



PROCESS SYSTEMS INTERNATIONAL, INC.

FEDERAL EXPRESS

TO : CALTECH (LIGO)  
391 S. HOLLISTON AVE.  
LIGO PROJECT MS 51-33  
PASADENA, CA 91125

DATE : 01/08/96  
TRANS. NO. : CT013  
PROJECT NO.: V59049

ATTN: LINDA TURNER

SENT BY : RICH BAGLEY

THE FOLLOWING [ ] DRAWINGS  
[ ] DOCUMENTS  
[ X ] SPECIFICATIONS

[ X ] ARE ATTACHED  
[ ] SENT SEPARATELY

Document No.	Rev.	Title	Dwg. Size	Sheets
① V049-2-001	2	ROUGHING PUMP CARTS	A	9
② V049-2-002	3	MAIN TURBOMOLECULAR CARTS	A	8
③ V049-2-003	2	AUXILIARY TURBOMOLECULAR CARTS	A	7
④ V049-2-033	2	GENERAL EQUIPMENT REQUIREMENTS	A	14

- ① LIG0-E960004-02-V
- ② LIG0-E960005-02-V
- ③ LIG0-E960006-02-V
- ④ LIG0-E960007-02-V

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Title: SPECIFICATION FOR GENERAL EQUIPMENT REQUIREMENTS

**SPECIFICATION FOR  
GENERAL EQUIPMENT REQUIREMENTS  
FOR  
LIGO VACUUM EQUIPMENT**

Hanford, Washington  
and  
Livingston, Louisiana

PREPARED BY: Thomas M. Stern  
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 TECHNICAL DIRECTOR: D.A. McWilliams  
 PROJECT MANAGER: Richard Bagley

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Information contained in this specification and its attachments is proprietary in nature and shall be kept confidential. It shall be used only as required to respond to the specification requirements, and shall not be disclosed to any other party.

REV LTR.	BY-DATE	APPD. DATE	DESCRIPTION OF CHANGE
2	AM 12/26/95		REVISED ATTACH. A PARA 6.5.1 DEO 0034
1	TMS 11-9-95	D.M.W 11-9-95	REVISED PER CUSTOMER COMMENTS / DEO 0019
0	TMS 10-14-95	D.M.W 10-28-95	REVISED AND ISSUED FOR QUOTATION AND APPROVAL / DEO 0004

<b>PROCESS SYSTEMS INTERNATIONAL, INC.</b>				<b>SPECIFICATION</b>			
INITIAL APPROVALS	PREPARED	DATE	APPROVED	DATE	Number	Rev.	
	TMS	10-26-95	ADB	10/27/95	V049-2-033 A LIGO-E960007-02-V	2	

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**SPECIFICATION FOR GENERAL EQUIPMENT REQUIREMENTS**

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**1.0 DEFINITIONS**

- 1.1 The "Vendor" is defined as the successful bidder accepting responsibility for meeting all requirements of this specification.
- 1.2 The "Owner" is defined as the California Institute of Technology (Caltech) in partnership with the Massachusetts Institute of Technology (MIT), under a grant from the National Science Foundation.
- 1.3 The "Buyer" is defined as Process Systems International, Inc. (PSI).
- 1.4 The "sites" are located on the Hanford reservation near Richland, Washington and in Livingston, Louisiana.

**2.0 DELETED****3.0 GENERAL REQUIREMENTS**

- 3.1 The Vendor shall be responsible for coordination of all sub-suppliers and for overall warranty and guarantees of all equipment, including their compatibility. The Vendor shall comply with all applicable referenced specifications and standards and invoke them on each sub-supplier purchase order.
- 3.2 Equipment will be installed at Hanford (near Richland), Washington and in Livingston, Louisiana. Unless otherwise indicated, equipment shall be capable of continuous service in an indoor location with a controlled temperature of  $23 \pm 1.5$  C and a relative humidity controlled at  $40 \pm 5\%$ . The equipment will, however, be exposed to diurnal and seasonal ranges during shipment, construction and power loss. It shall, therefore, not be damaged by exposure to temperature in the range of -20 to +40 C, or a humidity of 100%.
- 3.3 The Buyer shall be notified at least 10 working days prior to the start of major fabrication, assembly or testing.
- 3.4 Non-escort privileges for Buyer, Owner, Government and Owner representatives to all areas of the facilities where the work is being performed shall be arranged. This will include access to fabrication, assembly, cleaning and test areas for the purpose of monitoring activities.

