



SPECIFICATION  
FOR  
Metal Ducting

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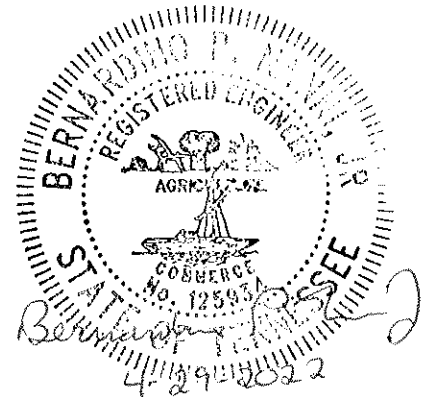
# TECHNICAL SPECIFICATION

FOR

ORNL Building 4501  
Exhaust Stack Modifications

Metal Ducting

23 31 13



PROPRIETARY INFORMATION

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PROJECT MANAGER	NAME Kevin Westervelt	PROJECT NAME	ORNL Building 4501 Exhaust Stack Modifications
		PROJECT NO.	21680004
<b>APPROVED BY:</b>	<b>DATE:</b>	TITLE	Metal Ducting
PREPARED	NAME Bernardino Nanni 4/25/22	SPEC NO.	23 31 13
CHECKED	NAME Colby Summers 4/27/22		
LEAD ENGINEER	NAME Bernardino Nanni 4/27/22		
PROJECT ENGINEER	NAME Alex Snyder 04/29/22	REV.	0
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**REVISIONS**

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REVISION TO UT BATTELLE CSI SPECIFICATION SECTION 23 31 13 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

- 1. Single-wall round ducts and fittings.
- 2. Sheet metal materials.
- 3. Sealants and gaskets.
- 4. Hangers and supports.

B. Related Sections:

- 1. Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.

1.3 PERFORMANCE REQUIREMENTS

- A. Delegated Duct Design: The Seller shall be responsible for detail design of the Makeup Air duct system including liner, stiffeners, flanges, hardware, and gasketing as may be required to meet the design conditions. Sheet metal thicknesses, seam and joint construction, flanges, and reinforcements shall comply with SMACNA's "Round Industrial Duct Construction Standard" and performance requirements and design criteria indicated in "Duct Schedule" Article.
- B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.4 ACTION SUBMITTALS

- A. Work on this project is to be completed in accordance with fabricators approved ASME NQA-1 program. Fabricator/constructor shall submit for review/approval their NQA-1 policies and procedures.
- B. Product Data: For each type of the following products:



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1. Gasket Material
2. Hardware

C. Submittals:

1. Leakage Test Report for Prerequisite EA 2: Documentation of work performed for compliance with ASHRAE/IESNA 90.1, Section 6.4.4.2.2 - "Duct Leakage Tests."
2. Duct-Cleaning Test Report for Prerequisite IEQ 1: Documentation of work performed for compliance with ASHRAE 62.1, Section 7.2.4 - "Ventilation System Start-up."
3. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.
4. Proposed changes to duct layout.

D. Shop Documentation:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement calculation that the gauge, stiffener size, and spacing meet the design requirements.
8. Seam and joint construction details.
9. Equipment installation based on equipment being used on Project.
10. Indicate welds by standard AWS symbols, distinguishing between shop and field welds, and show size, length, and type of each weld.
11. Indicate type, size, and length of hardware.

E. Fabricator shall provide their Welding Procedure Specifications (WPSs), Welder Performance Qualifications (WPQs) and Procedure Qualification Records (PQRs).

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services.
2. Structural members to which duct will be attached.

B. Mill test reports for duct and filler material including chemical and physical properties.

C. Fabrication, Tolerances, Inspection, and Testing shall comply with the requirements of ASME AG-1, 2019. Submittals shall be provided in accordance with section SA-8300.



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- D. Source quality-control documents (cost removed) demonstrating that requirements have been flowed down to suppliers.
- E. Shop and Field quality-control and inspection reports as per the requirements of ASME AG-1.

## 1.6 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to the following:
  - 1. AWS B2.1/2.1M "Base Metal Grouping for Welding Procedure and Performance Qualification".
  - 2. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
  - 3. AWS D1.6/D1.6M, "Structural Welding Code – Stainless Steel," for stainless steel ductwork materials.
  - 4. AWS QC1 "Specification for AWS Certification of Welding Inspectors".
- B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7 - "Construction and System Start-up."
- C. ASHRAE/IESNA Compliance: Applicable requirements in ANSI/ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

## PART 2 - PRODUCTS

### 2.1 SINGLE-WALL ROUND DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "Round Industrial Duct Construction Standard" based on indicated temperature, duct class, support spacing, and static pressure. Fabricator has discretion on duct gauge based on the optimum stiffener spacing and flange locations within the limitations in Section 3.6.A.1.
- B. Transverse Joints: Shall be designed as welded connections.
- C. Longitudinal Seams: Shall be designed as welded connections.
- D. Tees and Laterals: Shall be designed as welded connections. For additional information, see section 3.9.C below.
- E. Elbows: Elbows to be either stamped or gore type.
  - 1. Comply with SMACNA's "Round Industrial Duct Construction Standards". Minimum Radius-to-Diameter Ratio and Elbow Segments:



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- Round Elbows: Welded, 5 Gore,  $r/D = 1.5$ . Elbows with less than 90-degree change of direction have proportionately fewer segments.

- F. Flanged Connections: Shall be minimized. Flanged connections shall have an internal seal weld to the duct liner.

## 2.2 SHEET METAL MATERIALS

- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Stainless-Steel Sheets: Comply with ASTM A480/A480M, Type 304L as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet.

## 2.3 SEALANT AND GASKETS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
- B. Flange Gaskets:
  1. Neoprene.
  2. Gaskets shall be full faced and 1/4" thick

## PART 3 - EXECUTION

### 3.1 DUCT INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
- B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- C. Install round ducts in maximum practical lengths.
- D. Install ducts with fewest possible flanged joints.



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- E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines as indicated on mechanical drawings H3E020011A0004 thru H3E020011A0006, H3E020011A0008 and H3E020635G155.
- G. Coordinate with duct support locations as indicated on structural drawings S3E020635B054 thru S3E020635B058.
- H. Install ducts with a clearance of 1 inch, plus allowance for stiffener.
- I. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

### 3.2 INSTALLATION OF EXPOSED DUCTWORK

- A. Perform welding per AWS D1.1/D1.1M.
- B. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
- C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
- D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
- E. Repair or replace damaged sections and finished work that does not comply with these requirements.

### 3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Leakage Tests:
  - 1. Leakage Testing shall be completed in accordance with SMACNA Leakage Test Manual. Leakage shall be less than 2% of the total system design flow at operating pressure. The fabricator shall provide a test plan and report for each section tested. (Refer to Appendix E). Representative sections totaling no less than 25% of the total installed duct surface area for each designated pressure class shall be tested.
  - 2. Failure to meet the acceptance criteria will result in section repair/replacement, as applicable, retesting, and an additional 15% of testing of ductwork within the section.



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3. The duct sections to be tested shall be selected by the owner or owner's representative. Positive pressure leakage testing is acceptable for negative pressure ductwork.
4. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
6. Give seven days' advance notice for testing.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of metal duct system, chosen randomly by Company, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
  - a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

### 3.4 DUCT CLEANING

A. Clean new duct system(s) before testing, adjusting, and balancing.

B. Use service openings for entry and inspection.

1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Clean the following components by removing surface contaminants and deposits:

1. Air inlets (louvers).
2. Make Up Air ducts, dampers, actuators.





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D. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Provide drainage and cleanup for wash-down procedures.
6. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.5 START UP

- A. The Make Up Air (MUA) manual damper (D-14) shall be set at a position which allows the modulating damper (D-12) to support the range of operating conditions in Table 1. Approximate positions for the modulating damper are provided for reference.

Table 1  
Make Up Air Balancing

Hot Cell Flow	Hot Cell HEPA dP	MUA Flow	HOG System Flow	Approx. Mod. Damper Position
8,300 CFM	0 in. w.g.	3,900 CFM	0 CFM	10° Open
8,300 CFM	4 in. w.g.	3,900 CFM	0 CFM	39° Open
8,300 CFM	0 in. w.g.	3,300 CFM	600 CFM	34° Open
8,300 CFM	4 in. w.g.	3,300 CFM	600 CFM	46° Open

- B. System conditions may not allow the operating conditions in Table 1 to be achieved. The manual damper shall be set at a position to achieve the conditions as close to those provided in Table 1 as possible.

