used on the silver mordenite columns shall be qualified for use on austenitic stainless steel in accordance with ASTM C795 by conforming to the preproduction test requirements of ASTM C692 and the confirming quality control requirements for chemical analysis of ASTM C871.
- 4.1.14 All insulation shall meet ASTM E84 fire hazard rating not to exceed 25 for flame spread and 50 for fuel contributed and smoke developed. Ratings used are determined by Underwriters Laboratories, Inc. (UL).
- 4.1.15 All insulation screws shall be stainless steel No. 8 × 1/2 inch self-drilling.
- 4.1.16 Silver mordenite to be supplied per this specification shall be C-Chem AG-900 (10X16 mesh, cylindrical pellets) hydrogen reduced silver mordenite.

- 4.1.17 Testing media to be used to conduct shop testing shall be identical in size and shape to C-Chem AG-900 (10 × 16 mesh, cylindrical pellets) hydrogen reduced silver mordenite. Testing media shall be compatible with all testing agents to be used in the testing and qualification of the silver mordenite columns. Testing media shall be compatible with the silver mordenite column materials of construction.
- 4.1.18 All stainless steel bolts and studs shall conform to ASTM F593.
- 4.1.19 All stainless steel nuts shall conform to ASTM F594.
- 4.1.20 Material used in the construction of silver mordenite column support frames shall be resistant to radiation levels indicated in subsection 3.5 on this specification.

## 4.2 Positive Material Identification

Refer to Buyer specification 24590-WTP-3PS-G000-TP002, *Specification for Positive Material Identification (PMI)*, for PMI requirements.

## 4.3 Prohibited Materials

- 4.3.1 Mercury and other low melting point metals, their alloys, or materials containing such metals as their basic constituents shall not be used in the construction of the silver mordenite columns, column support frames, or shims.
- 4.3.2 Molybdenum and halides shall not be used in direct contact with stainless steel.
- 4.3.3 Asbestos shall not be included in any component of the silver mordenite columns.
- 4.3.4 Carbon steel shall not be included in any component of the silver mordenite columns or catwalk.
- 4.3.5 Halide containing materials shall not be used in any component of the silver mordenite columns.

## 4.4 Storage of Special Materials (e.g., stainless steel) prior to work

- 4.4.1 Stainless steel is susceptible to corrosion caused by the contact and interaction with incompatible materials. All stainless steel material shall be stored in separate areas away from other materials.
- 4.4.2 Storage of silver mordenite and testing media shall be per the manufacturers instructions to prevent contamination and degradation. Silver mordenite and testing media storage requirements and instructions shall be provided by the Seller to the Buyer for review prior to purchase.
- 4.4.3 Storage of insulation and insulation components shall be per ASTM C929 and all other applicable codes, standards, and reference documents in section 2 of this specification.

## 5 Fabrication

### 5.1 General Requirements

- 5.1.1 The silver mordenite columns, catwalk, and column support frames shall be fabricated per this specification and the applicable documents listed in section 2 of this specification.
- 5.1.2 ASME Boiler and Pressure Vessel Code, Section VIII, Div. 1 shall only be applied to the fabrication of the housing pressure boundary of the silver mordenite columns. The housing pressure boundary shall be fabricated generally in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, Div. 1.
- 5.1.3 All tolerances, surface flatness, and finish requirements for assembly and fabrication shall be determined and specified by the Seller when completing the detailed design to meet performance requirements set forth in this specification and its addenda and attachments. At a minimum, all tolerances, surface flatness, and finish requirements shall be per this section and all applicable codes, standards, and reference documents in section 2 of this specification.
- 5.1.4 Identification of fabrication methods shall be included in the detailed design of the silver mordenite columns and column support frames.
- 5.1.5 All fabrication shall be performed by personnel qualified in accordance with this specification and applicable documents in section 2 of this specification.

### 5.2 Assembly

- 5.2.1 Flatness of the completed silver mordenite columns, catwalk, and column support frames shall be 1/8 inch per foot minimum, with no greater than 3/16 inch over the entire length, except for areas around cutouts. Areas around cutouts shall be flat within 1/16 inch per foot.
- 5.2.2 Cutout locations shall be within  $\pm 1/8$  inch and cutout size shall be within  $\pm 1/16$  inch.
- 5.2.3 The silver mordenite columns, catwalk, column support frames, and shims shall have rounded edges that are both smooth and not sharp to the touch.
- 5.2.4 The method of fabrication shall minimize the number and amount of seams, overlaps, or other discontinuities, which could trap radioactive contamination.

### 5.3 Tolerances

- 5.3.1 Thickness tolerances shall conform to the requirements of the referenced commercial standard. In the absence of such criteria, allowable thickness shall be plus 0.010 inch, minus 0.005 inch.

5.3.2 General dimension tolerances as a minimum shall be per the following:

Decimals -

- X.X  $\pm$  0.2 inches
- X.XX  $\pm$  0.12 inches
- X.XXX  $\pm$  0.062 inches

Angles -

- $\pm$  2°

5.3.3 Nozzle and flange alignment shall be within  $\pm$ 0.5 degrees of design conditions.

5.3.4 Tolerances for insulation sheet metal thickness and wire diameter shall be  $\pm$ 12 % of nominal.

## 5.4 Welding Fabrication Requirements

5.4.1 Seller shall develop detailed welding, weld inspection, NDE, and weld repair procedures for fabrication of the silver mordenite columns, catwalk, and support frame and submit them to the Buyer for review prior to fabrication. Procedures shall include acceptance criteria. The procedures shall conform to the following, as applicable:

- Buyer Specification 24590-WTP-3PS-SS00-T0002
- Buyer Specification 24590-WTP-3PS-NWP0-T0001
- ASME AG-1a, Article HA-6000
- ASME AG-1, Articles FD-6000 and FG-6000
- ASME Boiler and Pressure Vessel Code, Section VIII, Div. 1
- ASME B31.3, Category M Fluid Service
- AWS D1.6

5.4.2 Silver mordenite column welding, weld inspection, NDE, and weld repair shall be carried out in accordance with the applicable procedures developed per the previous paragraph.

5.4.3 Silver mordenite column welder qualifications shall be performed in accordance with ASME Section VIII or AWS as required.

5.4.4 Welding or material manipulation shall be carried out indoors and only when the ambient, piping, or plate temperature is above 41 °F, or higher where elevated temperatures are called for by a process.

5.4.5 Personnel performing silver mordenite column weld inspections shall be qualified in accordance with ASME AG-1, Paragraph AA-6335, ASME Boiler and Pressure Vessel Code, Section VIII, Div. 1, and Buyer specification 24590-WTP-3PS-SS00-T0002, *Specification for Welding of Structural Stainless Steel and Welding of Structural Carbon Steel to Structural Stainless Steel*.