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**4.0 CODES AND STANDARDS****4.1 Priority of Codes and Standards**

1. Codes
2. Standards
3. Data Sheets
4. This Specification

4.2 All conflicts shall be brought to the attention of PSI for a written resolution prior to award of a purchase order. If more than one document applies to a technical requirement, the more stringent requirement shall have precedence.

**4.3 Applicable Codes and Standards:**

American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code  
 Pressure Vessels: Section VIII, Division 1  
 Welding and Brazing Qualifications: Section IX

American National Standards Institute (ANSI)  
 ANSI A58.1: ASCE Minimum Design loads for Buildings and Other Structures

International Standards Organization  
 ISO Standard 2861: Flange Standards

Expansion Joint Manufacturers' Association (EJMA)  
 EJMA Standards

Government Standards  
 Building and safety codes: local, state and federal, including OSHA  
 Federal Standard 209 for Cleanrooms

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**5.0 DESIGN REQUIREMENTS**

The construction of equipment shall be performed in the highest manner of workmanship using only new and unused top quality materials. The equipment shall be guaranteed against defects in design, materials and workmanship as required elsewhere in the Contract.

**5.1 Mechanical Requirements**

5.1.1 Equipment feet or mounting plates shall have machined surfaces. Shim stock used shall be stainless steel.

5.1.2 Each vacuum element greater than 12" in diameter shall be designed, fabricated and tested in accordance with the latest edition of the ASME B&PV Code, Section VIII, Division 1, and subsequent addenda (except as noted under section 8.0, Welding), even though vacuum chambers lie outside of the scope of that document..

5.1.3 Bolt holes in flanges shall straddle natural centerlines.

5.1.4 Reasonable measures shall be taken to minimize noise. The goal is for acoustic noise to not exceed NC-15 when measured at any point within 1' of the equipment.

5.1.5 Reasonable measures shall be taken to minimize vibration. The goal is for the vibration of any item of equipment not to induce motion of the walls of any vacuum chamber or of the facility floor within 1 meter of any chamber which exceeds the following spectral density limits:

<u>Frequency Band, Hz</u>	<u>Vibration Limit, m/√Hz</u>
0.1 - 10	$3 \times 10^{-11}$
10 - 1000	$3 \times 10^{-9} \times (1/f)^2$
1000 - 10000	$3 \times 10^{-15}$

The above limits apply when all simultaneously operating equipment is running, and in the absence of vibration from other sources. Limited narrow band exceptions may be permitted, subject to Buyer's acceptance. Compliance with this requirement may be demonstrated by any combination of measurements and analysis, subject to Buyer's acceptance.

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- 5.1.6 ANSI Standard A58.1 shall be applied to determine the probability of earthquakes and seismic coefficients at the two sites.
- 5.1.7 No equipment shall emit or harbor particulates at a level inconsistent with maintenance of a clean environment conforming to Federal Standard 209 Class 50,000.
- 5.1.8 The equipment shall be designed for a minimum serviceable life of 20 years.
- 5.1.9 Exposure of the equipment to ambient conditions during construction, power failure or control failure shall not result in damage.
- 5.1.10 Separable parts shall be fully interchangeable between assemblies.
- 5.1.11 Adequate clearance shall be provided for assembly of mating flanges and for handles. External access shall be provided to all vacuum seams for leak checking.
- 5.1.12 Elements heavier than 50 pounds shall have lifting lugs installed.
- 5.1.13 Vendor shall specify all bolt torque requirements in the equipment operating and maintenance manual.

## 5.2 Electrical Requirements

### 5.2.1 General Electrical Requirements

- 5.2.1.1 Electrical equipment and wiring shall conform to the National Electric Code.
- 5.2.1.2 All electrical equipment shall meet commercial standards for EMI (see Attachment A).
- 5.2.1.3 Electrical equipment shall meet the acoustic noise and vibration requirements of Sections 5.1.4 and 5.1.5, above.
- 5.2.1.4 See Attachment A for other electrical requirements.

### 5.2.2 Instrumentation Requirements

- 5.2.2.1 Instrumentation shall be of industrial quality and shall be subject to the acceptance of the Buyer.