3.6 DUCT SCHEDULE

A. Makeup Air Ducts:

1. Ducts Connected to Fans Exhausting Laboratory and Process (ASHRAE 62.1) shall be detailed in accordance with the following requirements:



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- a. Fluid - Air
  - b. Temperature: 15°F to 95°F
  - c. Duct Class: 1
  - d. Leakage Class: A
  - e. Type 304L, stainless-steel sheet. Minimum sheet metal thickness is 12 gauge.
    - 1) Exposed to View: No 2B finish
    - 2) Concealed: 2B finish
  - f. Pressure (Design): Positive or negative 20 in. wc.  
Pressure (Operating): Positive or negative 13 in. wc.  
Pressure (Test): 1.1 X Operating Pressure
  - g. Minimum SMACNA Seal Class: Not applicable. Use welded seams, joints, and penetrations.
2. The duct design shall comply with the International Building Code (IBC) 2015 and ASCE 7-10 as noted below:
- a. Seismic
    - 1) Earthquake loads shall be determined following the requirements as defined in Chapter 13, of ASCE 7-10 using the following criteria: Component Importance Factor of 1.0. Seismic Site Class = D; Spectral response acceleration a short period, (Ss) = 0.375 and spectral response acceleration at a 1-second period (S1) = 0.122; Site amplification factor at 0.2 sec, (Fa) = 1.5; Site amplification factor at 1.0 sec, (Fv) = 2.313; Long-period, TL = 12-seconds; Seismic coefficients for component amplification factor  $a_p = 2.5$ ,  $R_p = 6.0$  (refer to Table 13.6-1 of ASCE 7-10); Vertical seismic forces = +/- 0.20 SDSWp.
    - 2) Seismic loading components in multiple orthogonal directions should be combined using the 100-30-30 rule as defined in Section 12.5.3 of ASCE 7-10.

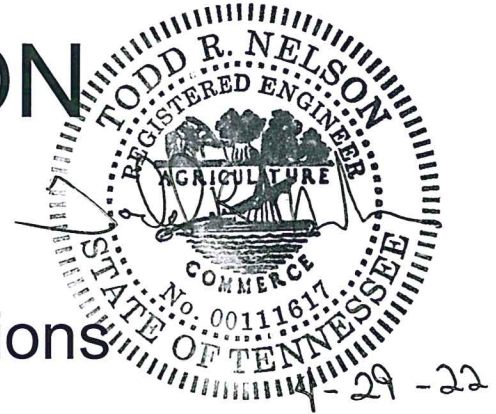


SPECIFICATION  
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COMMON WORK  
RESULTS FOR  
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# TECHNICAL SPECIFICATION

FOR  
ORNL Building 4501  
Exhaust Stack Modifications



## COMMON WORK RESULTS FOR ELECTRICAL 26 05 00

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PROJECT MANAGER	NAME Kevin Westervelt	PROJECT NAME	ORNL Building 4501 Exhaust Stack Modifications	
		PROJECT NO.	21680004	
<b>APPROVED BY:</b>		<b>DATE:</b>	TITLE	COMMON WORK RESULTS FOR ELECTRICAL
PREPARED	NAME T. Nelson	4/12/2022	SPEC NO.	26 05 00
CHECKED	NAME K. Swayne	4/12/2022		
LEAD ENGINEER	NAME T. Nelson	4/29/2022		
PROJECT ENGINEER	NAME Alex Snyder	4/29/2022	REV.	0
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SECTION 260500 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
1. Electrical equipment coordination and installation.
  2. Grout.
  3. Common electrical installation requirements.

1.3 COORDINATION

- A. Coordinate arrangement, mounting, and support of electrical equipment:
1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
  2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
  3. To allow right of way for piping and conduit installed at required slope.
  4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

PART 2 - PRODUCTS

2.1 GROUT

- A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION



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- A. Comply with NECA 1.
- B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
- D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

END OF SECTION 260500



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# TECHNICAL SPECIFICATION

FOR

ORNL Building 4501

Exhaust Stack Modifications

## LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

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		PROJECT NO.	21680004	
<b>APPROVED BY:</b>		<b>DATE:</b>	TITLE	LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES
PREPARED	NAME T. Nelson	4/12/2022	SPEC NO.	26 05 19
CHECKED	NAME K. Swayne	4/12/2022		
LEAD ENGINEER	NAME T. Nelson	4/29/2022		
PROJECT ENGINEER	NAME Alex Snyder	4/29/2022	REV.	0
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SECTION 26 05 19 – LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this section.

1.2 SUMMARY

- A. Section includes:
  - 1. Building wires and cables rated 600 volts (V) and less.
  - 2. Connectors, splices, and terminations rated 600 V and less.
- B. Related requirements:
  - 1. Section 260523 "Control-Voltage Electrical Power Cables"

1.3 ACTION SUBMITTALS

- A. Product data: for each type of product.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

- A. General
  - 1. Wires and cables shall be of annealed, 98 percent conductivity, soft drawn copper.
  - 2. All conductors shall be stranded.
- B. Subject to compliance with requirements, provide product by one of the following:
  - 1. Southwire.
  - 2. Belden Inc.



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3. General Cable


- C. Except for control, signal and instrumentation circuits, wire smaller than #12 AWG shall not be used.
- D. Single conductor wire for lighting, receptacles, and other circuits not exceeding 600 volts to ground shall be UL Listed, 600V NEC type THWN-2 90°C for dry and wet locations.
- E. Equipment grounding conductors shall be installed in all raceways. Conductors shall be NEC type THWN-2, green and sized per NEC Table 250-122. Ground conductors shall be uninsulated unless shown otherwise on the Drawings.
- F. Multi-conductor power cable shall be stranded, #12 AWG, minimum, 600V, UL type TC-ER, E-2 color code, 90° C wet or dry, FR-EPR insulation with a CPE Jacket or approved equal.

2.2 CONNECTORS AND SPLICES

- A. Description: factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.
- B. Unless otherwise indicated on the plans, no splices may be made in the cables without prior written approval of the ORNL. Where splicing is approved, then splicing material shall be approved by the ORNL and cable manufacturer. Splicing materials for all 600 Volt splices shall be made with long barrel tin plated copper compression (hydraulically pressed) connectors and insulated with heavy wall heat shrinkable tubing. The conductivity and insulation resistance of all completed connections of insulated conductors shall be not less than that of the uncut conductor.
- C. 600 Volt wire lugs shall be tin plated copper, long barrel compression type (hydraulically pressed) for wire sizes #8 AWG and larger. Lugs for No. #10AWG and smaller wire shall be locking spade type with insulated sleeve. Lugs shall be as manufactured by Thomas and Betts Co., or equal.

2.3 SYSTEM DESCRIPTION

- A. Electrical components, devices, and accessories: shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NFPA 70.

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## PART 3 - EXECUTION

### 3.1 INSTALLATION OF CONDUCTORS AND CABLES

- A. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.
- B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- C. Use pulling means including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cables or raceway.
- D. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems".

### 3.2 WIRE COLOR CODE

- A. All wire shall be color coded or coded using electrical tape in sizes where colored insulation is not available. Where tape is used as the identification system, it shall be applied in all junction boxes and other accessible intermediate locations as well as at each termination.



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B. The following coding shall be used:

<u>System</u>	<u>Wire</u>	<u>Color</u>
208Y/120 Volts	Neutral	White
3 Phase, 4 Wire	Phase A	Black
	Phase B	Red
	Phase C	Blue
480Y/277 Volts	Neutral	White
3 Phase, 4 Wire	Phase A	Brown
	Phase B	Orange
	Phase C	Yellow
Control (Individual Conductors)	AC	Red
	DC	Blue

### 3.3 IDENTIFICATION

- A. Identify cables according to Section 260553 "IDENTIFICATION FOR ELECTRICAL SYSTEMS".

### 3.4 FIELD QUALITY CONTROL

- A. Power and control cable testing
1. Test all 600 Volt wire insulation with a megohm meter after installation and prior to termination. Make tests at not less than 1000 Volts DC. Submit a written test report of the results to the ORNL. Notify ORNL in writing 48 hours prior to testing.
  2. Field testing and commissioning shall be done in accordance with the latest revision of the "Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems" published by the InterNational Electrical Testing Association (NETA Standard ATS-2017) unless otherwise modified by this Section. Minimum wire insulation resistance shall not be less than 250 Megaohms.
- B. Test and inspection reports – prepare a written report to record the following:
1. Procedures used.



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2. Results that comply with requirements.
3. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

C. Cables will be considered defective if they do not pass tests and inspections.

END OF SECTION 26 05 19

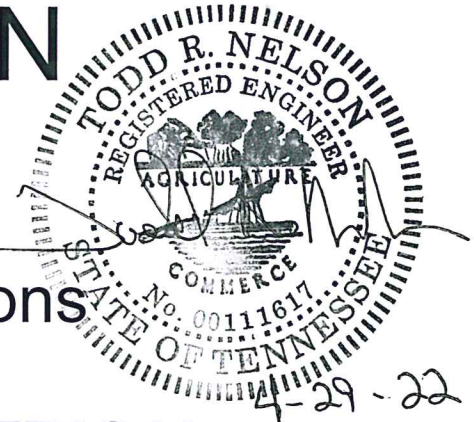


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# TECHNICAL SPECIFICATION

FOR  
ORNL Building 4501  
Exhaust Stack Modifications



## CONTROL-VOLTAGE ELECTRICAL POWER CABLES 26 05 23

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PROJECT MANAGER	NAME Kevin Westervelt	PROJECT NAME	ORNL Building 4501 Exhaust Stack Modifications	
		PROJECT NO.	21680004	
APPROVED BY:		DATE:	TITLE	CONTROL-VOLTAGE ELECTRICAL POWER CABLES
PREPARED	NAME T. Nelson	4/12/2022	SPEC NO.	26 05 23
CHECKED	NAME K. Swayne	4/12/2022		
LEAD ENGINEER	NAME T. Nelson	4/29/2022		
PROJECT ENGINEER	NAME Alex Snyder	4/29/2022	REV.	0
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SECTION 26 05 23 – CONTROL-VOLTAGE ELECTRICAL POWER CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this section.