- 5.4.6 Repairs required as a result of weld rejection by either the Buyer's or Seller's final inspection shall be fully documented in accordance with Seller's Quality Assurance Program (QAP). Silver mordenite column weld repairs shall be performed in accordance with ASME AG-1, subsubarticle AA-6330 and ASME Boiler and Pressure Vessel Code, Section VIII (housing pressure boundary only). Weld repair records shall be included with Seller's quality verification document package to be submitted to Buyer.
- 5.4.7 Joints and seams shall be fabricated in accordance with ASME AG-1a, subsubarticle HA-4330 and ASME Boiler and Pressure Vessel Code, Section VIII (housing pressure boundary only).
- 5.4.8 Each silver mordenite column procedure shall be prepared and qualified in accordance with the requirements of the listed specifications and standards in 5.4.1 above or ASME Section VIII, whichever is more stringent.
- 5.4.9 Seller shall develop detailed welding, weld inspection, NDE, and weld repair procedures for fabrication of the silver mordenite column support frames and submit them to the Buyer for review prior to fabrication. Procedures shall include acceptance criteria. Procedures shall be in accordance with Buyer specification 24590-WTP-3PS-SS00-T0002, *Engineering Specification for Welding of Structural Stainless Steel and Welding of Structural Carbon Steel to Structural Stainless Steel*.
- 5.4.10 Silver mordenite column support frame welding, weld inspection, NDE, and weld repair shall be carried out in accordance with the applicable procedures developed per the previous paragraph.
- 5.4.11 Silver mordenite column support frame welder qualifications shall be performed in accordance with Buyer specification 24590-WTP-3PS-SS00-T0002, *Engineering Specification for Welding of Structural Stainless Steel and Welding of Structural Carbon Steel to Structural Stainless Steel*.

## 5.5 Insulation

- 5.5.1 The Seller shall provide detailed insulation installation procedures complete with sketches showing methods and details for applying and securing insulation, metal jacketing, etc., to the silver mordenite columns and support frames. The insulation procedures shall be in accordance with PIP INIH1000, PIP INSH 2000, and NACE Standard RP0198, and this specification. The insulation installation procedures shall be reviewed by the Buyer prior to commencement of work to install insulation on the silver mordenite columns.
- 5.5.2 Insulation shall be stored, handled, and installed in accordance with the procedures developed per 5.5.1 above, PIP INSH2000, and Buyer specification 24590-WTP-3PS-G000-T0003, *General Specification for Packaging, Handling and Storage Requirements*.
- 5.5.3 Seller personnel used for supervising insulation installation shall have a minimum of five (5) years experience in such work. All other personnel shall have special training and will work under the supervision of personnel having a minimum of five (5) years experience. Training records for personnel shall be provided to Buyer's Representative upon request.
- 5.5.4 Surfaces to be insulated shall be dry and free of loose scale, dirt, and oil before the insulation is applied.

- 5.5.5 All insulation materials shall be stored, mixed, thinned, and applied in accordance with the manufacturer's printed instructions. All conflicts between this specification and the manufacturer's instruction shall be brought to the attention of the Buyer for resolution.
- 5.5.6 Insulation thicknesses greater than three (3) inch shall be applied in multiple layers with staggered joints. Each layer of multiple layer and double insulation shall be held in place separately.
- 5.5.7 Provide removable/replaceable insulation on flanges, manholes, doors, and access openings.
- 5.5.8 Stainless steel jacketing to be installed on curved surfaces and piping shall be machine rolled for circumferential fit.
- 5.5.9 Provide continuous jacketing with an overlap of 2 inch minimum between sections. Standard process industry practices shall be followed.
- 5.5.10 Exposed edges of stainless steel jacketing shall be machine-bent or rolled to eliminate sharp corners.
- 5.5.11 The jacketing shall be secured with 3/4 inch stainless steel bands. One-half inch stainless steel bands shall be used for 2 inch and smaller piping.
- 5.5.12 Securely fasten metal jacketing on flat surfaces of silver mordenite columns on maximum 18 inch centers.
- 5.5.13 All cut ends of wire shall be embedded into the insulation.
- 5.5.14 The use of screws as holding material for insulation is unacceptable.
- 5.5.15 No insulation shall be installed on the silver mordenite columns until a written release has been obtained from the Buyer's Representative by the Seller.

## 6 Tests and Inspections

### 6.1 General Requirements

- 6.1.1 The silver mordenite columns, catwalk between the column platforms, and column support frames shall be tested and inspected per this specification and the applicable documents listed in section 2 of this specification.
- 6.1.2 Seller shall conduct and be responsible for all testing and inspections required per this specification, applicable codes, applicable standards, and reference documents.
- 6.1.3 Seller shall submit a detailed test and inspection plan identifying all the inspections and tests planned, including recommended witness and hold points. Buyer's inspector will advise the Seller of witness and hold points and identify the shop tests that the Buyer intends to witness.

- 6.1.4 Seller shall develop and submit to Buyer detailed test procedures for conducting all shop and field acceptance testing required per this specification, applicable codes, standards, and reference documents for review by the Buyer prior to silver mordenite column fabrication. Procedures shall include acceptance criteria and detailed drawings of the shop and field testing configurations. Seller shall identify on drawings location of taps, ports, piping connections, and/or manifolds made on housing and ductwork in order to take measurements during shop and field tests. These taps, ports, piping connections, and/or manifolds shall be temporarily capped for use in the field during acceptance testing. Seller shall provide instructions on permanently sealing these taps after field acceptance testing. Drawings shall be scaleable and shall include plan and elevation views of the following:
- silver mordenite column
  - any Seller furnished materials, fittings, and ductwork required to perform the tests
  - Seller furnished discharge roughing filter
  - all Seller furnished equipment, apparatus, and instrumentation
- 6.1.5 Seller shall develop and submit to Buyer detailed testing and inspection procedures for conducting all testing and inspections required per this specification, applicable codes, standards, and reference documents for review by the Buyer prior to silver mordenite column fabrication.
- 6.1.6 Seller shall complete reports of all testing and inspections and submit them to Buyer. Reports shall identify the component tested, date performed, applicable test procedure, acceptance criteria, person performing the test or inspection, test results, and conclusions. Drawings of test setups shall be included. All testing and inspection results shall be certified.
- 6.1.7 Control and calibration of measuring and test equipment shall be in accordance with ASME AG-1, subsubarticle AA-5130.
- 6.1.8 All testing and inspection instruments used to conduct testing on the silver mordenite columns and column platform shall meet the requirements set forth in ASME AG-1, Article TA-3000. All testing and inspection instruments shall be in calibration and traceable to the appropriate national standard.
- 6.1.9 Any non-conforming work shall be redone by the Seller at Seller's cost.

## 6.2 Welding Inspection Requirements

- 6.2.1 Silver mordenite column welds shall be inspected, examined, and tested in accordance with ASME AG-1, subsubarticle AA-6330, ASME Boiler and Pressure Vessel Code, Section VIII, Div. 1 (housing pressure boundary only), Buyer specification 24590-WTP-3PS-SS00-T0002, *Specification for Welding of Structural Stainless Steel and Welding of Structural Carbon Steel to Structural Stainless Steel*, and Buyer specification 24590-WTP-3PS-NWP0-T0001, *Engineering Specification for General Welding and NDE Requirements for Supplier Fabricated Piping*. Surface inspections shall be performed using the dye penetrant method.

6.2.2 Silver mordenite column support frame welds shall be inspected, examined, and tested in accordance with Buyer specification 24590-WTP-3PS-SS00-T0002, *Engineering Specification for Welding of Structural Stainless Steel and Welding of Structural Carbon Steel to Structural Stainless Steel*.

### 6.3 Personnel Qualifications

6.3.1 All inspection and testing shall be performed by personnel qualified per the requirements set forth in this specification and all applicable documents in section 2 of this specification.