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5.2.2.2 Vibration monitoring is not a requirement of this specification.

5.2.2.3 Unless otherwise indicated, analog instrument signals shall be 4-20 ma or 0-10 VDC.

### 5.2.3 Controls Requirements

Control signals shall be 24 VDC.

### 5.2.4 Power Requirements

5.2.4.1 Motors shall comply with the Vendor's standard specifications, unless otherwise required by this specification. The minimum service factor of motors shall be 1.15. Motors shall be sized so that they can start and accelerate their loads to design speed at 90% voltage, and shall be energy efficient, if required by local or state codes.

5.2.4.2 Motors less than 3/4 HP shall be 120 VAC, 1 phase, 60 Hz. Those 3/4 HP to 200 HP shall be 460 VAC, 3 phase, 60 Hz.

## 6.0 MATERIALS

6.1 Materials used for pressure or vacuum retaining parts, nuts, bolts and studs shall be new. Where practicable, materials shall be of US origin; where not, materials from Canada, the European Community or Japan may be used. The Vendor's quotation shall identify the country of origin and how he intends to establish material traceability and conformance of composition and properties to applicable codes.

6.2 Copies of mill test reports of chamber and flange materials shall be furnished. Other nozzles, small parts, small flange nozzles, and bolting materials shall be furnished with a Certificate of Compliance.

6.3 Fabricated components exposed to vacuum shall be made from type 304L or 316L stainless steel using low carbon weld filler wire, where required. Standard catalog items of 304 or 316 stainless steel are acceptable if not available in 304L or 316L. Copper, aluminum and prebaked Viton (Dupont Type E-60C, manufactured by Parker or Buyer-accepted equal) must be used for seals. Vacuum feedthroughs must utilize UHV compatible glass or ceramic. All other materials are subject to Buyer's acceptance.

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- 6.4 Vacuum surfaces shall not be allowed to come into contact with carbon steel or oil, including during forming, handling or manufacture. Machining fluids shall be water soluble and free of oil and sulfur.
- 6.5 When manufacturing materials are marked for material identification or traceability, marking shall be done on the outside, and not on surfaces that will be exposed to vacuum.

## 7.0 UTILITIES

The following utilities are available. The vendor shall state in his proposal the usage of each utility.

### 7.1 Electric Power

120 VAC, 1 phase, 60 Hz

480 VAC, 3 phase, 60 Hz or 208/120 VAC, 3 phase, 60 Hz

### 7.2 Instrument Air: 80 psig, -60 C Dew Point

### 7.3 Deleted.

## 8.0 WELDING

- 8.1 Welding exposed to vacuum shall be done by the gas tungsten arc inert gas (GTAW) process, with a 100% Argon shield and purged back gas.
- 8.2 Welding techniques shall deviate from the ASME Code in accordance with the best ultra high vacuum practice to eliminate any "virtual leaks" in the welds. Wherever practicable, welds shall be internal and continuous. External welds for structural purposes shall be intermittent to eliminate trapped volumes.
- 8.3 Defective welds shall be repaired by removal to sound metal and rewelding.
- 8.4 Vacuum weld procedures shall include steps to avoid contamination of the heat affected zone with air, hydrogen, hydrocarbons or water. This requires that inert purge gas, such as argon, be used to flood the vacuum side of heated portions. All vacuum surfaces and weld wire shall be cleaned prior to welding

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- 8.5 The finished product shall be free of weld spatter, cutoff spatter, free iron, weld oxidation and defects. There shall be no grinding or abrasion of completed welds or internal vacuum surfaces. Completed welds shall only be cleaned with SS wire brushes that have not previously come in contact with carbon steel.
- 8.6 All welding procedures, procedure qualifications and welders employed on this job shall be qualified in accordance with ASME Section IX, latest edition.