1.2 SUMMARY

- A. Section includes:
  - 1. Unshielded twisted pair (UTP) cabling.
  - 2. Low-Voltage control cabling.

1.3 DEFINITIONS

- A. Electromagnetic interference (EMI).
- B. Low voltage: As defined in National Fire Protection Association (NFPA) 70 for circuits and equipment operating at less than 50 Volts (V) or for remote-control and signaling power-limited circuits.
- C. Plenum: a space forming part of the air distribution system to which one or more air ducts are connected. An air duct is a passageway, other than a plenum, for transporting air to or from heating, ventilating, or air-conditioning equipment.

1.4 ACTION SUBMITTALS

- A. Product data: for each type of product.

1.5 INFORMATIONAL SUBMITTALS

- A. Source quality-control reports.
- B. Field quality-control reports.





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## PART 2 - PRODUCTS

### 2.1 SYSTEM DESCRIPTION

- A. Electrical components, devices, and accessories: listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

### 2.2 Unshielded Twisted Pair (UTP) CABLE

- A. Subject to compliance with requirements, provide product by one of the following:
  - 1. Belden Inc.
  - 2. CommScope, Inc.
  - 3. General Cable
  - 4. Southwire
- B. Description: 100-ohm, four-pair UTP.
  - 1. Comply with TIA-568-C.2, Category 6
  - 2. UL Listed and labeled as complying with NFPA 70 for the following types:
    - a. Communications, plenum (CMP) rated: Type CMP complying with UL 1685.

### 2.3 UTP CABLE HARDWARE

- A. Subject to compliance with requirements, provide product by one of the following:
  - 1. Belden Inc.
  - 2. Hubbell Incorporated.
  - 3. Panduit Corp.
- B. General requirements for cable connecting hardware: comply with TIA/EIA-568-C.2, insulation displacement (IDC) type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.

### 2.4 LOW-VOLTAGE CONTROL CABLE

- A. Process instrumentation wire shall be twisted pair, 600 V, UL type TC, individual and overall shielded pairs or triad, method 1 colored, FR-EPR insulation with a CPE jacket, unless specifically called out on the Drawings.
- B. Cable for 4-20 mA instrumentation, potentiometer, RTD and similar analog circuits shall be multi-conductor twisted and shielded.
  - 1. Single pair cable:



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- a. Conductors: 2 #16 AWG stranded and twisted
  - b. Shield: 100 percent tape with drain wire
  - c. Jacket: Black Jacket with UL and manufacturers identification
2. Three conductor (triad) cable:
    - a. Conductors: 3 #16 AWG stranded and twisted
    - b. Shield: 100 percent tape with drain wire
    - c. Jacket: Black Jacket with UL and manufacturers identification
  3. Multiple pair cables (where shown on the Drawings):
    - a. Conductor: Multiple 2 #16 AWG stranded and twisted
    - b. Shield: Individual pairs and overall shielded with 100 percent tape and drain wire
    - c. Jacket: Black Jacket with UL manufacturers identification

### PART 3 - EXECUTION

#### 3.1 EXAMINATION

- A. Test cables on receipt at Project site.
  1. Test each pair of UTP cable for open and short circuits.

#### 3.2 INSTALLATION OF RACEWAYS AND BOXES

- A. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for raceway selection and installation requirements for boxes, conduits, and wire-ways as supplemented or modified in this section.

#### 3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Comply with National Electrical Contractors Association (NECA) 1 and NFPA 70.
- B. Installation of UTP and control-circuit conductors:
  1. Install wiring in raceways. Comply with requirements specified in Section 260533 "Raceways and Boxes for Electrical Systems".
- C. General requirements for cabling:
  1. Cables may not be spliced.
  2. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii.
  3. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.



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4. Secure: fasten securely in place with hardware specifically designed and installed so as to not damage cables.

D. The UTP cable installation:

1. Comply with TIA-568-C.2.
2. Do not untwist UTP cables more than ½” at the point of termination to maintain cable geometry.

### 3.4 IDENTIFICATION

A. Identify cables according to Section 260553 “IDENTIFICATION FOR ELECTRICAL SYSTEMS”.

### 3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Visually inspect UTP and control cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments, and inspect cabling connections to confirm compliance with TIA-568-C.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Test UTP cabling for direct-current loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not after cross-connection.

B. End-To-End cabling will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 26 05 23

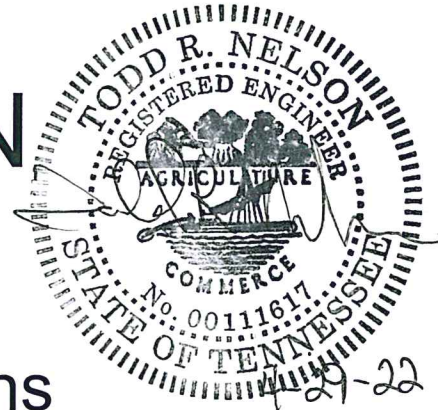


SPECIFICATION  
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# TECHNICAL SPECIFICATION

FOR  
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## GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS 26 05 26

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PROJECT MANAGER	NAME Kevin Westervelt	PROJECT NAME	ORNL Building 4501 Exhaust Stack Modifications	
		PROJECT NO.	21680004	
<b>APPROVED BY:</b>		<b>DATE:</b>	TITLE	GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS
PREPARED	NAME T. Nelson	4/12/2022	SPEC NO.	26 05 26
CHECKED	NAME K. Swayne	4/12/2022		
LEAD ENGINEER	NAME T. Nelson	4/29/2022		
PROJECT ENGINEER	NAME Alex Snyder	4/29/2022	REV.	0
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SECTION 26 05 26 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes grounding and bonding systems and equipment, plus the following special applications:
  - 1. Underground distribution grounding.
  - 2. Ground bonding common with lightning protection system.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.

1.4 INFORMATIONAL SUBMITTALS

- A. As-Built Data: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article, including the following:
  - 1. Ground rods.
  - 2. Ground rings.
  - 3. Grounding arrangements and connections for separately derived systems.
- B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
  - 1. Burndy; Part of Hubbell Electrical Systems.



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2. ERICO International Corporation.
3. Harger Lightning and Grounding.
4. ILSCO.
5. O-Z/Gedney; A Brand of the EGS Electrical Group.
6. Robbins Lightning, Inc.

## 2.2 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Shall be Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 467 for grounding and bonding materials and equipment.

## 2.3 CONDUCTORS

- A. Insulated Conductors: Copper or tinned-copper wire insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Tinned Copper Conductors:
  1. Solid Conductors: ASTM B 3.
  2. Stranded Conductors: ASTM B 8.
  3. Tinned Conductors: ASTM B 33.

## 2.4 CONNECTORS

- A. Listed and labeled by an National Recognized Testing Laboratory (NRTL) acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
- B. Bolted Connectors for Conductors: Copper or copper alloy.
- C. Irreversible crimp connectors: Copper or copper alloy.
- D. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- E. Grounding conduit hubs shall be malleable iron type, manufactured by Thomas & Betts Co., Catalog No. 3940 (3/4-inch conduit size), similar to Burndy; O.Z./Gedney Co. or approved equal, and of the correct size for the conduit.



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2.5 GROUNDING ELECTRODES

- A. Ground rods shall be 3/4-inch diameter by 10-ft copper clad steel and constructed in accordance with UL 467. The minimum copper thickness shall be 10 mm. Ground rods shall be Copperweld or approved equal.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Conductors: Install stranded conductors unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare tinned copper conductor, No. 4/0 AWG minimum.
  - 1. Bury at least 30 inches below grade.
  - 2. Bury grounds not less than 24 inches from building foundation.
- C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.
- D. Conductor Terminations and Connections:
  - 1. Equipment Grounding Conductor Terminations: Bolted connectors.
  - 2. Underground Connections: Welded connectors or irreversible crimp except at test wells and as otherwise indicated.
  - 3. Connections to Ground Rods at Test Wells: Bolted connectors.
  - 4. Connections to Structural Steel: Welded connectors or irreversible crimp.

3.2 GROUNDING SEPARATELY DERIVED SYSTEMS

- A. Ground transformer neutrals to the nearest available grounding electrode with a minimum conductor sized in accordance with NEC Article 250-66 or as shown on the Drawings.

3.3 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.





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### 3.4 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- B. Protect above ground grounding conductors when less than 6 feet above grounding using schedule 80 PVC conduit.
- C. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.
- D. Ground Rods: Drive rods until tops are 12 inches below finished floor or final grade unless otherwise indicated.
  - 1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
  - 2. For grounding electrode system, install at least two rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
- E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
  - 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
  - 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
  - 3. Use exothermic-welded or irreversible crimp connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.
- F. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.

### 3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Tests and Inspections:



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1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
  2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
  3. Test ground resistance at individual ground rods. Make tests at ground rods before any conductors are connected.
    - a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
    - b. Perform tests by fall-of-potential method according to IEEE 81.
  4. Prepare dimensioned Drawings locating each ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
- C. Grounding system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.
- E. Report measured ground resistances that exceed the following values:
1. 3 ohms.
- F. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify ORNL promptly and include recommendations to reduce ground resistance.

