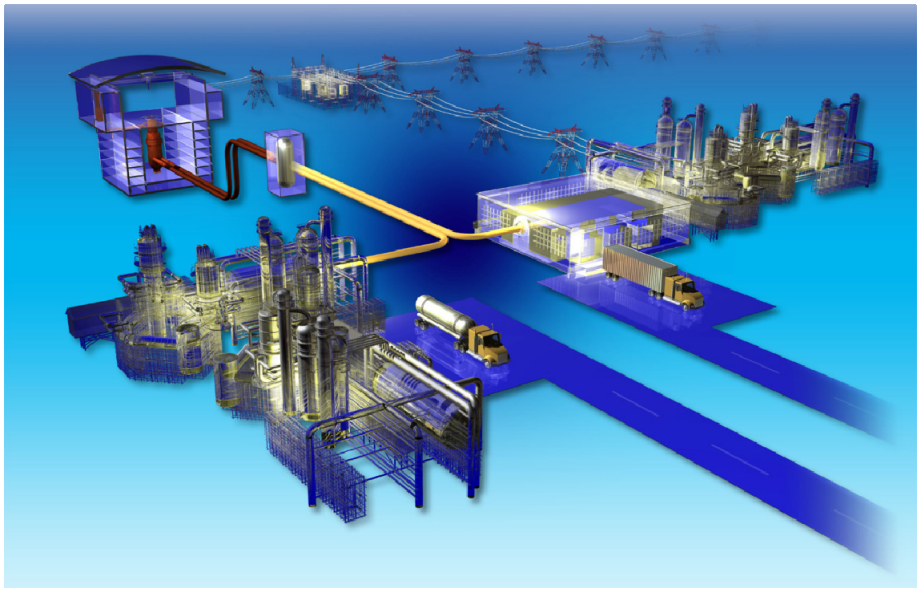
Document ID: SPC-1252
Revision ID: 1
Effective Date: 08/11/10

Specification

Project No. 23843

Custom Furnace System for Small Pressure Cycling Test Rig



The INL is a
U.S. Department of Energy
National Laboratory
operated by
Battelle Energy Alliance

Idaho National Laboratory

Idaho National Laboratory

CUSTOM FURNACE SYSTEM FOR SMALL PRESSURE CYCLING TEST RIG	Identifier: SPC-1252 Revision: 1 Effective Date: 08/11/10 Page: 2 of 23

NGNP Project	Specification		

412.15
10/31/2002
Rev. 04

DOCUMENT MANAGEMENT CONTROL SYSTEM (DMCS)
DOCUMENT APPROVAL SHEET
See Instructions for Completion of Form

1. Document Identifier: SPC-1252 2. Project File No. (optional): 23843 3. Revision No.: 0
4. Document Title: Custom Furnace System for Small Pressure Cycling Test Rig
5. Comments:

SIGNATURES

6. Typed or Printed Name/ Signature	7. Signature Code	7. Date	8. Organization/Discipline
W. H. Landman	AU	8/9/10	Project Engineer
B. C. Benefiel	AU	8/10/10	Mechanical Engineer
Dale Walhquist	R	8/10/2010	Design Engineering Manager
B. W. Stutzman	OA	10 Aug 2010	Nuclear Programs QA/Quality Engineer
M. W. Patterson	R	8/10/2010	Project Manager

9. Document Control Release Signature: Donna Rich EROB Date: 8/16/10

RECORDS MANAGEMENT

10. Is this a Construction Specification? Yes ☐ No ☒ 11. NCR Related? Yes ☐ No ☒
Does document contain sensitive, unclassified information? ☐ Yes ☒ No
12. If Yes, what category:
13. Can document be externally distributed? Yes ☒ No ☐
14. Area Index Code: Area N/A Type N/A SSC ID N/A
15. Uniform File Code: 8201 16. Disposition Authority: A17-31-a-1 Record Retention Period: Until dismantlement
17. For QA Records Classification Only: Lifetime ☒, Nonpermanent ☐, Permanent ☐
Item or activity to which the QA Records apply: Engineering Activity
18. Periodic Review Frequency: N/A ☒, 5 years ☐, or Other