## 9.0 REQUIRED DOCUMENTATION

### 9.1 Drawings

- 9.1.1 Assembly drawings shall be submitted for the Buyer's review prior to fabrication. They shall include all pertinent design data and calculations, including design pressures and temperatures.
- 9.1.2 Drawing acceptance must be obtained from the Buyer prior to the start of fabrication. Drawing acceptance does not constitute acceptance of any errors or of any deviation from these specifications or any instructions relating to the work. The Vendor shall call attention to any such deviations by separate written notice. Unless specific written acceptance is obtained from the Buyer, deviations are not acceptable.
- 9.1.3 If changes are made to any drawing subsequent to acceptance, drawings shall be resubmitted with all changes clearly identified. "As-Built" drawings shall be submitted.
- 9.1.4 Drawings in AutoCad, Release 12.0 are preferred. All documents stored electronically (procedures and CAD drawings) shall be backed up daily and the back-up tape shall be stored in a fire-proof safe.

### 9.2 Mechanical Data

- 9.2.1 Dimensioned outline drawings (indicating weights and center of gravity). These shall be submitted with the Vendor's proposal.
- 9.2.2 Connection sizes and ratings, design and test pressures and temperatures.
- 9.2.3 Cross-section drawings of all seals identifying all seal parts and materials.

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9.2.4 Allowable nozzle loads, if applicable.

9.2.5 All procedures to be utilized shall be submitted for acceptance prior to use. This includes welding, QA, cleaning, testing, welding, Heat Treating, leak testing, etc.

9.3 Electrical Data

9.3.1 Electrical schematics and wiring diagrams

9.3.2 Control logic documentation

9.3.3 Instrument data sheets

9.3.4 Motor data sheets

9.4 Acoustic Noise and Vibration (See Sections 5.1.4 and 5.1.5)

9.4.1 A plan describing how the Vendor will address the design issues associated with acoustic noise and vibration is to be submitted.

9.4.2 An analysis of the equipment's design dynamic characteristics (mass, center of gravity, isolator stiffness, transmissibility). The analysis shall support the Vendor's claim of meeting or not meeting the specification requirements. In the case that the requirements are not met, the Vendor shall show that all reasonable engineering attempts have been made to meet them, and the design will be subject to the Buyer's written acceptance prior to the start of manufacturing.

9.5 Test and QA Data

The following shall be submitted where applicable:

9.5.1 Manufacturer's Code Data Report

9.5.2 Nameplate facsimile

9.5.3 Hydrotest results (Deleted)

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9.5.4 Performance and leak test procedures and results

9.5.5 Mill test reports and certificates of conformance per Section 6.2

9.6 Other Documentation

9.6.1 Schedule, including design, material procurement and fabrication activities

9.6.2 Priced spare parts list with recommended spares

9.6.3 Installation, Operation and Maintenance Manual, including drawings

9.6.4 A status report with updated schedule shall be submitted monthly

**10.0 NAMEPLATES**

10.1 Each separable part (except fasteners, seals and interchangeable, standard blank flanges) shall be permanently marked with a unique identification number in a location readily viewable.

10.2 Each item shall have a stainless steel nameplate (permanently attached if practical). Nameplates shall include the Vendor's standard data. Where provided, each motor shall also have a nameplate.

**11.0 CLEANING AND PAINTING**

11.1 Equipment internals shall be cleaned and free of all foreign materials.

11.2 External carbon steel surfaces shall be cleaned and painted. The Vendor's standard is acceptable if it meets specification requirements and is compatible with federal standard 209 class 50,000.

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- 11.3 Surfaces exposed to vacuum shall be cleaned in accordance with procedures accepted by the Buyer prior to fabrication and installation. Surface recontamination during subsequent processes shall be prevented. Cleaning procedures for ultra high vacuum service shall be required.
- 11.4 Items shall be wrapped or sealed after cleaning to maintain cleanliness through handling, transportation and storage. Care shall be taken to minimize exposure to corrosive environments, such as those containing chloride compounds.

## 12.0 QUALITY ASSURANCE REQUIREMENTS

The responsibility for inspection and testing rests with the Vendor. However, the Buyer reserves the right to review equipment at any time during the fabrication to assure that the work performed is in accordance with this contract. The Vendor shall give the Buyer 10 working days notice prior to the start of major fabrication, assembly or testing so that his representative may witness these tests.

The vendor shall have implemented inspection system in effect at all times during this contract. The inspection system shall comply with the following:

### Design Control And Change Control

Provide a system to control the issuance of documents and drawings including changes to the locations where the work is being performed. The system shall address both electronic files and hard copies.

### Material Control

Provides system that controls materials from receipt through the finished product. This system shall assure that only accepted items are used and installed. Physical identification shall be used to the maximum extent possible.