END OF SECTION 26 05 26

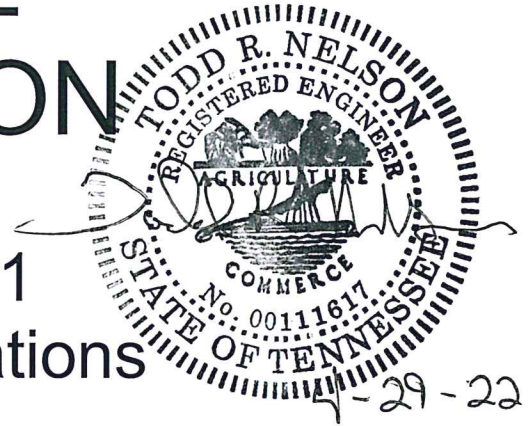


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# TECHNICAL SPECIFICATION

FOR  
ORNL Building 4501  
Exhaust Stack Modifications



## HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS 26 05 29

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PROJECT MANAGER	NAME Kevin Westervelt	PROJECT NAME	ORNL Building 4501 Exhaust Stack Modifications	
		PROJECT NO.	21680004	
<b>APPROVED BY:</b>		<b>DATE:</b>	TITLE	HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS
PREPARED	NAME T. Nelson	4/12/2022	SPEC NO.	26 05 29
CHECKED	NAME K. Swayne	4/12/2022		
LEAD ENGINEER	NAME T. Nelson	4/29/2022		
PROJECT ENGINEER	NAME Alex Snyder	4/29/2022	REV.	0
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SECTION 26 05 29 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following:
  - 1. Hangers and supports for electrical equipment and systems.

1.3 DEFINITIONS


- A. EMT: Electrical metallic tubing.
- B. RMC: Rigid metal conduit.

1.4 PERFORMANCE REQUIREMENTS

- A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
- B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.5 ACTION SUBMITTALS

- A. Product Data: For the following:
  - 1. Steel slotted support systems.

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## PART 2 - PRODUCTS

### 2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Cooper B-Line, Inc.; a division of Cooper Industries.
    - b. Thomas & Betts Corporation.
    - c. Unistrut; Tyco International, Ltd.
  - 2. Channel Dimensions: Selected for applicable load criteria.
  - 3. Material: 316 stainless steel or pre-galvanized zinc carbon steel
  
- B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
  
- C. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
  - 1. Mechanical-Expansion Anchors: Insert-wedge-type, stainless steel or carbon steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
    - a. Manufacturer: Subject to compliance with requirements, provide products by one of the following:
      - 1) Hilti Inc.
  - 2. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
  - 3. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
  - 4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
  - 5. Toggle Bolts: All-steel springhead type.
  - 6. Hanger Rods: Threaded steel.

## PART 3 - EXECUTION

### 3.1 APPLICATION

- A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.



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- B. In dry indoor areas, hangers, rods, backplates, beam clamps, channel, fasteners, anchors, nuts, washers, etc., shall be pre-galvanized zinc carbon steel.
- C. 316 stainless steel channel with 316 stainless steel hardware (hangers, rods, backplates, beam clamps, fasteners, anchors, nuts, washers, etc.) shall be used in outdoor locations and in the basement below 12" above finished floor.
- D. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT and RMC as required by NFPA 70. Minimum rod size shall be 3/8 inch in diameter.
- E. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system.
  - 1. Secure raceways and cables to these supports with two-bolt conduit clamps.

### 3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, EMT and RMC may be supported by openings through structure members, as permitted in NFPA 70.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
  - 1. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
  - 2. To Existing Concrete: Expansion anchor fasteners.
  - 3. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69
  - 4. To Light Steel: Sheet metal screws.
  - 5. Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks.
- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.



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3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

3.4 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
  - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 26 05 29



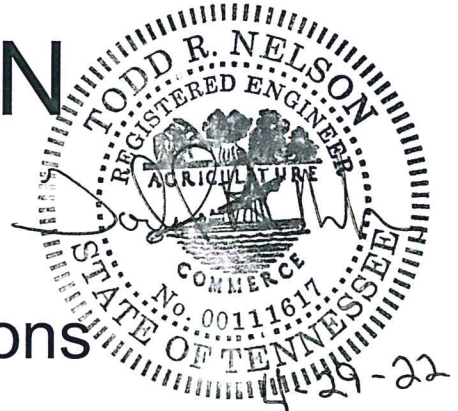


SPECIFICATION  
FOR  
RACEWAY AND BOXES  
FOR ELECTRICAL  
SYSTEMS

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# TECHNICAL SPECIFICATION

FOR  
ORNL Building 4501  
Exhaust Stack Modifications



## RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS 26 05 33

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PROJECT MANAGER	NAME Kevin Westervelt	PROJECT NAME	ORNL Building 4501 Exhaust Stack Modifications	
		PROJECT NO.	21680004	
<b>APPROVED BY:</b>		<b>DATE:</b>	TITLE	RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS
PREPARED	NAME T. Nelson	4/12/2022	SPEC NO.	26 05 33
CHECKED	NAME K. Swayne	4/12/2022		
LEAD ENGINEER	NAME T. Nelson	4/29/2022		
PROJECT ENGINEER	NAME Alex Snyder	4/29/2022	REV.	0
<input checked="" type="checkbox"/> New Specification <input type="checkbox"/> Title Change <input type="checkbox"/> Minor Revision <input type="checkbox"/> General Revision <input type="checkbox"/> Rewrite				



SPECIFICATION  
FOR  
RACEWAY AND BOXES  
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SECTION 26 05 33 - RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following:
  - 1. Rigid metal conduit and fittings, electrical metallic tubing and fittings, liquid-tight flexible metal conduit and fitting, and pull and junction boxes.

1.3 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. RMC: Rigid metal conduit.

1.4 ACTION SUBMITTALS

- A. Product Data: For the following:
  - 1. Raceway, boxes, and fittings.

PART 2 - PRODUCTS

2.1 RIGID METAL CONDUIT AND FITTINGS

- A. Heavy-Wall Rigid Galvanized Steel Conduit: ANSI C80.1; UL 6 listed; Schedule 40 hot dipped galvanized or electrogalvanized conduit.
- B. Fittings and Conduit Bodies: NEMA FB 1; threaded type, material to match conduit; Appleton, Crouse-Hinds, or Killark.



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- C. Bushings: Nonmetallic, insulating-type; O-Z/Gedney Type A, Thomas & Betts Series 200, or Appleton Type BBU.

## 2.2 LIQUIDTIGHT FLEXIBLE METAL CONDUIT AND FITTINGS

- A. Liquidtight Flexible Metal Conduit: UL 360 listed; galvanized steel flexible tubing with synthetic jacket extruded over tubing.
- B. Fittings and Conduit Bodies: NEMA FB 1.
- C. Liquidtight Conduit Assemblies: Thomas & Betts Company Series 5300; insulated, straight, or 90-degree angle connector on each end.

## 2.3 ELECTRICAL METALLIC TUBING (EMT) AND FITTINGS

- A. EMT: ANSI C80.3; UL 797 listed; zinc-coated, enamel-lined, threadless, thin-wall steel tubing.
- B. Fittings and Conduit Bodies: NEMA FB 1; steel compression type.

## 2.4 BOXES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
  - 2. Hoffman.
  - 3. Hubbell Incorporated; Killark Electric Manufacturing Co. Division.
  - 4. O-Z/Gedney; a unit of General Signal.
  - 5. Thomas & Betts Corporation.
- B. Sheet Metal Outlet and Device Boxes: NEMA OS 1.
- C. Cast-Metal Outlet and Device Boxes: NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.
- D. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- E. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, galvanized, cast iron with gasketed cover.

## 2.5 SLEEVES FOR RACEWAYS



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- A. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052-inch or 0.138-inch (1.3-mm or 3.5-mm) thickness as indicated and of length to suit application.

## 2.6 FIRESTOPPING

- A. Wall and floor slab openings shall be sealed with "FLAME-SAFE" as manufactured by Rector Seal or equal.

## PART 3 - EXECUTION

### 3.1 RACEWAY APPLICATION

- A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:
  - 1. Exposed Conduit: Rigid steel conduit.
  - 2. Concealed Conduit, Aboveground: Rigid steel conduit.
  - 3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
  - 4. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.
- B. Comply with the following indoor applications, unless otherwise indicated:
  - 1. Exposed, Subject to Physical Damage: EMT.
  - 2. Exposed, Subject to Severe Physical Damage: Rigid steel conduit..
  - 3. Concealed in Ceilings and Interior Walls and Partitions: EMT.
  - 4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
  - 5. Damp or Wet Locations: Rigid steel conduit.
  - 6. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 3R, in damp or wet locations.
- C. No wire shall be pulled until the conduit system is complete in all details; in the case of concealed work, until all rough plastering or masonry has been completed; in the case of exposed work, until the conduit system has been completed in every detail.



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- D. No conduit smaller than 3/4 inch electrical trade size shall be used, nor shall any have more than the equivalent of three 90 degree bends in any one run. Pull boxes shall be provided as required or directed.
- E. Where conduits pass through openings in walls or floor slabs, the remaining openings shall be sealed against the passage of flame and smoke.
- F. The use of running threads is prohibited. Where such threads are necessary, a 3-piece union shall be used.
- G. Coat field cut threads in rigid steel conduit with Thomas & Betts "Kopr Shield."
- H. Fasten rigid metal conduit to outlet boxes, pull boxes, cabinets, and switch boxes with double lock nuts and insulating bushings unless boxes with hubs are furnished.
- I. Conduits passing from heated to unheated spaces, exterior spaces, refrigerated spaces, cold air plenums, etc, shall be sealed with "Duxseal" as manufactured by Johns-Manville Co. or seal fitting to prevent the accumulation of condensation.
- J. Terminate EMT with raintight, compression-type connectors with insulated throats. Use couplings for EMT that are raintight, compression type. Set screw type connectors and couplings are not acceptable.