REVISION LOG

Rev.	Date	Affected Pages	Revision Description
0	06/01/2010	All	Newly issued document
1	08/11/2010	11, 12, 13, 14, 16, 17, 21	Pg 11: Corrected references to P&ID and Attachment A Pg 12: Changed design pressure to 150 psig, deleted statement that the vessel need not be stamped Pg 13: Added requirement that vessel be deisgn to ASME Section VIII, added requirements for verification of computer codes and submittal of calculations for review and approval, deleted option for 36 in cube configuration Pg 14: Deleted "If cooling system is required…", deleted options for 208/240 voltage Pg 16: updated drawing format requirement Pg 17: Revised Pressure Vessel Calculations to require submittal of ASME Section VIII calculations for review Pg 21: Added requirements for examination and testing in accordance with ASME Section VIII

CONTENTS

1. SCOPE

1.1 General

This specification describes the requirements for designing and fabricating a custom-built vacuum furnace and associated structures and equipment that will form a significant part of the Small Pressure Cycling Test Rig (SPECTR). The SPECTR will initially be used to perform pressure cycling tests of diffusion bonded specimens in an inert atmosphere. The subcontractor shall provide a turn-key vacuum furnace system capable of operating for extended periods of time without operator or technician intervention. The furnace system shall be capable of evacuating the containment vessel, backfilling it with inert gas to a slight positive pressure, and ramping to temperature at a user-defined rate. At a minimum, the unit shall consist of the following components:

A. Stainless steel containment vessel

B. Internal furnace and associated insulation package

C. Internal structure for support of test articles

D. Vacuum system

E. Inert gas supply system

F. Venting system with overpressure protection

G. Closed loop cooling system (if required)

H. Control and data acquisition system.

The term contractor, as used herein, refers to Battelle Energy Alliance, LLC (BEA), which is the Idaho National Laboratory (INL) operating contractor for the Department of Energy. The term subcontractor, as used herein, refers to the company providing the SPECTR furnace system.

1.2 Work Included

The subcontractor shall provide all labor, material, equipment, and services necessary to design, fabricate, assemble, test, disassemble, and deliver the SPECTR furnace system, complete and in accordance with this specification and the applicable contract drawings and subject to terms and conditions of the contract or purchase order. The work includes, but is not limited to:

A. Design of the furnace

B. Fabrication and assembly the furnace

C. Procurement of the necessary materials and equipment to construct the furnace system

D. Fabrication and assembly of associated piping systems

E. Programming of control system for the furnace system

F. Performance of all inspections and testing as specified herein

G. Preparation of all documentation as described herein.

H. Provision of all crates, skids, protective devices, and materials for shipping and handling to the INL

I. Packaging and shipping of the furnace system to the INL

J. Onsite support for installation at a location in Idaho Falls, ID.

1.3 Work Not Included

The following work is not included in this scope:

A. Final installation of the furnace system at the INL

B. Modifications to 12 in. blind flange on process port (see Section 4.2.3).

2. APPLICABLE CODES, PROCEDURES, AND REFERENCES

The following documents form a part of this specification to the extent specified herein. Unless otherwise specified, the issue in effect on the date of invitation to bid shall apply. In the event of a conflict between the documents referenced herein and the contents of this specification, the requirements in this specification shall supersede.

A. Occupational Safety and Health Administration (OSHA) *Code of Federal Regulations* (CFR).

B. Occupational Safety and Health Standards, (OSHA) 29 CFR 1910.

C. American Society of Mechanical Engineers (ASME):

- B31.3-2008, Process Piping
- Boiler and Pressure Vessel Code, Section VIII, Division 1.

D. National Fire Protection Association (NFPA):

- NFPA-55, Standard for Storage, Use, and Handling of Compressed Gasses
- NFPA-70, National Electric Code
- NFPA-79, Electrical Standard for Industrial Machinery

- NFPA-86, Standards for Ovens and Furnaces.

E. International Code Council:

- International Building Code (IBC).

F. American Society of Testing and Materials (ASTM):

- ASTM A 36, Standard Specification for Carbon Structural Steel
- ASTM A 167, Standard Specification for Stainless and Heat- Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
- ASTM A 240, Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels
- ASTM A 276, Standard Specification for Stainless and Heat-Resisting Steel Bars and Shapes
- ASTM A 269, Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.