6.3.2 Seller shall submit personnel qualification documents, including years of experience for Seller's inspection and test personnel, for Buyer review.

### 6.4 Shop Tests

6.4.1 Seller shall provide all materials, labor, tools, equipment, apparatus, instrumentation, testing media, and challenge gas to conduct all shop testing on the silver mordenite columns.

6.4.2 All shop tests requiring that adsorbent media be installed in the silver mordenite columns shall be conducted using silver mordenite if available in time to meet delivery schedule requirements in Section 1 of the MR. The Seller shall ensure that the silver mordenite does not become contaminated or degraded at any time before, during, or after completion of shop testing.

6.4.3 In the event that the silver mordenite is not available in time for shop acceptance testing due to silver mordenite production limitations, testing media shall be used. Testing media shall be loaded into adsorber cells and tested per applicable portions of ASME AG-1, Article FD-5000. Seller shall issue manufacturer's information for testing media to the Buyer for review prior to purchase.

6.4.4 Seller shall conduct the following acceptance tests in the shop on each unit using air at ambient temperature, with exception to the airflow distribution test (which shall be performed on a single column to verify design), prior to shipment:

- Visual Inspection
- Structural Capability Test
- Mounting Frame Pressure Leak Test
- System Bypass Test
- Differential Pressure Test
- Airflow Distribution Test

All silver mordenite column shop acceptance testing procedures shall conform to ASME AG-1 (Section TA), N509 (Section 9), and ERDA 76-21 (Chapter 8).

- 6.4.5 Pneumatic testing per ASME Boiler and Pressure Vessel Code, Section VIII, Div. 1 shall be conducted on the silver mordenite column housing pressure boundary. **U-stamp and National Board Registration for the silver mordenite columns are not required.**
- 6.4.6 Structural Capability Test: Conduct at (+) 4 psig and (-) 4 psig and ambient conditions.
- 6.4.7 Mounting Frame Pressure Leak Test: Leakage shall not exceed 0.2 % of design flowrate at a minimum testing pressure equal to 150 % of maximum operating pressure.
- 6.4.8 System Bypass Test: At  $\pm 10$  % of design flowrate through the silver mordenite column, challenge gas leakage rate shall not exceed 0.1 % at 99.9 % efficiency.
- 6.4.9 The Seller shall conduct proof testing in-situ on the silver mordenite column, catwalk, and support frame lifting points in the shop.
- 6.4.10 All test results shall be documented, certified, and submitted to the Buyer for review.

## 6.5 Field Tests

- 6.5.1 Seller shall provide the services of a technical representative during all field testing required per this specification, applicable codes, applicable standards, and reference documents. Seller shall provide all tooling, equipment, material, apparatus, instrumentation, and challenge gas necessary to conduct all field testing and inspections.
- 6.5.2 All silver mordenite column field acceptance testing procedures shall conform to ASME AG-1 (Section TA), N509 (Section 9), and ERDA 76-21 (Chapter 8).

## 6.6 Bag-in/Bag-out Procedure Demonstration

- 6.6.1 Seller shall provide all personnel, equipment, apparatus, labor, PPE (if applicable), materials, film, special tools, glovebags, bags, HEPA filters, etc. to simulate field conditions, demonstrate, and videotape the bag-in/bag-out procedure to be provided by the Seller per this specification.
- 6.6.2 Demonstration shall be conducted in Seller's shop on one (1) of the fully assembled silver mordenite columns and witnessed by Buyer's Representatives. The column to be used for the demonstration shall be chosen by the Buyer.
- 6.6.3 Demonstration shall include removal and replacement of one adsorber cell loaded with silver mordenite (or testing media) and the discharge roughing filter(s) for one of the silver mordenite columns. Actual adsorber cell to be removed shall be chosen by the Buyer.
- 6.6.4 When conducting the demonstration, Seller personnel shall be wearing all PPE required per the final bag-in/bag-out procedure.
- 6.6.5 Field conditions shall be simulated in the shop when performing the bag-in/bag-out procedure demonstration, which will include pulling a vacuum on the silver mordenite column and imposing crane clearance, room clearance, and lifting constraints shown in Figure 3 and Figure 4.

## 7 Preparation for Shipment

### 7.1 General Requirements

- 7.1.1 The silver mordenite columns, and catwalk shall be packaged/prepared for shipment, handled, and stored in accordance with Buyer specification 24590-WTP-3PS-G000-T0003, and ASME AG-1a, Article HA-7000 (Level C).
- 7.1.2 The silver mordenite column adsorbers shall be packaged/prepared for shipment, handled, and stored in accordance with Buyer specification 24590-WTP-3PS-G000-T0003, and ASME AG-1, Article FF-7000 (Level B).
- 7.1.3 The silver mordenite columns, adsorbers, catwalk, column support frames, and shims shall not be packaged for shipping until all shop tests and inspections have been performed and the Buyer's Representative reviews the results.
- 7.1.4 Silver mordenite column support frames and shims shall be packaged/prepared for shipment, handled, and stored in accordance with Buyer specification 24590-WTP-3PS-G000-T0003, *General Specification for Packaging, Handling and Storage Requirements*.

### 7.2 Cleanliness

- 7.2.1 Cleanliness shall be per the applicable documents in Paragraphs 7.1.1 and 7.1.2 above.
- 7.2.2 Solvents and cleaning solutions used on stainless steel shall have a halogen content of less than 200 ppm.

### 7.3 Painting

If applicable, support frames and shims shall be primed. Surface preparation, primer application, inspection, and repair shall be in accordance with Buyer specification 24590-WTP-3PS-AFPS-T0001, *Shop Applied Special Protective Coatings for Steel Items and Equipment*.

### 7.4 Tagging

- 7.4.1 Tagging of the silver mordenite columns shall be as specified in ASME AG-1a, Article HA-9000 and shall include associated plant item number specified in the attached data sheets that are in Section 2 of the MR.
- 7.4.2 A stainless steel nameplate shall be rigidly attached to the northwest corner of the silver mordenite column housings (refer to Figure 3) in a prominent position for ease of visibility and include:
- manufacturer's name
  - shop location
  - date of manufacture
  - serial number

- equipment ratings (pressure, flow, temperature)
- plant item number
- weight of assembly
- purchase order number

7.4.3 Nameplates shall be visible after the insulation is installed, or a duplicate nameplate shall be provided on the top of the insulation.

7.4.4 All field testing materials and filters shall be tagged as required for field testing.

7.4.5 A stainless steel nameplate shall be rigidly attached to the northwest corner of the silver mordenite column support frames and include:

- Manufacturer's name
- Shop location
- Date of manufacture
- Serial number
- Plant item number for associated silver mordenite column
- Weight
- Purchase order number

## 7.5 Packaging

Packaging shall be per Paragraphs 7.1.1 and 7.1.2 above.

## 7.6 Documentation

7.6.1 Seller shall ensure that appropriate documentation is prepared and, if required, signed by the appropriate person (s). The shipping documentation shall accurately reflect specific traceability to the items being shipped.

7.6.2 Seller shall ensure that appropriate documentation is prepared for the silver mordenite columns, catwalk, column support frames, and shims. At a minimum, documentation shall include the following information, as applicable:

- Manufacturer name, model number, and serial number
- Plant Item Number

## 7.7 Shipment Preparation Instructions

Shipment of items shall be conducted in accordance with ASME AG-1a, Article HA-7300, Buyer specification 24590-WTP-3PS-G000-T0003, and ASTM C929.