### 3.2 BOX APPLICATIONS

- A. Unless otherwise specified herein or shown on the Drawings, all boxes shall be metal.
- B. Indoors: Code gage, galvanized sheet steel; welded construction, without conduit knockouts or raceway openings and hinged or screwed covers as noted.
- C. Outdoor and Wet Location Installations: NEMA 250; Type 3R surface mounted; box and cover with ground flange, neoprene gasket, and stainless steel cover screws; UL listed as rain-tight.
- D. Locate pull boxes and junction boxes above accessible ceilings or in unfinished areas.
- E. Support pull and junction boxes independent of conduit.

### 3.3 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used.
- B. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.



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- C. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies.
- D. Cut sleeves to length for mounting flush with both surfaces of walls.
- E. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.
- F. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway unless sleeve seal is to be installed.
- G. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.
- H. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway, using joint sealant appropriate for size, depth, and location of joint.
- I. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway penetrations. Install sleeves and seal with firestop materials.
- J. Roof-Penetration Sleeves: Seal penetration of individual raceways with flexible, boot-type flashing units applied in coordination with roofing work.
- K. Aboveground, Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- L. Underground, Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway and sleeve for installing mechanical sleeve seals.

#### 3.4 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly.

END OF SECTION 26 05 33

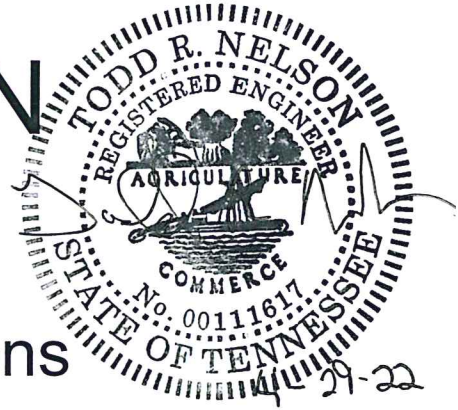


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# TECHNICAL SPECIFICATION

FOR  
ORNL Building 4501  
Exhaust Stack Modifications



## IDENTIFICATION FOR ELECTRICAL SYSTEMS 26 05 53

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PROJECT MANAGER	NAME Kevin Westervelt	PROJECT NAME	ORNL Building 4501 Exhaust Stack Modifications	
		PROJECT NO.	21680004	
<b>APPROVED BY:</b>		<b>DATE:</b>	TITLE	IDENTIFICATION FOR ELECTRICAL SYSTEMS
PREPARED	NAME T. Nelson	4/12/2022	SPEC NO.	26 05 53
CHECKED	NAME K. Swayne	4/12/2022		
LEAD ENGINEER	NAME T. Nelson	4/29/2022		
PROJECT ENGINEER	NAME Alex Snyder	4/29/2022	REV.	0
<input checked="" type="checkbox"/> New Specification <input type="checkbox"/> Title Change <input type="checkbox"/> Minor Revision <input type="checkbox"/> General Revision <input type="checkbox"/> Rewrite				





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SECTION 26 05 53 – IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
  1. Identification for conductors.
  2. Warning labels and signs.
  3. Equipment identification labels.
  4. Miscellaneous identification products.

1.3 SUBMITTALS

- A. Product Data: For each electrical identification product indicated.
- B. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.

1.4 QUALITY ASSURANCE

- A. Comply with ANSI A13.1.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
- D. Comply with ANSI Z535.4 for safety signs and labels.
- E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

1.5 SYSTEM IDENTIFICATION

- A. Identify electrical equipment according to the one-line diagram.



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1. Include the following:
  - a. Source identification (FED FROM PP-25 CKT 1,3,5)
  - b. Voltage and number of phases (208Y/120V 3PH)
  - c. Equipment description (Exhaust Fan EF-101A)
- B. Identify safety switches, enclosed circuit breakers, motor starters, lighting panels, power panelboards, and other similar electrical equipment with 3/4 inch to 1-inch engraved three-layer laminated plastic labels with white letters on a black background having approximately 1/2 inch tall (minimum) black letters.
- C. Identify light switches, receptacles, and other similar electrical devices with 1/2 inch white plastic adhesive tape having approximately 5/32 inch tall letters.
  1. Example: A lighting switch on Circuit 15 from panel LP-25-7 would be marked “120V, 1Ø, Circuit 15, LP-25-7.”
- D. Panelboard Directories: Indicate for each circuit the equipment served, floor and column location, and room number. Identify spare circuits.
- E. Identify branch circuit conductors originating from panelboards.
  1. Refer to Division 26 Section 260519 “Low Voltage Electrical Power Conductors and Cables” for color coding of conductors.
  2. Identify conductors with heat shrinkable, printable wire markers utilizing alphanumeric characters of 1/8 inch to 3/16 inch height, printed with black ink on white background.
  3. Place markers within 1 inch of where insulation has been removed for junctions or terminations.
  4. In addition to indicating the panelboard number and branch circuit number, identify conductors as follows:
    - a. 120-V, single phase, two wire system 120V-1PH
    - b. 208Y/120-V, three phase, four wire systems 208Y/120V-3PH-A  
208Y/120V-3PH-B  
208Y/120V-3PH-C
    - c. 480Y/277V, three phase, four wire systems 480Y/277V-3PH-A  
480Y/277V-3PH-B  
480Y/277V-3PH-C

1.6 COORDINATION

- A. Coordinate installation of identifying devices with location of access panels and doors.
- B. Install identifying devices before installing acoustical ceilings and similar concealment.



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## PART 2 - PRODUCTS

### 2.1 MATERIALS

- A. Nameplates: Engraved three-layer laminated plastic, white letters on black background.
- B. Wire and Cable Markers:
  - 1. Heat shrinkable: W.H. Brady Company.
- C. Tape Labels:
  - 1. 3/4 inch to 1-inch plastic tape with permanent pressure sensitive adhesive, black letters on white background, adjustable font size (1/2 inch tall minimum). Use outdoor rated tape for outdoor installations.
  - 2. 1/2 inch plastic tape with permanent pressure sensitive adhesive, black letter on white background, adjustable font size (5/32 inch tall minimum). Use outdoor rated tape for outdoor installations.

## PART 3 - EXECUTION

### 3.1 PREPARATION

- A. Degrease and clean surfaces to receive nameplates, tape labels, and cable markers.

### 3.2 INSTALLATION

- A. Verify identity of each item before installing identification products.
- B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- C. Apply identification devices to surfaces that require finish after completing finish work.
- D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- E. System Identification Color-Coding Bands for Cables: Each color-coding band shall completely encircle cable. Place adjacent bands of two-color markings in contact, side by side.
- F. Cable Ties: Use general-purpose type.



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IDENTIFICATION FOR  
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### 3.3 IDENTIFICATION SCHEDULE

- A. Cables:
  - 1. Uniquely identify all wires, cables and each conductor of multi-conductor cables at each end with wire and cable markers.
  - 2. Identify each spare conductor at each end with identity number and location of other end of conductor and identify as spare conductor.
  
- B. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.
  
- C. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels.
  - 1. Comply with 29 CFR 1910.145.
  - 2. Identify system voltage with black letters on an orange background.
  - 3. Apply to exterior of door, cover, or other access.
  
- D. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
  - 1. Equipment to Be Labeled:
    - a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be self-adhesive, engraved, laminated acrylic or melamine label.
    - b. Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.

END OF SECTION 26 05 53

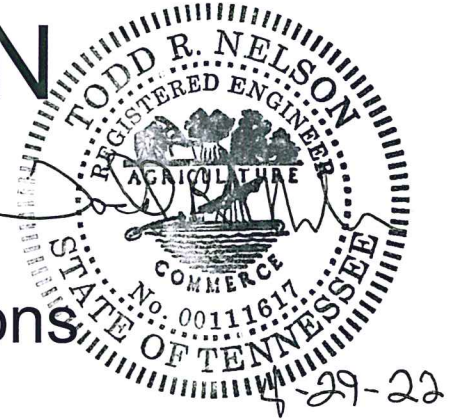


SPECIFICATION  
FOR  
LIGHTNING PROTECTION  
FOR STRUCTURES

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# TECHNICAL SPECIFICATION

FOR  
ORNL Building 4501  
Exhaust Stack Modifications



## LIGHTNING PROTECTION FOR STRUCTURES 26 41 13

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PROJECT MANAGER	NAME Kevin Westervelt	PROJECT NAME	ORNL Building 4501 Exhaust Stack Modifications	
		PROJECT NO.	21680004	
<b>APPROVED BY:</b>		<b>DATE:</b>	TITLE	LIGHTNING PROTECTION FOR STRUCTURES
PREPARED	NAME T. Nelson	4/14/2022	SPEC NO.	26 41 13
CHECKED	NAME K. Swayne	4/14/2022		
LEAD ENGINEER	NAME T. Nelson	4/29/2022		
PROJECT ENGINEER	NAME Alex Snyder	4/29/2022	REV.	0
<input checked="" type="checkbox"/> New Specification <input type="checkbox"/> Title Change <input type="checkbox"/> Minor Revision <input type="checkbox"/> General Revision <input type="checkbox"/> Rewrite				



SPECIFICATION  
FOR  
LIGHTNING PROTECTION  
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FOR  
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SECTION 26 41 13 - LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes lightning protection for building site components.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For air terminals and mounting accessories.
  - 1. Layout of the lightning protection system, along with details of the components to be used in the installation.
  - 2. Include indications for use of raceway and calculations required by NFPA 780 for bonding of grounded and isolated metal bodies.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer and manufacturer. Include data on listing or certification by UL.
- B. Field quality-control reports.
- C. Comply with recommendations in NFPA 780, Annex D, "Inspection and Maintenance of Lightning Protection Systems," for maintenance of the lightning protection system.
- D. Other Informational Submittals: Plans showing dimensioned as-built locations of grounding features, including the following:
  - 1. Ground rods.
  - 2. Ground loop conductor.