G. American Welding Society (AWS):

- AWS D1.1, Structural Welding Code – Steel
- AWS D1.3, Structural Welding Code – Sheet Metal
- AWS D1.6, Structural Welding Code – Stainless Steel.

H. INL Drawing:

- Drawing 768668, “Small Pressure Cycling Test Rig”

3. SUBMITTALS

3.1 General

Vendor data shall be submitted as instruments of the subcontractor; therefore, before submittal, the subcontractor shall ascertain that material and equipment covered by the submittal and its contents meet all the requirements of the subcontract specifications, drawings, and other contract documents.

Each submittal shall contain identification for each separable and separate piece of material, equipment, and literature with respect to the information provided in the specification and on the Vendor Data Schedule. Submittals shall be numbered consecutively for each different submittal.

Vendor data required by this specification to support design, fabrication, testing, and shipment is identified on the Vendor Data Schedule. The Vendor Data Schedule provides a tabular listing by specification, reference, and description of the item or service. The type of submittal is identified by a vendor data code, and the time required to submit the item is identified by a when-to-submit code. An approval code specifies whether the submittal is for Mandatory Approval or for Information Only. One copy of routine paper or electronic file submittals is required; however, additional copies may be required by the Vendor Data Schedule. Electronic file submittals are preferred.

All vendor data shall be submitted to the contractor using Form 431.13, "Construction Vendor Data Transmittal and Disposition Form,"which provides the subcontractor with a convenient method to submit vendor data and provides the contractor with a means of dispositioning the submittal. The subcontractor shall list the Vendor Data Schedule item number, a vendor data transmittal tracking number (if applicable), specification number reference, a tag number (if applicable), the submittal status (e.g., mandatory approval, information only, or resubmittal), the revision level, and the item description.

Comments by the contractor and required action by the subcontractor will be indicated by a disposition code on the submittal. The disposition codes will be classed as follows:

- ***Disposition Code A*** **(***Work May Proceed)*. Submittals so noted shall generally be classed as data that appears to be satisfactory without corrections.

- **Disposition Code B (***Work May Proceed with Comments Incorporated. Revise Affected Sections and Resubmit)*. This category covers data that, with the correction of comments noted or marked on the submittal, appear to be satisfactory and require no further review by the contractor before construction. Revised drawings shall be provided upon request.

- **Disposition Code C** (*Work May NOT Proceed. Revise and Resubmit)*. Submittals so dispositioned require a corrected resubmittal and approval before proceeding with work for one of the following reasons:

  A. Submittal requires corrections in accordance with comments before final review

  B. Submittal data are incomplete and require more detailed information before final review

  C. Submittal data do not meet subcontract document requirements.

- **Disposition Code D (***Accepted for Use. Information Only Submittal)*. Submittals so dispositioned will generally be classified as Information Only for as-specified material and equipment.

Mandatory-Approval coded vendor data shall be reviewed by the contractor and receive an A, B, or C disposition. Information Only submittals without comments shall receive a D disposition. A, B, and C-coded dispositioned submittals shall be returned to the subcontractor. Submittals dispositioned as D-coded shall not be returned to the subcontractor. The contractor may provide internal review of Information Only submittals. In the event that comments are generated on an Information Only submittal, the submittal may be dispositioned B or C and be returned to the subcontractor for appropriate action. Acknowledgment of receipt of dispositioned vendor data by the subcontractor will not be required.

The contractor shall return dispositioned submittals with reasonable promptness. The subcontractor shall note that a prompt review is dependent on timely and complete submittals in strict accordance with these instructions.

All vendor data must be dispositioned as A or D before the subcontract can be considered complete.

Where submittal of data items such as drawings, vendor data, and analysis, require approval or concurrence, the contractor shall return such concurrence, corrections, or comments to the subcontractor within 5 working days after receipt of the submittal. Where corrections are required, the subcontractor shall submit corrected drawings, analysis, or other work, until approval is granted, at which time the contractor shall return one approved and signed copy to the subcontractor. It is not the intent of the contractor to be obstructive, arbitrary, or capricious in reviewing data submittals, but to simply ensure compliance with the intent and requirements of this specification.