7.7.1 The silver mordenite columns shall be shipped as completely assembled except for adsorbers. Adsorbers and catwalk shall be shipped separately.

- 7.7.2 Weatherproof shipping lists (two per packaged item) shall be prepared and submitted, and shall clearly identify the contents of each package sent to the Buyer. All submittals and shipping boxes shall be identified with the Buyer's purchase order number.
- 7.7.3 Buyer shall provide a complete identification and location of temporary material contained within the equipment for shipment, handling, or storage that must be removed prior to commissioning (e.g., shipping blocks, desiccant bags, components shipped inside larger sections, etc.). In addition, the Seller shall provide instructions for removal of temporary materials, as required.
- 7.7.4 The silver mordenite columns, adsorbers, catwalk, column support frames, and shims shall be mounted on skids, in crates, or in boxes as suited for the intended method of transport. Lifting weight and center of gravity shall be clearly marked on both the equipment and its shipping documents.

## 8 Quality Assurance

### 8.1 General Requirements

- 8.1.1 The Seller's QAP Requirements are included in Buyer specification 24590-WTP-3PS-G000-T0001, *General Specification for Supplier Quality Assurance Program Requirements*.
- 8.1.2 Seller's QAP Manual shall be submitted to Buyer for review in accordance with Buyer specification 24590-WTP-3PS-G000-T0001, *General Specification for Supplier Quality Assurance Program Requirements*.
- 8.1.3 Seller's QAP, as a minimum, shall contain the requirements detailed in the Supplier Quality Assurance Program Requirements Data Sheets listed in Section 2 of the MR.

### 8.2 Quality (Q) Related Components

- 8.2.1 Seller shall have in place a QAP meeting the requirements of ASME-NQA-1, marked as applicable in Supplier Quality Assurance Program Requirements Data Sheet attached to the MR, and Buyer specification 24590-WTP-3PS-G000-T0001, *General Specification for Supplier Quality Assurance Program Requirements*.
- 8.2.2 The successful bidder must pass a pre-award survey by the Buyer. Seller shall demonstrate that its quality program is in compliance with the procurement quality requirements listed in the Supplier Quality Assurance Program Requirements Data Sheet. The Seller shall allow the Buyer, its agent, and DOE access to their facility and records pertaining to this purchase order for the purpose of Quality Assurance (QA) Audits and Surveillance at mutually agreed times.
- 8.2.3 All items shall be manufactured in accordance with the Seller's QAP that meets the requirements of ASME NQA-1, and has been previously evaluated and accepted by the WTP Quality Organization.

- 8.2.4 Seller shall submit their QAP and work plan to Buyer for review prior to commencement of work. The plan shall include documents and procedures to implement the work and include a matrix of essential QA elements cross referenced with the documents/procedures.

## 9 Configuration Management

Equipment and/or components covered by this specification are identified with Plant Item Numbers shown in the attached data sheets in Section 2 of the MR. Each item shall be identified in accordance with Tagging in section 7 of this specification.

## 10 Documentation and Submittals

### 10.1 General

- 10.1.1 Seller shall submit to Buyer all detailed designs, documentation, procedures, instructions, calculations, analyses, models, manufacturer data, inspection reports, test reports, certifications, certificates, manuals, MSDSs, video tapes, and drawings required per this specification, the applicable codes, standards, and reference documents in section 2 of this specification, and the MR.
- 10.1.2 All detailed designs, drawings, shop drawings, supporting calculations, supporting analyses, supporting models, procedures, instructions, manufacturer data, operation manuals, and maintenance manuals shall be issued to the Buyer for review prior to manufacture of the silver mordenite columns, column catwalk, special tools, and/or the purchase of special tools, filters, and gaskets.
- 10.1.3 Seller shall submit storage requirements and instructions for Buyer's review.
- 10.1.4 Seller shall submit to Buyer Engineering and Quality Verification documents in the forms and quantities shown in Form G-321-E, Engineering Document Requirement, and Form G-321-V, Quality Verification Document Requirements attached to the MR.
- 10.1.5 Seller shall submit a report identifying any deviations and/or conflicts per Section 2 of the MR to the Buyer for review.
- 10.1.6 Each documentation transmittal package shall have a documentation inventory sheet attached listing all documents and the number of pages each.
- 10.1.7 Data sheets in Section 2 of the MR shall be marked-up by the Seller and submitted to the Buyer for review with the detailed design. Seller shall fill in all information that is marked as TBD and mark-up actual overall silver mordenite column dimensions based on the detailed design.
- 10.1.8 Seller shall provide all operation manuals, maintenance manuals, and spare parts lists for silver mordenite column components, as applicable.

## 10.2 30 % Design Review

- 10.2.1 Seller shall conduct a 30 % design review with the Buyer. Seller shall submit all drawings, procedures, calculations, analyses, and information necessary to conduct the 30 % design review to the Buyer for review.
- 10.2.2 Finalized outline dimensions of the silver mordenite columns, catwalk, and support frame shall be included in the 30 % design review. Finalized dimensions shall, at a minimum, include the following:
- overall dimensions for silver mordenite columns
  - silver mordenite column inlet and outlet nozzle locations
  - roughing filter location and size
  - testing port and manifold locations and size
  - adsorber cell overall dimensions
  - mounting details (anchor size, location, layout, etc.)
  - dimensioned layout of silver mordenite columns showing column inlet and outlet locations, discharge roughing filter locations, ladder location, testing port locations, manifold locations, and openings in column platform guardrails
  - dimensioned layout of the catwalk and column supports frames.
  - preliminary bag-in/bag-out plan
- 10.2.3 Provide maximum allowable inlet and outlet nozzle loadings in all directions with column material yield strength value for silver mordenite columns per thermal analysis results.
- 10.2.4 Provide silver mordenite column anchorage design loads.
- 10.2.5 Provide MSDS for Seller's recommended challenge gas.

## 10.3 90 % Design Review

Seller shall conduct a 90 % design review with the Buyer. Seller shall submit all drawings, procedures, calculations, analyses, and information necessary to conduct the 90 % design review to the Buyer for review.

## 10.4 Drawings

- 10.4.1 Seller shall provide all drawings required per this specification and the applicable documents in section 2 of this specification.
- 10.4.2 All drawings shall be produced per the drawing practices set forth in ASME Y14.100, Engineering Drawing Practices.

## 10.5 Calculations

All calculations to be provided shall be orderly, complete, and sufficiently clear to permit verification. The body of the calculations shall include:

- a concise statement of the purpose of the calculation
- input data, applicable criteria, and stated assumptions
- a list of references used, including drawings, codes, standards, and computer programs (indicate the version or issue date)
- a discussion of rationale used for design assumption basis
- equations used for all computations
- numerical calculations including identification of units used
- a concise statement addressing the calculation results and/or recommendations
- a table of contents for complex calculations

## 10.6 Schedules

10.6.1 A detailed schedule of engineering, document submittals, material purchases, fabrication, shop tests, and shipment shall be submitted.