### Quality Planning (Traveler)

A system of shop travelers shall be established for all work in process. The traveler shall contain Hold/Witness points of the Vendor, the Buyer and the Owner. All planning documents shall be submitted to the buyer for acceptance prior to fabrication.

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**Receiving Inspection**

Measures shall be established to inspect incoming materials to the applicable procurement documents. Status of materials shall be visible, by tagging or marking.

**In-Process And Final Inspection**

A system of inspection and test status shall be maintained using tags, markings, shop travelers, stamps or inspection records.

**Control Of Special Process' And Testing**

A system shall be established to assure that welding, heat treatment, cleaning and NDE are accomplished under controlled conditions, in accordance with written procedures, using qualified personnel, to the applicable codes and standards.

**Calibration Of Measuring And Test Equipment**

A system shall be established and documented to assure that tools, gages, instruments and other inspection, measuring, and testing equipment are of the proper range, type and accuracy. The above shall be controlled, calibrated, and certified against nationally known standards (NIST).

**Control Of Non-Conformances**

A system shall be established and documented to control items or services which do not conform to requirements. The system shall include appropriate procedures for identification, documentation, segregation, disposition and notification.

**Documentation And Records**

Sufficient records shall be prepared as work is performed to furnish documentary evidence of the quality of items and activities affecting quality.

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**13.0 PREPARATION FOR SHIPMENT**

- 13.1 Items shall be completely drained and dried.
- 13.2 Bolted connections shall be made up before shipment.
- 13.3 Aluminum plate shipping covers shall be attached with bolts to flanged connections, and with suitable attachments to other connections.
- 13.4 Units shall be completely covered for protection against the ambient and weather conditions expected during transportation. Units shall be adequately protected for unsheltered storage at the sites.
- 13.5 The Vendor shall have a signed "Release for Shipment" form provided by the Buyer's Quality Assurance representative prior to full or partial shipment of product.
- 13.6 Shipping crates shall have the Buyer's purchase order number, Vendor's name and list of tag numbers or part numbers on the outside of each crate.
- 13.7 Surfaces that will see vacuum shall be further protected by, after final cleaning, sealing openings with oil-free heavy duty aluminum foil, attaching the nozzle cover and applying shrink wrapped plastic.

**14.0 STARTUP ASSISTANCE**

The services of a qualified startup assistant shall be provided on request of the Buyer or the Owner to provide operator training and startup assistance at the sites.

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**ATTACHMENT A**

**OTHER ELECTRICAL REQUIREMENTS**

- 1.0 Definitions
- 2.0 Exceptions
- 3.0 Codes and Standards
- 4.0 Labeled and Listed Equipment
- 5.0 General Assembly Requirements
- 6.0 Wiring
- 7.0 Field Connection Boxes
- 8.0 Testing
- 9.0 Deleted
- 10.0 Motor Data Sheets

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**1.0 DEFINITIONS**

Indicated	Shown or noted.
Labeled	Approved by nationally recognized testing company.
Permitted	As by code, Contract Documents, or Buyer.
Provide	Furnish and assemble.
Buyer	Process Systems International (PSI)
Required	As by Contract Documents and/or applicable codes and standards.
Submittal	Information required to show that the proposed equipment meets project requirements.
Use	<i>Provide material or equipment referenced.</i>
Vendor	Successful bidder accepting responsibility for equipment fabrication.
Work	Material, equipment and fabrication and other requirements as established in the Contract Documents.
Wire (Verb)	Connect to equipment indicated and provide wiring required for connection.
Wiring	Conductors, raceways, and accessories as required for a complete installation.

**2.0 EXCEPTIONS**

If the Vendor cannot meet requirements established under this specification and its attachments, provide a list of deviations with your proposal. In the absence of a list of deviations, it shall be deemed that the Vendor's product is fully in compliance with this specification.