Contractor approval of drawings does not imply that the contractor accepts any responsibility for errors that may result in component reworks, schedule delays, or increased fabrication costs.

3.2 Vendor Data Schedule

The subcontractor shall submit the following information as indicated on the Vendor Data Schedule:

A. A schedule, 10 days after award of the subcontract identifying when the following action items will be completed: furnace system design, fabrication, testing, packaging, and shipment to the INL. A revised schedule for contractor approval within 7 working days of any modification to the subcontract that revises the scheduled delivery date.

B. Instructions that will allow the contractor to install the furnace system.

C. A SPECTR Furnace System Operation and Maintenance Manual.

D. A parts list for the furnace system.

E. A list of suggested spare parts for the furnace system. The spare parts list shall include cost of the parts for a given length of time and where the parts can be obtained if not from the subcontractor.

F. A list of any special tools required for installation, maintenance or repair of the furnace system. The special tools list shall include cost of the tools for a given length of time and where the parts can be obtained if not from the subcontractor.

4. DESIGN

A preliminary piping and instrumentation diagram (P&ID) that depicts the entire SPECTR system and shows how the furnace system integrates into the entire system is shown on INL drawing 768668. A conceptual sketch of the physical configuration of the furnace is shown in Attachment 1. The sketch is intended to depict relevant features of the system. Alternate designs that accomplish the functions specified herein are acceptable.

The furnace system shall be designed in accordance with the following requirements.

4.1 Process Requirements

4.1.1 Operating Environment

The interior of the containment vessel during high temperature options shall be helium gas.

4.1.2 Heating requirements

The furnace shall be capable of maintaining the heated zone at a temperature of 1,200°C.

The furnace shall be capable of heating from room temperature to 950°C at an average rate of at least 5°C per minute.

There is no requirement for a fast cool-down rate.

The furnace design shall maximize the thermal efficiency and minimize power usage.

4.1.3 Vacuum Design

The containment vessel shall be designed for a vacuum of 10^{-2} torr.

A vacuum system shall be provided to evacuate the vessel to 10^{-2} torr.

4.1.4 Pressure Design

The containment vessel shall be designed for internal pressures up to 150 psig and vacuums of 10^{-2} torr.

Valving and piping as indicated in the P&ID shall be designed in accordance with ASME B31.3.

The system shall be capable of back-filling the containment vessel with helium to an operating pressure between 0 and 5 psig after evacuation.

The system shall be capable of maintaining the desired pressure setting by introducing more gas or venting excess pressure.

Overpressure protection (relief valves, pressure safety valves, or rupture disks) shall be provided to assure that the containment vessel or piping systems do not exceed their design pressures.

4.1.5 Operating time

The furnace system shall be capable of operating continuously for up to 5,000 hours.

4.1.6 External Temperature

The external surfaces of the containment vessel shall be less than 50°C.

4.1.7 Failed Condition States

Upon loss of power, the system shall fail to the vented state. Operator action shall be required to reset the system.

If a cooling system is provided, failure of the cooling system shall cause power to the furnace heaters to be cut off and the system to fail to the vented state. Operator action shall be required to reset the system.

Over-temperature protection shall be provided to cut off power to the furnace if the temperature exceeds the furnace design temperature.

4.2 System Configuration

4.2.1 Vessel design

The vessel shall be designed and stamped in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code.

If computer calculations are to be used, the Applicant shall demonstrate that the computer program has the capability of producing acceptable calculations.

Shop drawings and calculations shall be provided for review and approval. The ASME Manufacturer's Data Report shall be provided for review and approval.

4.2.2 Vessel size

The furnace shall provide a heated zone that is 36 in. in diameter and 36 in. long.

4.2.3 Vessel Penetrations

At a minimum, the furnace vessel shall have the following penetrations:

- *Observation port*: 4 in. diameter sight glass as indicated in Attachment 2. A 4 in. diameter sight glass with retractable shutter shall be installed for visual observation of the test article.
- *Process port*: Nominal 12 in. diameter port as indicated in Attachment 2. A 12 in. diameter port and mating blind flange shall be provided. The blind flange will be modified by the contractor to provide tubing to the heated zone.
- *Accessory port*: Nominal 2 in. diameter port as indicated in Attachment 2. A 2 in. diameter port and blind flange shall be provided approximately as shown in Attachment 2.
- *Internal test article support*: The internal support system for the test article must be capable of holding an 8 × 8 × 8 in. test article weighing 150 pounds in the center of the heated zone. The test article, process connections, and 12 in. access port will need to be integral with the door assembly and accessed as a single unit.