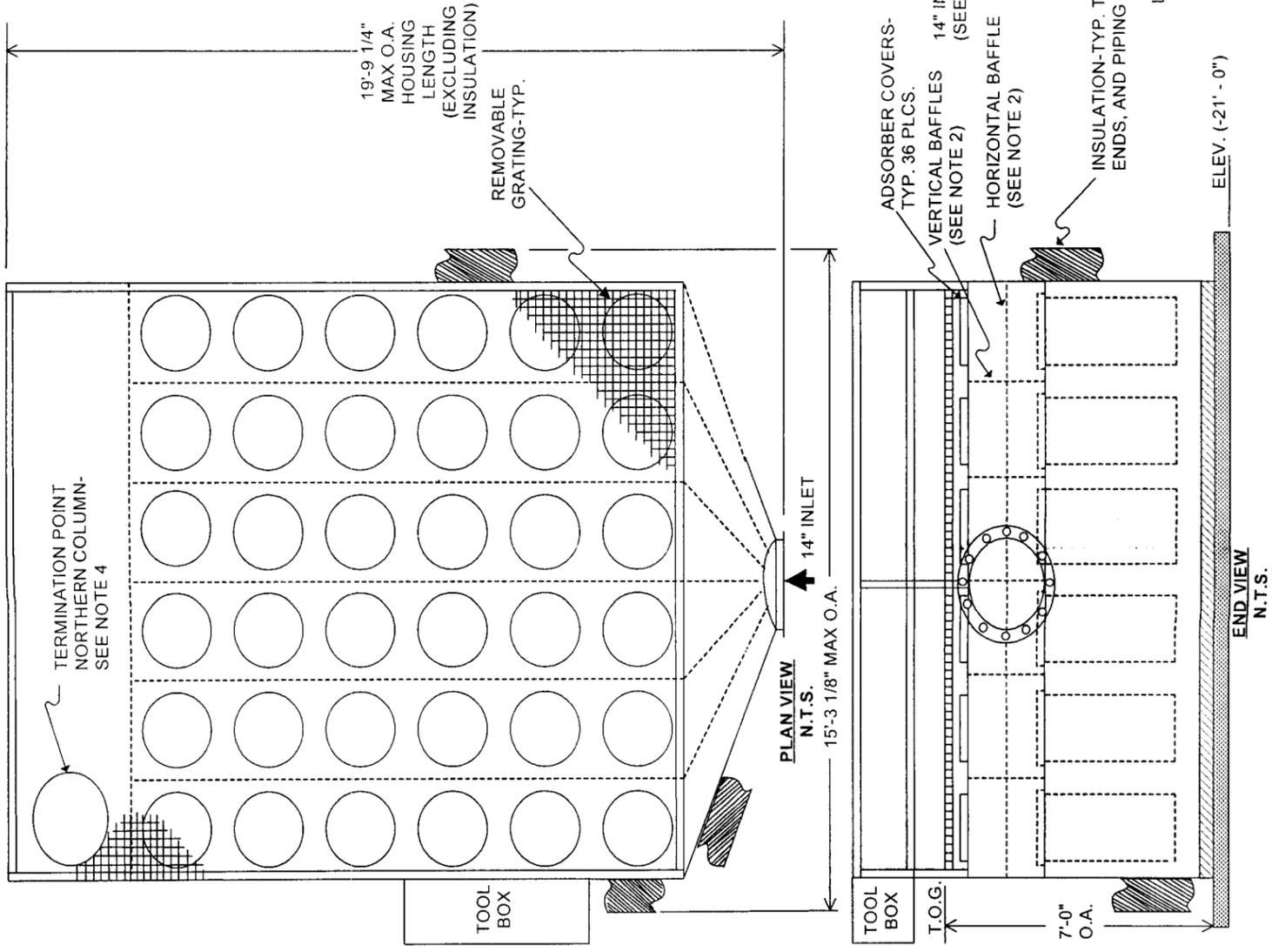
10.6.2 All procedures and instructions shall be completed and submitted to the Buyer a minimum of eight (8) weeks prior to silver mordenite column, catwalk, and support frame shipment.

# 11 References

### Incorporated Design Changes

- 24590-WTP-SDDR-PROC-03-0003
- 24590-WTP-SDDR-PROC-03-0137
- 24590-WTP-SDDR-PROC-03-0138
- 24590-WTP-SDDR-PROC-03-0139
- 24590-WTP-SDDR-PROC-03-0252
- 24590-HLW-3PN-MBT0-00002
- 24590-WTP-SDDR-PROC-03-0385
- 24590-WTP-SDDR-PROC-03-0411
- 24590-HLW-3PN-MBT0-00003
- 24590-WTP-SDDR-PROC-04-00132
- 24590-WTP-SDDR-PROC-04-00136
- 24590-WTP-SDDR-PROC-04-00200
- 24590-WTP-SDDR-PROC-04-00202
- 24590-WTP-SDDR-PROC-04-00256
- 24590-WTP-SDDR-PROC-04-00300

Figure 1  
Typical Silver Mordenite Column



NOTES:

1. ALL COMPONENTS SHOWN OR IMPLIED IN THIS FIGURE SHALL BE CONSIDERED PART OF THE SILVER MORDENITE COLUMNS TO BE SUPPLIED TO THE BUYER BY THE SUPPLIER. THIS FIGURE ONLY REPRESENTS A PROPOSED DESIGN AND LAYOUT. A DETAILED DESIGN WITH CALCULATIONS, ANALYSIS, AND MODELING WILL BE REQUIRED TO DETERMINE ACTUAL DESIGN AND LAYOUT DETAILS. THIS FIGURE IS TYPICAL OF BOTH SILVER MORDENITE COLUMNS TO BE PROVIDED PER THIS SPECIFICATION.
2. HORIZONTAL BAFFLES, VERTICAL BAFFLES, MIXING VANES, AND CROSS-VENTING HOLES SHALL BE INCLUDED (AS REQUIRED) TO ACHIEVE UNIFORM OFFGAS FLOW DISTRIBUTION THROUGH THE COLUMN ADSORBERS.
3. OVERALL DIMENSIONS SHOWN FOR SILVER MORDENITE COLUMN SHALL NOT BE EXCEEDED. ONLY THE HOUSING OUTLET SHALL BE ABLE TO EXTEND ABOVE THE PLATFORM. EVERY EFFORT SHALL BE MADE BY THE SUPPLIER TO MINIMIZE THE OVERALL DIMENSIONS OF THE SILVER MORDENITE COLUMN WHILE STILL MEETING THE REQUIREMENTS OF THIS SPECIFICATION.
4. THE HOUSING OUTLET CONFIGURATION IS NOT SHOWN. ONLY THE REQUIRED OUTLET TERMINATION POINT IS SHOWN. THE HOUSING OUTLET SHALL BE 14 INCH AND SHALL BE ROUTED TO ENABLE CONNECTION TO VERTICAL PIPING AS SHOWN IN FIGURE 4. THE OUTLET SHALL TERMINATE FACING IN THE UPWARD DIRECTION. THE CONFIGURATION OF THE HOUSING OUTLET SHALL BE DETERMINED BY THE SUPPLIER TO ACHIEVE UNIFORM OFFGAS FLOW DISTRIBUTION THROUGH THE SILVER MORDENITE COLUMN. THE HEIGHT OF THE OUTLET ABOVE THE PLATFORM SHALL BE MINIMIZED. DIMENSION SHALL ONLY BE AS TALL AS NECESSARY TO ENABLE REPLACEMENT OF THE DISCHARGE ROUGHING FILTER FROM THE PLATFORM.
5. TESTING, SAMPLING, AND PRESSURE DROP CONNECTIONS AND MANIFOLDS NOT SHOWN.
6. FASTENERS AND HOLD-DOWNS NOT SHOWN.
7. PLATFORM ACCESS LADDER TO BE INSTALLED ON ONLY ONE (1) OF THE COLUMNS IS NOT SHOWN. OPENING IN GUARDRAIL FOR ACCESS LADDER SHALL HAVE SAFETY GATE OR CHAIN INSTALLED.
8. MOUNTING CHANNEL BASE WITH ANCHORAGE PROVISIONS NOT SHOWN.
9. OPENING IN GUARDRAILS FOR ADSORBER REMOVAL, WITH SAFETY GATE OR CHAIN INSTALLED, IS NOT SHOWN. GUARDRAIL SHALL NOT BE INSTALLED BETWEEN COLUMN PLATFORMS (REFER TO FIGURE 3).
10. HEIGHT OF INLET CENTERLINE SHALL BE 5'-6 1/2" FROM THE TOP OF THE FOUNDATION CONCRETE SLAB.
11. MAX SKIN TEMPERATURE FOR INSULATED AND UNINSULATED PORTIONS OF TOP, SIDES, ENDS, AND PIPING, WITH POTENTIAL FOR PERSONNEL EXPOSURE, SHALL NOT EXCEED 140F.
12. COLUMN SUPPORT FRAME SHALL NOT EXCEED AN OVERALL LENGTH OF 19'-9 1/2" (EXCLUDING INSULATION) AND AN OVERALL WIDTH OF 15'-3 1/8" (INCLUDING INSULATION).