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### 3.0 CODES AND STANDARDS

The assembly shall comply with applicable parts of latest editions of publications by the following organizations:

- American National Standards Institute, Inc. (ANSI)
- Code of Federal Regulations (CFR) Title 47, Part 15
- Electrical Standards for Industrial Machinery (NFPA 79) unless otherwise indicated
- Factory Mutual (FM)
- Federal Communications Commission (FCC) Part 15
- Institute of Electrical and Electronics Engineers (IEEE)
- Insulated Cable Engineers Association (ICEA)
- National Electric Code (NFPA 70)
- National Electrical Manufacturers Association (NEMA)
- Underwriter's Laboratories (UL) or equipment and installation standards by other nationally recognized testing companies

### 4.0 LABELED AND LISTED EQUIPMENT

Provide UL label (or that of other nationally recognized testing company) or listed components where such standards exist.

### 5.0 GENERAL ASSEMBLY REQUIREMENTS

- 5.1 Arrange and assemble components in accordance with their manufacturers' specifications.
- 5.2 Label components with the equipment designation as indicated using adhesive backed labels with 1/8" high lettering.
- 5.3 Label terminal strips as indicated using printed manufacturer's labels.
- 5.4 Where air-actuated valves require pilot solenoids, mount the solenoid valves on the air operated valves.

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**6.0 WIRING**

Install wiring in raceways, wireways, or neatly tirewrapped wire bundles. Provide product data for all cables.

**6.1 Power Wire**

6.1.1 Provide #12 AWG or larger single, stranded copper conductors with Type THHN-THWN or MTW insulation rated 90 C, 600 volts.

6.1.2 Use black colored insulation, except green for equipment grounding conductors.

**6.2 Control Wire (Discrete Signals)**

6.2.1 120 VAC: Provide #14 AWG, stranded copper, multiconductor cable with Type THHN-THWN or MTW insulation rated 90 C, 600 volts.

6.2.2 24 VDC: provide #16 AWG stranded copper, twisted pairs, single or multipair cables rated 90 C and 300 volts.

6.2.3 Color code conductors as follows:

120 VAC—Line	Red
120 VAC—Neutral	White
24 VDC	Blue
External Source	Yellow
Ground	Green

6.2.4 Identify each single conductor at each end with wire number or designation. Use printed, sleeve type wire marker.

**6.3 Instrument Wire (Analog Signals)**

6.3.1 4-20 mA: Provide #16 AWG or larger, stranded copper, individually shielded twisted pairs, single or multipair cables rated 90 C, 300 volts unless otherwise indicated. Where practicable, install cables spaced at least 12 inches away from power and control wiring.

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6.3.2 Provide shielded twisted pair cables with one black and one white conductor.

6.4 Thermocouple Wire

6.4.1 Provide #16 AWG solid thermocouple extension cable shielded, rated 105 C, 300 volts of type required.

6.4.2 Provide thermocouple extension wire in accordance ISA color coding standards.

6.5 Wire and Cable Installations

6.5.1 Identify each cable end with cable number or designation. Use printed sleeve wire marker.

6.5.2 Provide sufficient wire length to permit grouping and training the wires and cables. Where applicable, use self-locking nylon wire ties; cut off loose ends. Do not exceed manufacturer's wire bending radii. Do not allow wiring to bear against edges of enclosures. Replace wiring cut too short to meet installation requirements.

6.6 Wiring Terminations and Connectors

6.6.1 Control Wiring

6.6.1.1 To terminate #10 AWG and smaller conductors to buses, enclosures, and similar applications, provide compression (crimp) terminals.

6.6.1.2 To terminate #8 AWG and larger conductors, provide either compression (crimp) connectors using matching installing tool or mechanical screw type connectors.

6.6.1.3 Where more than one conductor requires termination, provide screw or pressure type insulated terminal blocks.

6.6.2 Instrument Wire

6.6.2.1 Use insulating sleeve to secure shielding at instrument end of cable. Clip shields to avoid protruding from insulating sleeve.

6.6.2.2 Coil, insulate, and label ends of spare conductors.

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6.6.2.3 Remove insulation from ends of conductors using mechanical or electric heat type stripper.

**6.7 Equipment Grounding**

6.7.1 Bond motors, heaters, and other electrical equipment to skid base. Weld to diagonal corners of skid base a 4 by 6 by 1/2 inch steel plate with two 3/8"-16 tapped holes spaced two inches apart, or if steel base is at least 1/2 inch thick, tap holes directly into steel base.

6.7.2 Do not ground instrument shielding. Use insulating tape or heat shrink to secure shielding at instrument end of cable. Connect shielding at other end of cable to junction box terminal. (Shielding connects to a single ground reference point at Owner's controller or I/O rack.)