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1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Certified by UL trained and approved for installation of units required for this Project.
- B. System Certificate:
  - 1. UL Master Label or Letter of Findings.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 780, "Definitions" Article.

1.6 COORDINATION

- A. Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes.
- B. Coordinate installation of conductor attachments to roof systems with roofing manufacturer and Installer.

PART 2 - PRODUCTS

2.1 LIGHTNING PROTECTION SYSTEM COMPONENTS

- A. Comply with UL 96.
- B. Roof-Mounted Air Terminals: NFPA 780, Class II copper unless otherwise indicated.
  - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings (Harger) or comparable product by one of the following:
    - a. Robbins Lightning, Inc.
    - b. Thompson Lightning Protection, Inc.
  - 2. Air Terminals More than 24 Inches Long: With brace attached to the terminal at not less than half the height of the terminal.
- C. Main and Bonding Conductors: Copper.
- D. Ground Loop Conductor: The same size and type as the main conductor except tinned.
- E. Ground Rods: Copper-clad 3/4 inch in diameter by 10 feet long.
- F. Heavy-Duty, Stack-Mounted, Lightning Protection Components: Solid copper



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### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Install lightning protection components and systems according to UL 96A.
- B. Install conductors with direct paths from air terminals to ground connections. Avoid sharp bends.
- C. Cable Connections: Use irreversible crimped or bolted connections for all conductor splices and connections between conductors and other components. Use exothermic-welded or irreversible crimp connections in underground portions of the system.
- D. Bond extremities of vertical metal bodies exceeding 60 feet in length to lightning protection components.
- E. Protect above ground lightning protection conductors when less than 6 feet above grounding using schedule 80 PVC conduit.
- F. Underground Ground Conductors: Install bare tinned copper conductor, No. 4/0 AWG minimum.
  - 1. Bury grounds not less than 24 inches from building foundation.
  - 2. Bury at least 30 inches below grade.

#### 3.2 CORROSION PROTECTION

- A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.
- B. Use conductors with protective coatings where conditions cause deterioration or corrosion of conductors.

#### 3.3 FIELD QUALITY CONTROL

- A. Notify ORNL at least 48 hours in advance of inspection before concealing lightning protection components.
- B. UL Inspection: Meet requirements to obtain a UL Master Label for system or provide a Letter of Findings.

END OF SECTION 26 41 13



SPECIFICATION  
FOR  
Design and Installation of  
CAMs, Probes and Tubing

SPECIFICATION NO.:  
21680004-MS100-002  
REV. 0  
4/29/2022

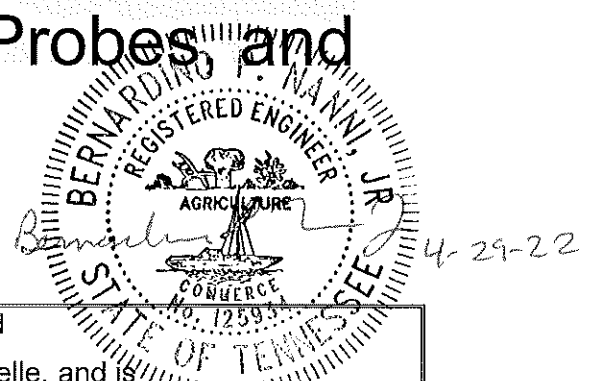
# TECHNICAL SPECIFICATION

FOR

ORNL

Building 4501 Exhaust Stack Modifications

Design and Installation of Continuous  
Air Monitors, Shrouded Probes, and  
Tubing



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PROJECT MANAGER	NAME Kevin Westervelt	PROJECT NAME	Building 4501 Exhaust Stack Modifications
		PROJECT NO.	21680004
<b>APPROVED BY:</b>	<b>DATE:</b>	TITLE	Design and Installation of CAMs
PREPARED	NAME Bernardino Nanni 4/20/22	SPEC NO.	21680004-MS100-002
CHECKED	NAME Colby Summers 4/21/22		
LEAD ENGINEER	NAME Bernardino Nanni 4/26/22		
PROJECT ENGINEER	NAME Alex Snyder 04/26/22	REV.	0
<input checked="" type="checkbox"/> New Specification <input type="checkbox"/> Title Change <input type="checkbox"/> Minor Revision <input type="checkbox"/> General Revision <input type="checkbox"/> Rewrite			



SPECIFICATION  
FOR  
Design and Installation of  
CAMs, Probes and Tubing

SPECIFICATION NO.:  
21680004-MS100-002  
REV. 0  
4/29/2022

**REVISIONS**

<b><u>REV.</u></b>	<b><u>DATE</u></b>	<b><u>PAGE</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>APPROVAL</u></b>
0	4/29/22	ALL	INITIAL ISSUE	BN



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## PART 1 - GENERAL

### 1.1 PROJECT OVERVIEW

- A. ORNL will be extending the Building 4501 Stack and adding additional Continuous Air Monitoring (CAM) equipment. The shrouded probe for the existing CAM will be re-installed into the stack and the existing tubing rerouted to the existing CAM unit. New CAM equipment (a Particulate, Iodine and Noble Gas (PING) unit and a mobile alpha and beta monitoring unit) will be installed in Room 213. One new shrouded probe will be installed in the stack and new tubing installed to the new CAM equipment.

### 1.2 REFERENCE DRAWINGS

- A. H3E020011A006 HVAC Enlarged Basement Plan
- B. H3E020011A008 Building 4501/4505 Hot Cell Exhaust P&ID
- C. H3E020635G155 HVAC Make-Up Air Duct System Second Floor

### 1.3 GENERAL

- A. This specification is for the design and installation of shrouded probes, new CAM equipment, and the associated tubing for the existing and new CAM equipment.
- B. ORNL will furnish the new PING and mobile alpha and beta monitoring units. The Vendor shall furnish all other materials including but not limited to shrouded probes, tubing, splitter, and fittings.

## PART 2 - MATERIALS

### 2.1 TUBING

- A. Thermon TubeTrace® Type SE/ME Electronically Heated Instrument Tubing
- B. Power supply for the tubing heating feature is single phase, 120VAC.



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### PART 3 - CODES AND SPECIFICATIONS

#### 3.1 GENERAL

- A. The latest version of the following specifications shall be used.
1. ANSI/HPS N13.1 Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities.
  2. 40 CFR Part 61, Subpart H, National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities.

#### 3.2 ARCHITECTURAL

- A. The following codes are as referenced by the governing local code:
1. International Building Code (2012)
  2. NPPA 70 National Electrical Code (2020)
  3. International Fire Code (2012)
  4. International Mechanical Code (2012)
  5. International Plumbing Code (2012)

### PART 4 - DESIGN CRITERIA

- 4.1 Refer to Drawing H3E020635G155 for the arrangement of the CAM equipment in Room 213. The orientation and location of the equipment is to be modified as necessary to facilitate efficient routing to each CAM unit
- 4.2 A minimum 18-inch clearance is to be maintained between each CAM unit and adjacent walls and equipment. Obtain Owner approval of clearances less than the minimum specified.
- 4.3 The PC Cabinet shall be located to maintain a maximum ten-foot cable length to the PING unit. Obtain Owner approval of locations that exceed the maximum cable length
- 4.4 Tubing is to penetrate the building exterior wall at an elevation to facilitate efficient routing to each CAM unit.
- 4.5 Refer to Drawing H3E020011A006 for the shrouded probe locations in the stack.
- 4.6 The shrouded probe nozzle tips are to be located within the center third (10.6 inch diameter) of the stack as shown in Appendix 9.1.



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- 4.7 Tube bends are to be  $r = 5D$ . However, smaller radius bends can be used to accommodate spatial limitations, the minimum bend radius is  $r = 3D$ .
- 4.8 Ball valves and filter holders for the new CAMs are to be located in Room 213 adjacent to each CAM.
- 4.9 The existing stack supports are to be used to support the tube routings along the stack.
- 4.10 Refer to Appendix 9.2 for details of the flange for the shrouded probe.
- 4.11 Refer to Appendix 9.3 for typical tube routing details.
- 4.12 Connect the return line to the sample return flange on the stack using a 3/4" Swagelok.

#### PART 5 - SUBMITTALS

- 5.1 Submit detailed drawings and Bill of Material of the following for Owner review and approval:
  - A. Shrouded probe installation.
  - B. CAM locations in Room 213.
  - C. Tube routing between the stack and the existing CAM unit.
- 5.2 Tube routing between the stack and the new CAM units.
- 5.3 Drawings shall be stamped by a Professional Engineer (PE), registered in the state of Tennessee.
- 5.4 Procurement and installation shall not proceed prior to receipt of Owner approval.