4.2.4 System Arrangement

The furnace assembly shall be skid mounted and lifting points on the skid identified. A lifting diagram showing the center of gravity shall be provided.

Rails or other mechanical supports shall be provided to facilitate opening and closing of the vessel head/door.

4.2.5 Cooling System

The subcontractor shall provide a self contained closed loop cooling system capable of operating continuously for up to 5,000 hours. The system shall include all necessary pressure, temperature, and flow instrumentation for unattended operation. The system shall include the necessary valving/plumbing to allow for automatic transfer to city water in case of power failure.

4.3 Electrical

The electrical design shall comply with the requirements of NFPA-70.

The INL facility will be capable of providing power at 120 or 480 V.

The furnace system shall be designed with a single point for isolation of hazardous electrical energy to facilitate lock-out/tag-out procedures.

4.4 Instrumentation and Controls

All control equipment shall be designed for indoor installation. All components shall meet all operational performance and functional requirements over the entire range of environmental conditions identified below:

- Temperature of 60 to 105°F
- Relative humidity of 20 to 80% noncondensing
- Atmospheric pressure of 0 to 6,000 ft above sea level.

4.4.1 Instrumentation

As a minimum, the instrumentation located within the “Subcontractor Scope” boundaries on the P&ID shall be provided.

Additional instrumentation shall be provided by the subcontractor as needed for safe and effective operation of the system.

4.4.2 Control System

The subcontractor shall supply a programmable logic controller-based system with data acquisition, graphical user interface, runtime parameter displays, trending ability, and database management. The control system shall be expandable/modular to allow for future additions and upgrades, including additional input/output (I/O), code, and graphic creations to be completed by the contractor.

4.4.2.1 Programmable Logic Controller

The programmable logic controller shall be an Allen Bradley 1769 CompactLogix with a 1769-L35E - EtherNet Processor, 1.5 Mbyte Memory. The power supply shall be a 1769-PB4 – Power Supply 24 Vdc Input 4A. The input/output modules shall be selected from the 1769 CompactLogix platform.

Power supplies shall include overcurrent protection in the form of a fuse or circuit breaker on the input power. This overcurrent device shall be an integral part of the power supply and allow resetting of the circuit breaker or replacement of the fuse without removing the power supply from the chassis.

All digital input/output hardware shall be available with 24 Vdc input/output channels required for maintenance activities and panel entrance.

4.4.2.2 Supervisory Control and Data Acquisition

The Supervisory Control and Data Acquisition shall be RSView32 Works or equivalent with a minimum tag database of 300 tags/points. The graphic screens will be viewed on a 24 in. widescreen monitor. The programming language shall offer the following features:

- Predefined objects such as pushbuttons, keypads, multistate indicators, bar graphs, numeric displays.
- Complete graphics functions such as lines, circles, and rectangles to generate user-defined objects.
- Message functions that allow messages to be configured, displayed, prioritized, acknowledged, and archived.

- Alarm functions that allow alarms to be configured, displayed, acknowledged, and archived.
- Password protection.

4.4.2.3 Software

The processor configuration and programming software shall be compatible with Microsoft Windows XP operating systems.

The subcontractor shall provide all developed ladder logic code and Human Machine Interface data-base programmed in routines that can be isolated from contractor's additions.

The supplier shall provide one licensed copy of each software development package on a CD-ROM. The licensed copies of the software shall include all documentation necessary to support the software and any security components such as physical or software keys required to activate the software.

4.4.3 Uninterruptible Power Supply

Uninterruptable power supply to provide power to controls systems for a minimum of 12 hours.

4.5 Design Documentation

Upon completion of the design, the subcontractor shall submit information that allows the contractor to verify that the design of the furnace system meets the requirements of this specification. It is preferred that all drawings submitted by the subcontractor be prepared using AutoCAD (Rev. 2002) or Mechanical Desktop (Rev. 6); however, if the subcontractor uses another format, the final drawings shall be converted to the AutoCAD drawing format.