ACRONYMS/ABBREVIATIONS

FLG.	FLANGE
S.S.	STAINLESS STEEL
PLCS.	PLACES
N.T.S.	NOT TO SCALE
T.O.G.	TOP OF GRATING
O.A.	OVERALL
THK.	THICK
TYP.	TYPICAL

Figure 2 Typical Silver Mordenite Column Adsorber

NOTES:

1. ADSORBERS SHALL BE SIZED TO FIT INSIDE OF A STANDARD 55-GALLON DRUM, NOT INCLUDING LUG FOR LIFTING.
2. ADSORBER CELLS SHALL BE ALL 316L STAINLESS STEEL CONSTRUCTION.
3. THIS FIGURE REPRESENTS TYPICAL CONFIGURATION FOR ALL SILVER MORDENITE ADSORBERS (36 EACH COLUMN).
4. ADSORBER LIFTING LUG SHALL BE SECURELY ATTACHED TO EACH ADSORBER DURING OPERATION OF THE SILVER MORDENITE COLUMNS, BUT SHALL BE REMOVABLE.
5. LIFTING LUG CONFIGURATION SHOWN IS ONLY PRELIMINARY. ACTUAL CONFIGURATION FOR LIFTING LUG SHALL BE DETERMINED BY THE SUPPLIER WHEN COMPLETING THE DETAILED DESIGN.

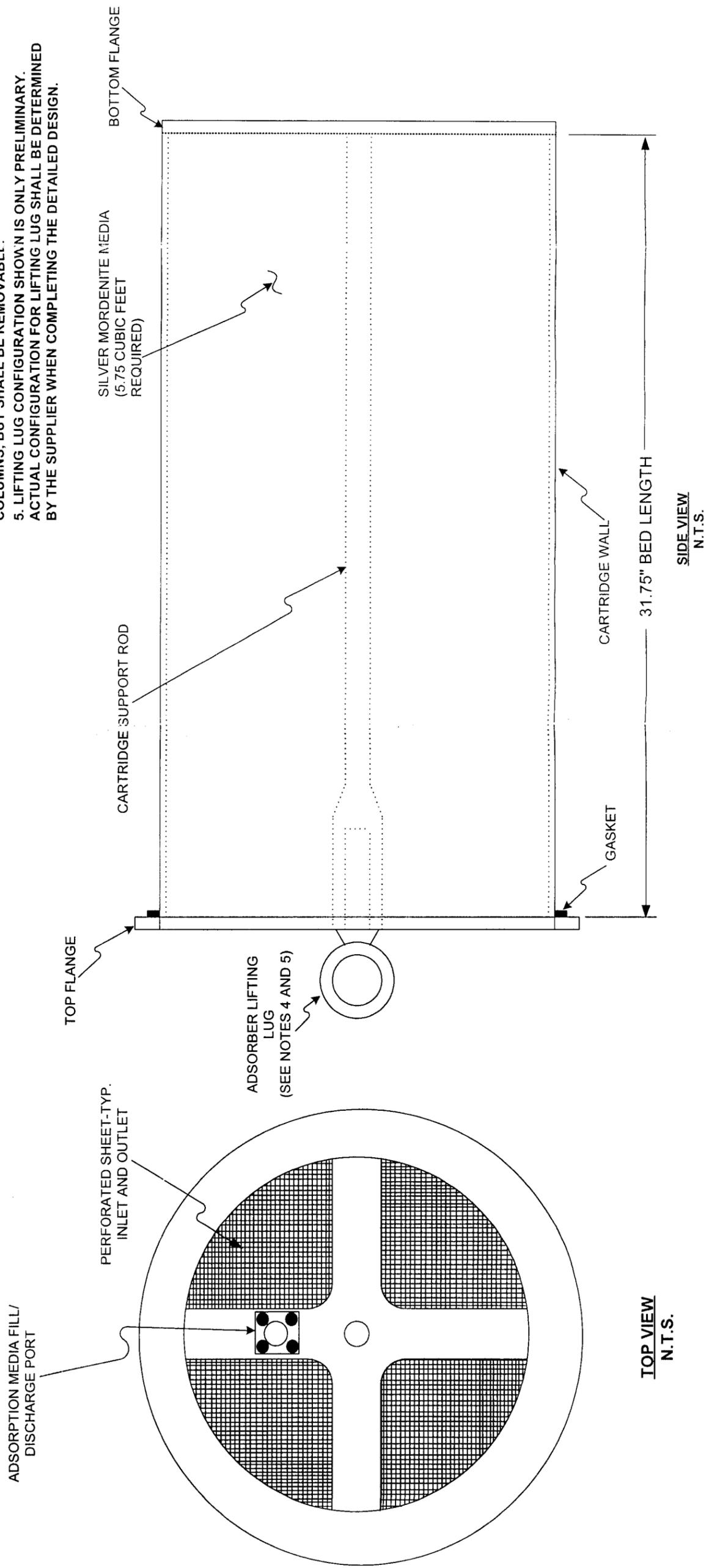
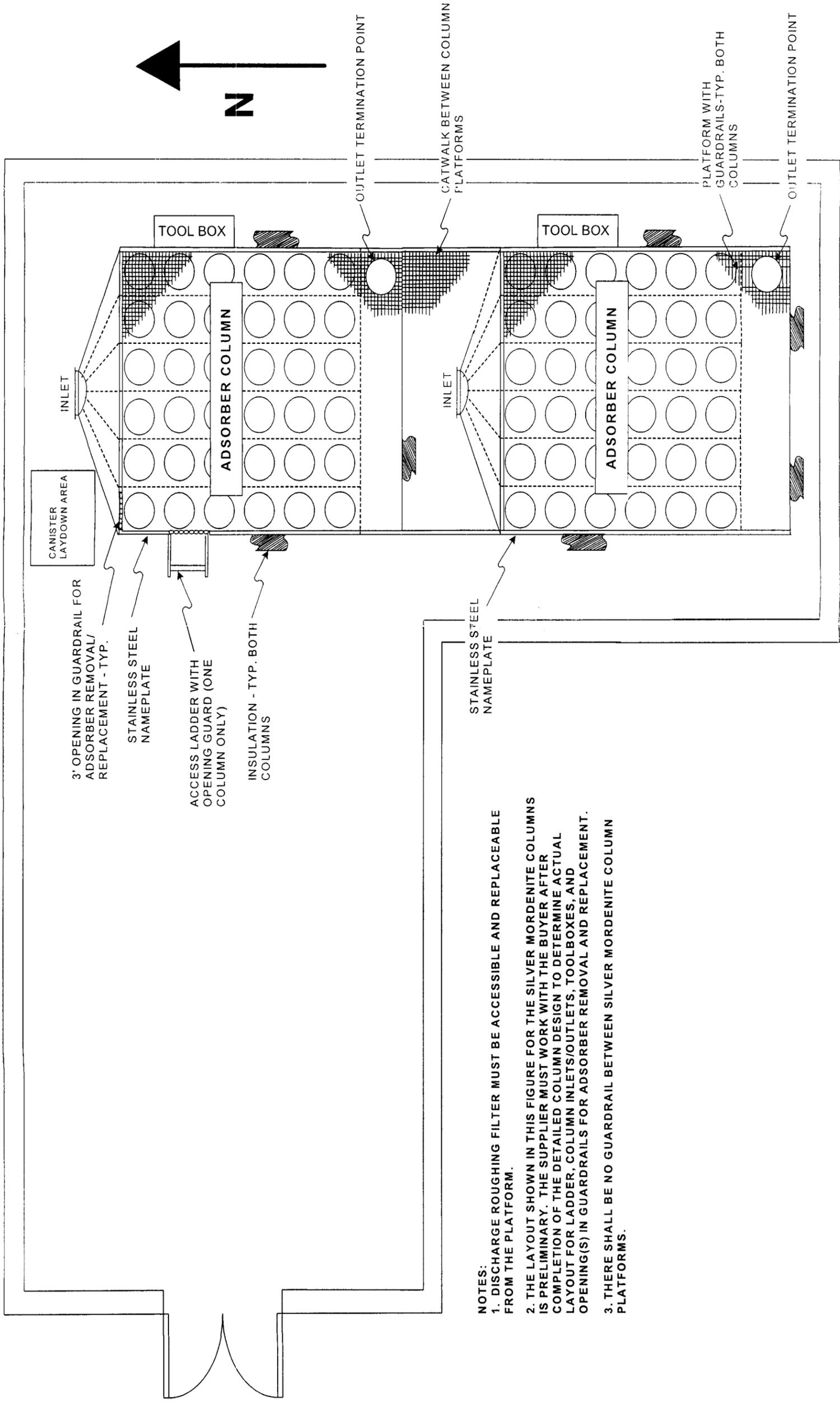