#### PART 6 - INSTALLATION

- 6.1 Coordinate installation of work with related work of other trades.
- 6.2 Avoid making wall penetrations thru grouted and reinforced concrete masonry unit (CMU) cells



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by using magnetic or ultrasound detection prior to hole coring. Do not cut rebar reinforcement or structural steel.

6.3 Seal the annular space between the operating lines (tube bundle) and the chase with UL1497 Acrylic Intumescent Caulk.

6.4 Flash around wall penetrations as required to achieve a watertight seal.

#### PART 7 - DELIVERY AND STORAGE

7.1 Materials shall be prepared for shipment and packaged or crated to provide maximum protection during shipment.

7.2 Tubing shall have protective caps to prevent intrusion of foreign material. Materials shall be delivered to the site in an undamaged condition.

7.3 Vendor shall coordinate indoor and outdoor storage requirements with the Owner four weeks prior to delivery.

7.4 Vendor shall store all materials above ground, and outdoor storage shall be covered with weather tight covering and kept dry.

#### PART 8 - GUARANTEES

8.1 The installation shall be guaranteed against leaks for five years.

8.2 The guarantee shall start upon final acceptance of the installation by the Owner.

#### PART 9 - APPENDICES

9.1 Stack Installation.

9.2 Flange for the Shrouded Probe on 32-Inch Stack.

9.3 ORNL 32-Inch Stack Shrouded Probe Installation/Assembly

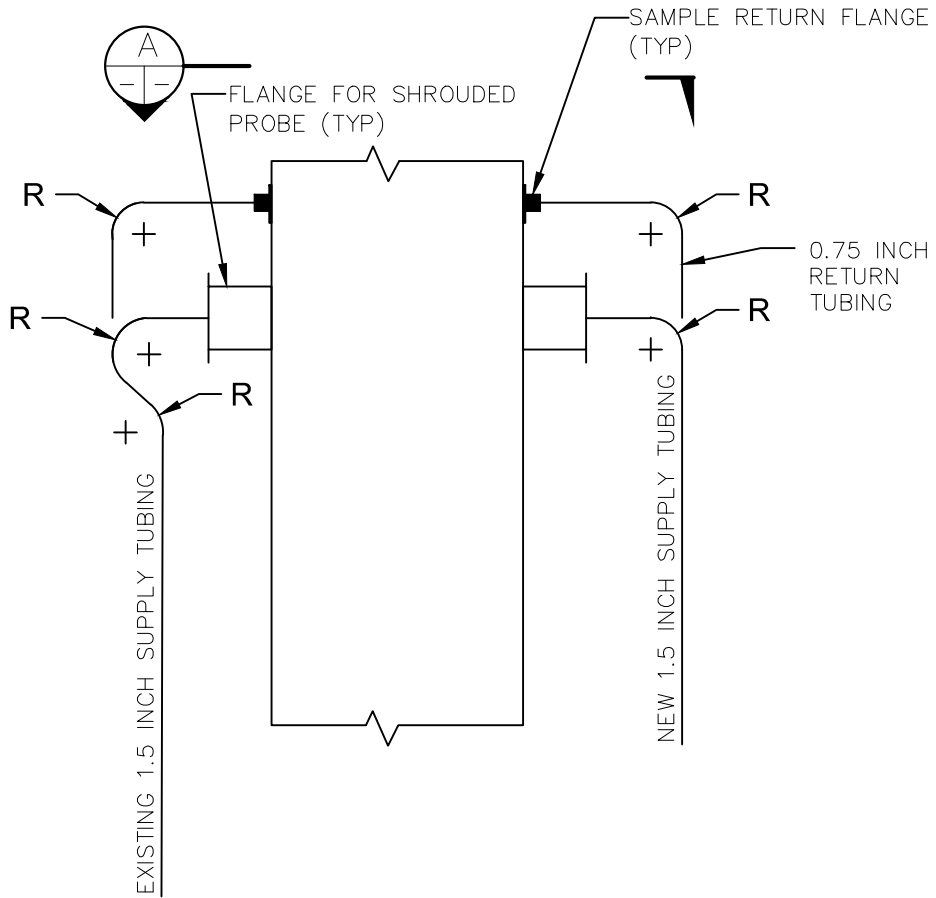
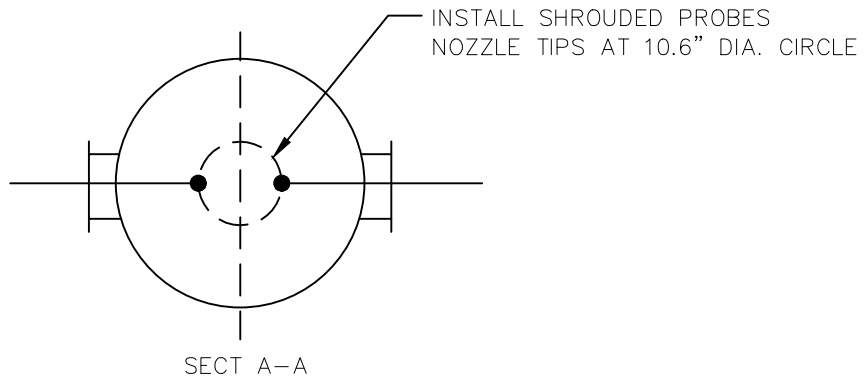




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## Appendix 9.1 Stack Installation



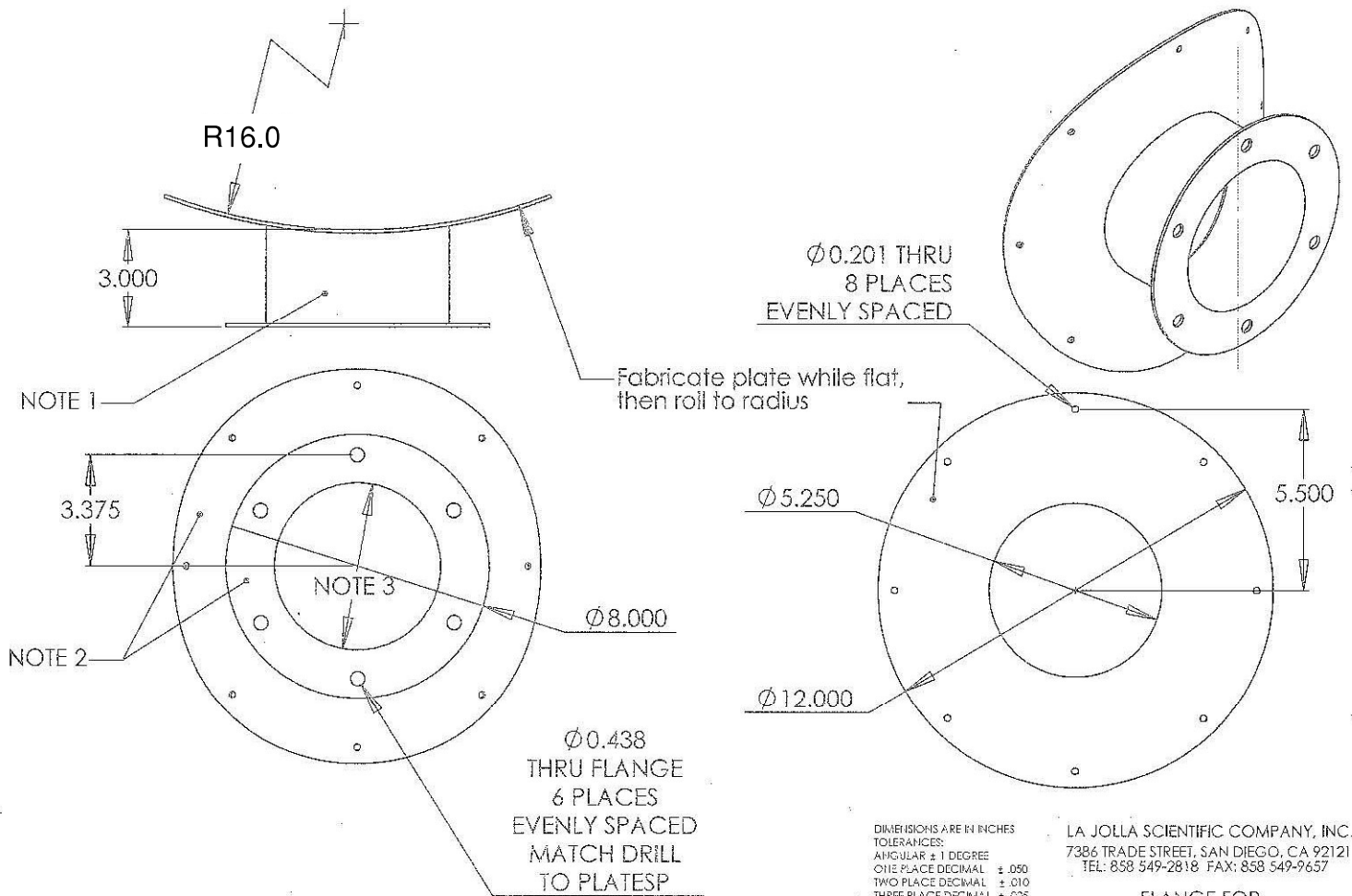


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## Appendix 9.2

### Flange for the Shrouded Probe on 32-Inch Stack



- NOTES:
1. STAINLESS STEEL 5 INCH SCH 40 PIPE
  2. 12 GAUGE (.105) STAINLESS STEEL
  3. ID OF NOTE 1 (NOMINAL  $\phi$  5.05)