4.5.1 Assembly Drawings

The subcontractor shall prepare and submit assembly drawings that can be used during installation and routine maintenance or repair of the furnace system.

4.5.2 Electrical Diagrams

The subcontractor shall prepare and submit electrical diagrams that can be used during installation and routine maintenance or repair of the furnace system.

4.5.3 Piping Diagrams

The subcontractor shall prepare and submit piping and instrumentation diagrams for all pressure systems.

4.5.4 Data Sheets

The subcontractor shall provide data sheets for all equipment and instrumentation used in the system. An O&M manual must be provided for each piece of OEM equipment in addition to the O&M manual for the system as a whole.

4.5.5 Power and Heat Loss Calculations

The subcontractor shall provide the calculations used to determine the power requirements for the furnace. These calculations shall include heater efficiency, insulation characterization, and heat loss.

4.5.6 Pressure Vessel Calculations

The subcontractor shall provide calculations required for an ASME pressure vessel for review and approval.

4.5.7 Pressure Relief Calculations

The subcontractor shall provide the design criteria and accompanying calculations for the sizing of the pressure relief system.

5. FABRICATION

5.1 Materials

The containment vessel shall be fabricated of ASTM-240 stainless steel.

Insulation materials shall not off-gas potential contaminants that would corrode stainless steel or high alloy steels such as Inconel 617. These contaminants include, but are not limited to, methane, carbon monoxide, carbon dioxide, or chlorinated compounds.

Pressure tubing shall be in accordance with ASTM A269.

5.2 Welding

Welding of the containment vessel and piping systems shall comply with the requirements of ASME Section VIII, Division 1.

Welding of structural components shall comply with AWS D1.1 for carbon steels and AWS D1.6 for stainless steels.

5.3 Assembly

All carbon steel parts shall be painted in accordance with manufacture's standards.

5.4 Electrical Installation

The electrical installation shall comply with the requirements of NFPA-70 2008.

All components shall be UL listed.

The subcontractor shall furnish, install, and terminate all portable power cables and flexible cords to make complete and operational systems for this project.

Minimum size of power conductors shall be No. 12.

Wiring shall be color-coded as indicated in the table below:

Conductor Code Color

Conductor	208/120 Volts*	480/277 Volts	240/120 Volts*
Phase A	Black	Brown	Black
Phase B	Red	Orange	Red
Phase C	Blue	Yellow	—
Neutral	White	Gray	White
Ground	Green	Green	Green
DC +	Red**		
DC -	Black**		

* For new circuits installed in existing panels only, black may be used for any phase conductor, white for neutral and green for ground.

** DC conductors colors shall conform to the above table or to NFPA 79.

All connections shall be tightened to the manufacturer's published torque values. Where manufacturer does not specify torque requirements, connections shall be torqued to values specified in UL 486A-486B.

Flexible cords and cables shall be connected to devices and to fittings so that tension is not transmitted to joints or terminals. Provide flexible cords and cables with suitable strain relief devices at terminations to suit application.

Flexible cords and cables shall be protected by bushings or fittings where passing through holes in covers, outlet boxes, or similar enclosures.

Bundle and form wires inside wire-ways and control panels to clear pinch points, hinges, screws, and clamps associated with the enclosure cover.

Flexible cord shall be used only in continuous lengths without splice or tap.

5.5 Instrument and Controls System Installation

Furnish new electrical products, free of defects and harmful deterioration, at the time of installation. Provide each product complete with trim, accessories, finish, guards, safety devices, and similar components specified or recognized as integral parts of the product, or required by governing regulations.

All hardware shall be installed in a common mounting chassis or rack that can also contain processors, power supplies, and communication hardware as follows:

A. *Conductors*: Stranded tinned copper.

B. *Unshielded Twisted Pair (UTP) Cable*: Two, thermoplastic or PVC-insulated, individually twisted pairs of conductors; No. 18 AWG, color-coded; enclosed in PVC jacket.

C. *Multipair Shielded Signal Cable (TSP)*: Two, thermoplastic or PVC-insulated, individually twisted pairs of conductors; No. 18 AWG, color-coded, overall aluminum and polyester shield and minimum No. 22 AWG, tinned or solid-copper drain wire; enclosed in PVC jacket.