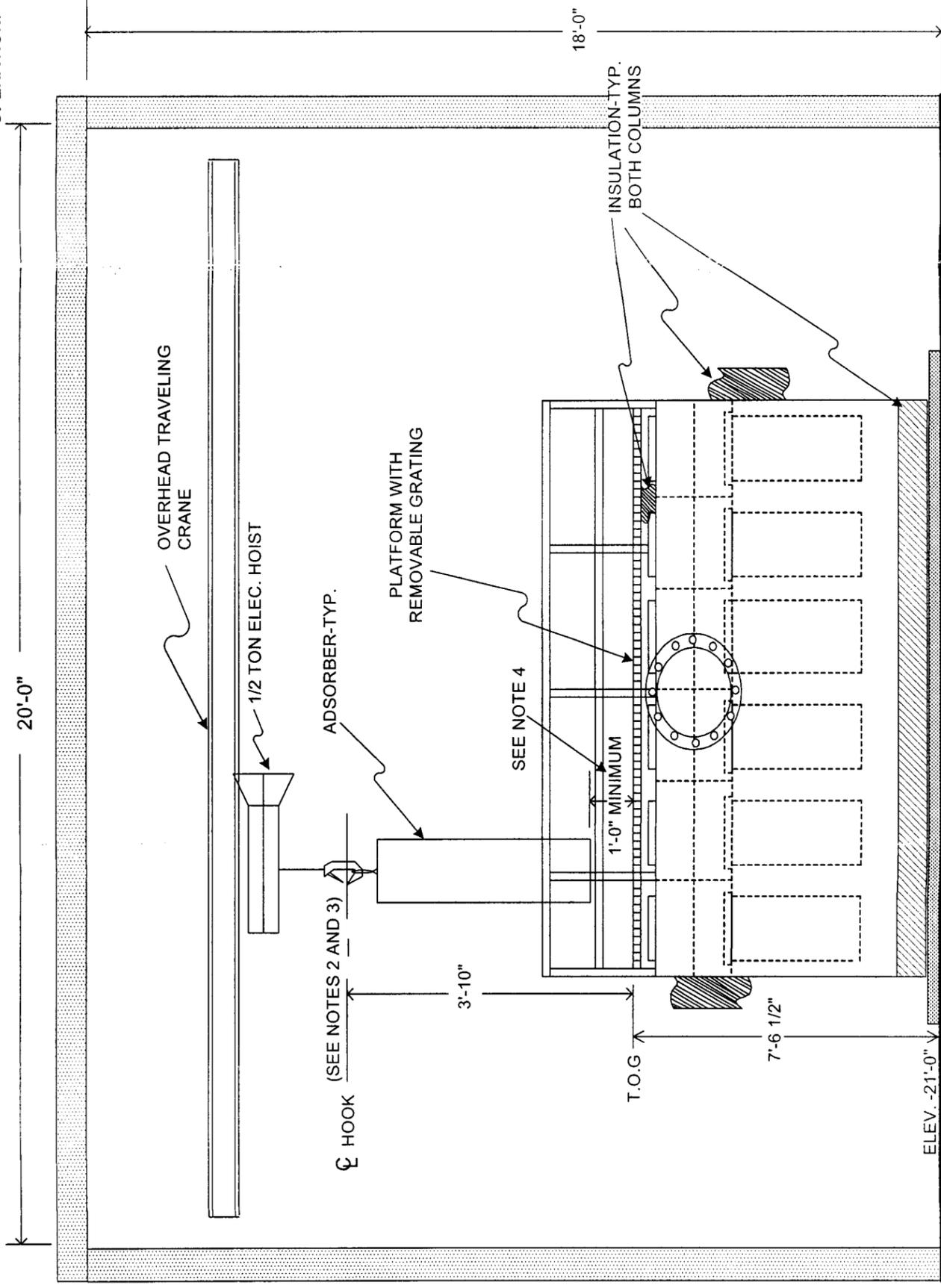
Figure 3 Silver Mordenite Column Layout in HLW Facility



- NOTES:
1. DISCHARGE ROUGHING FILTER MUST BE ACCESSIBLE AND REPLACEABLE FROM THE PLATFORM.
  2. THE LAYOUT SHOWN IN THIS FIGURE FOR THE SILVER MORDENITE COLUMNS IS PRELIMINARY. THE SUPPLIER MUST WORK WITH THE BUYER AFTER COMPLETION OF THE DETAILED COLUMN DESIGN TO DETERMINE ACTUAL LAYOUT FOR LADDER, COLUMN INLETS/OUTLETS, TOOLBOXES, AND OPENING(S) IN GUARDRAILS FOR ADSORBER REMOVAL AND REPLACEMENT.
  3. THERE SHALL BE NO GUARDRAIL BETWEEN SILVER MORDENITE COLUMN PLATFORMS.