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DIMENSIONS ARE IN INCHES  
 TOLERANCES:  
 ANGULAR  $\pm$  1 DEGREE  
 ONE PLACE DECIMAL  $\pm$  .050  
 TWO PLACE DECIMAL  $\pm$  .010  
 THREE PLACE DECIMAL  $\pm$  .005  
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FLANGE FOR  
 SHROUDED PROBE  
 ON 32 INCH STACK

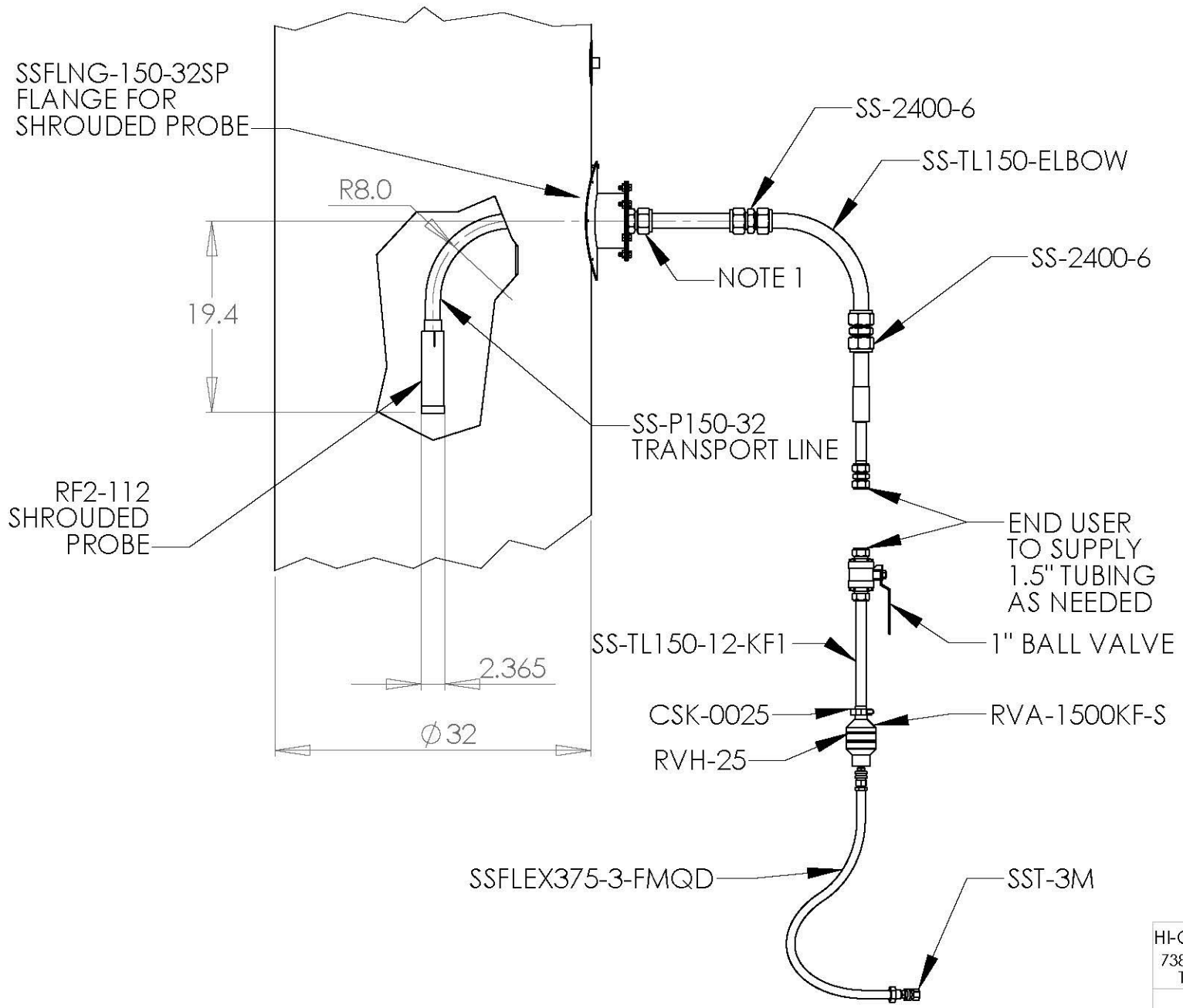
MATERIAL: SS  
 FINISH: N/A  
 DRAWN BY: S.A. OWEN DATE: 3/17/17  
 SIZE: Dwg. No. A FLANGESP33  
 CAD FILE: 09NL 32 Inch Stack Shrouded Pro...  
 REV. A  
 SHEET 3 OF 3



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Appendix 9.3  
ORNL 32-Inch Stack Shrouded Probe  
Installation/Assembly



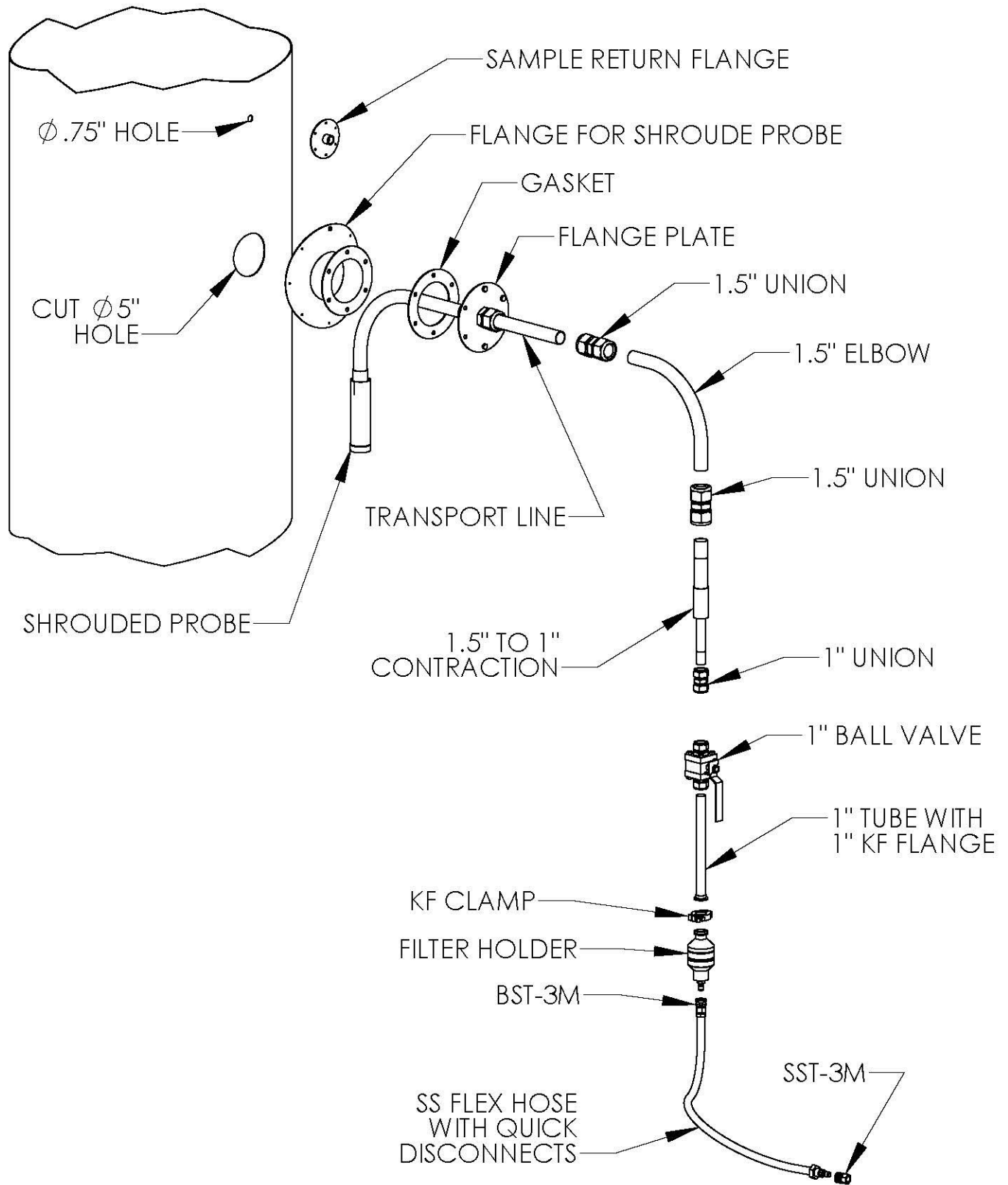
NOTES:  
 1. SWAGelok 1.5" UNION, BORED THRU, PLASTIC FERRULES

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**ORNL 32 INCH STACK SHROUDED PROBE INSTALLATION/ASSEMBLY**  
 DWG. NO. ORNL 32 INCH INSTALL REV. A  
 CAD FILE: ORNL 32 Inch Stack Shrouded Probe... SHEET 1 OF 2



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**ORNL 32 INCH STACK SHROUDED PROBE INSTALLATION/ASSEMBLY**  
 SIZE **A** DWG. NO. **ORNL 32 INCH INSTALL** REV. **A**  
 CAD FILE: SHEET 2 OF 2