D. *Connectors and Splices*: Factory-fabricated connectors of size, ampacity rating, material, type, and class for application and service indicated. Splices are NOT allowed.

E. *Terminal Blocks*: All hardware shall have removable terminal blocks for making field terminations that incorporate either screw- or spring-type terminals approved to accept wire sizes of #14 to 18 AWG.

F. *Wiring within Panel Enclosure*: Provide conductors of adequate length. Train conductors to terminal points with no excess. Use lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.

G. *Separation of Wires*: Wiring shall be separated by voltage. All 120 Vac circuits shall be routed separately from all other circuits. Parallel runs (of 120 Vac and other circuits) shall be separated by at least 3 inches. If it becomes necessary to bring a 120 Vac bundle across a non-120 Vac bundle, the crossing shall be made at a 90-degree angle. Arrange wiring to allow access for testing, removal, and maintenance of circuits and components. Splicing or tapping of wires is not allowed in panels.

Ground cable shields and drain conductors to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments. Ground equipment to eliminate shock hazard.

Bond shields and drain conductors to ground at only one point in each circuit.

5.6 Labeling

5.6.1 Equipment Labeling

Labels shall be laminated black phenolic or plastic with white engraved letters.

Equipment mounted outside shall be labeled with a stainless steel tag of a thickness not less than 19 gauge with legend letters not less than one-quarter in. tall.

Equipment name tags shall be installed by one of the following means:

A. Attached to equipment with one-sixteenth in. stainless steel bead chain or cable.

B. Attached to equipment or immediately next to equipment using a suitable adhesive such as General Electric RTV silicone rubber. They may also be attached to equipment or immediately next to equipment using bolts, screws or rivets.

5.6.2 Wire Labeling

All conductors or cables shall be identified with white heat shrink tubing with black typed on minimum three-thirty second in. letters with non-smear ink such as Brady 321, Brady 322, or an approved equal. Hand lettered labels shall not be used. All conductors or cables shall be labeled with point-to-point destination. Wire label legends shall follow an origin/destination practice.

5.6.3 Electrical Continuity

After conductor connectors are installed and conductors are labeled, but prior to termination to terminals or devices, an electrical continuity test shall be performed on each conductor using a battery powered buzzer or ohmmeter to determine that all power, control, grounding and other conductors are properly installed and identified.

6. TESTING

6.1 Pressure Vessel Testing and Examination

The containment vessel shall be subjected to the examinations and testing required by Section VIII of the ASME Code.

6.2 Performance Testing

Testing shall be performed to ensure that the furnace system operates in accordance with the parameters outlined in this document. Testing documentation shall include a test procedure and test report.

6.2.1 Test Procedure

The subcontractor shall prepare and submit a procedure that documents the testing that will be performed to verify the performance of the furnace system.

6.2.2 Test Report

The subcontractor shall prepare and submit a report documenting the testing that was performed to verify the operability of the furnace system. The report shall document the results of the tests.

7. QUALITY ASSURANCE

7.1 Program

The furnace system shall be manufactured in accordance with the subcontractor's quality program requirements.

8. PACKAGING AND SHIPPING

8.1 Packing and Packaging

The subcontractor shall provide adequate protection for shipping the fabricated components to the INL without damage. Particular care shall be exercised to

ensure that the insulation and electrical heating systems are not damaged during shipment.

8.2 Marking and Handling

Crates shall be marked with the contract number, the actual weight of the loaded crate, the assembly orientation in the crate, and the contents of the crate. Bulky items or pallets requiring movement by forklift or crane shall have the weight conspicuously identified or labeled. Handling and storage instructions shall be permanently marked on or attached to the shipping crate.

8.3 Special Transportation Requirements

The subcontractor is responsible for all necessary packaging and shipping. The subcontractor shall notify the contractor of the method of shipment, waybill number, pick-up date, and other relevant information immediately following delivery to or pick-up by the shipper. An itemized packing list shall accompany the shipment.

9. ATTACHMENTS

Attachment 1 – Conceptual Sketch of the Physical Configuration of the Furnace

Attachment 1 – Conceptual Sketch of Furnace's Physical Configuration