6.7.3 Completely remove paint, dirt, and corrosion down to bare metal where connectors, lugs, and other metal components are attached to mounting panels and enclosures to assure grounding continuity.

6.7.4 Where a grounding stud or existing panel mounting bolt is used, the Vendor may provide the grounding conductor with a ring-tongue terminal and a "star" type washer installed between the panel and terminal. Use hexagon nut to secure tightly.

**7.0 FIELD CONNECTION BOXES**

7.1 To facilitate field wiring, provide separate power, control, and instrument NEMA 4 or 12 type enclosures, unless otherwise required, with terminals and a minimum of 20 percent spare terminals.

7.2 Arrange surrounding work and location of boxes to permit box accessibility and to permit (bottom, sides, top, and rear) entrance of field conduits.

7.3 In power box, segregate voltage systems using barriers or separate boxes. Use box to terminate motors, heaters, and other branch circuits with #8 AWG and small wiring. PSI will field wire larger circuits directly to equipment junction boxes.

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7.4 In instrument box, segregate temperature element wiring using barriers or separate boxes.

**8.0 TESTING**

It is the Vendor's responsibility to conduct the following tests without damage to equipment.

**8.1 Wire Testing**

8.1.1 Check point-to-point continuity of each conductor to ensure that wiring is intact and terminated at the proper place at both ends.

8.1.2 Verify wire connections are made in accordance with terminal wiring diagrams and schedules.

8.1.3 Deleted

8.1.4 All defective wiring shall be replaced and the unit retested.

**8.2 Motors**

8.2.1 Before connecting motor, measure motor winding resistance in accordance with manufacturer's recommendations.

8.3 Test each three-phase motor for proper rotary direction.

8.4 Submit a signed test report for each electrical test conductor.

9.0 Deleted

**10.0 MOTOR DATA SHEETS**

The attached motor data sheets shall be completed by the Vendor and submitted to the Buyer with the Vendor's proposal.

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### MOTOR DATA SHEET - DESIGN PARAMETERS

ITEM	DESIGN PARAMETERS	MOTOR DATA	MOTOR DATA	MOTOR DATA	MOTOR DATA
1	Motor Identification (tag)				
2a	Volts				
2b	Phases				
2c	Hertz				
3	Synchronous RPMs				
4	Efficiency (premium/energy/norm)				
5	Service Factor				
6	Load Brake Horse Power				
7	Starting Torque				
8	Type Load (fan/pump/comp)				
9	Drive (belt/direct couple)				
10	Rotation (CW/CCW)				
11	Enclosure				
12	Mounting (horz/vert)				
12a	NEMA Type Flange				
12b	Vertical Trust (up/down)				
13	Indoor/Outdoor Use				
14	Space Heater, 120V (no/watts)				
15	Winding Temp Sensor (yes/no)				
16	Bearing Temp Sensor (yes/no)				

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## MOTOR DATA SHEET - MANUFACTURER'S NAMEPLATE

ITEM	MANUFACTURER'S NAMEPLATE	MOTOR DATA	MOTOR DATA	MOTOR DATA	MOTOR DATA
1	Motor Identification (tag)				
2a	Mfr:				
2b	Type				
2c	Frame Size				
3	Horsepower Output				
4	Time Rating (NEMA MG1-10.35)				
5	Max Ambient Temperature				
6	Insulation System				
7	RPM @ Rated Load				
8	Frequency				
9	Phases				
10	Rated Load Amps				
11	Voltage				
12	Locked Rotor Amps or NEMA Code Ltr				
13	NEMA Design Letter				
14	Efficiency				
15	Service Factor				
16	Thermal Protectors				

ITEM	MANUFACTURER'S DATA	MOTOR DATA	MOTOR DATA	MOTOR DATA	MOTOR DATA
1	Motor Identification (tag)				
2	Bearing Type				
3	Bearing Lub				
4	Efficiency @ Full Load				
5	Efficiency @ 3/4 Load				
6	Efficiency @ 1/2 Load				
7	Power Factor @ Full Load				
8	Power Factor @ 3/4 Load				
9	Power Factor @ 1/2 Load				
10	Space Heater Voltage				
11	Space Heater Watts				

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