Figure 4 Crane Layout with Clearance Limitations for Silver Mordenite Adsorber Replacement

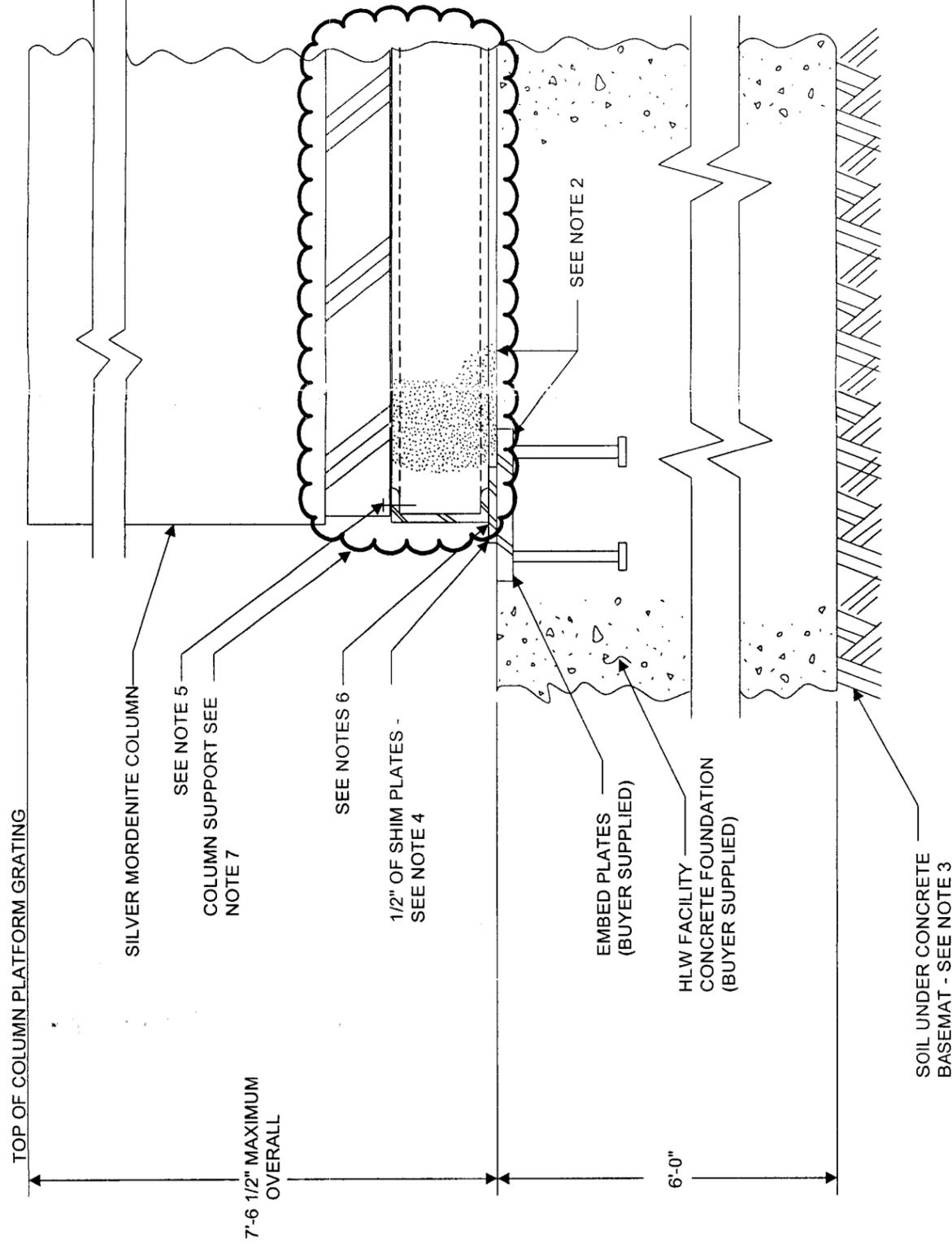
- NOTES:
1. REFER TO FIGURE 3 FOR ROOM LAYOUT.
  2. MAXIMUM CRANE HOOK LIFT HEIGHT.
  3. SUPPLIER MAY PROPOSE USING SOMETHING OTHER THAN A CRANE HOOK AS REQUIRED TO MEET SPECIFICATION REQUIREMENTS (E.G. GRAB, GRAPPLE, ETC.).
  4. CLEARANCE FROM T.O.G. TO BOTTOM OF ADSORBER SHALL BE 1'-0" AT MINIMUM TO ENABLE COMPLETION OF BAG-IN/BAG-OUT OPERATION.



ACRONYMS/ABBREVIATIONS

FLG.	FLANGE
S.S.	STAINLESS STEEL
PLCS.	PLACES
N.T.S.	NOT TO SCALE
T.O.G.	TOP OF GRATING
O.A.	OVERALL
THK.	THICK

Figure 5 Silver Mordenite Column Support Frame and Anchorage



NOTES:

1. ALL ITEMS SHOWN IN THIS FIGURE SHALL BE SUPPLIED BY SELLER UNLESS IDENTIFIED AS BUYER SUPPLIED.
2. SURFACE TO CONCRETE INTERFACES SHALL NOT EXCEED 100 F. EMBED PLATE TO CONCRETE INTERFACES SHALL NOT EXCEED 150 F.
3. DATA REGARDING SOIL TEMPERATURE BELOW CONCRETE BASEMAT IS UNAVAILABLE.
4. SHIM PLATES ARE FOR LEVELING FRAME PRIOR TO MOUNTING SILVER MORDENITE COLUMN. SHIM PLATES SHALL BE SUPPLIED BY SELLER.
5. BOLTS/STUDS SHALL BE USED TO ANCHOR SILVER MORDENITE COLUMN TO COLUMN SUPPORT FRAME. ANCHOR BOLTS/STUDS SHALL EITHER BE WELDED TO FRAME OR MECHANICALLY FASTENED BY SELLER IN SHOP (I.E., GROUTING OF ANCHOR BOLTS IS NOT PERMITTED).
6. AFTER COLUMN SUPPORT FRAME IS LEVELED ON SHIMS, SHIM PLATES SHALL BE FIELD WELDED TOGETHER AND FIELD WELDED TO EMBED PLATES BY BUYER. SUPPORT FRAME SHALL BE FIELD WELDED TO SHIMS BY BUYER. SELLER SHALL PROVIDE WELDING PROCEDURE, SPECIFY WELD TYPES, AND SPECIFY EXTENT OF WELDING REQUIRED.
7. SELLER SHALL DESIGN COLUMN SUPPORT FRAME TO MEET THERMAL AND SEISMIC REQUIREMENTS OF THIS SPECIFICATION. THE HEIGHT OF COLUMN SUPPORT SHALL NOT EXCEED 12 INCHES.