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0	ORIGINAL ISSUE

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PRELIMINARY

**ELECTRIC HEATER**

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1 INTRODUCTION

This specification covers the minimum requirements for the design, engineering, material selection, fabrication, inspection, testing, installation, pre-commissioning and commissioning of **ELECTRICAL HEATERS** to be installed on PETROBRAS platforms.

It includes not only requirements for the **HEATER** itself, but also for all associated instruments, control panels, electrical accessories, as well as for any piping supplied within the scope of the package.

The **HEATERS** shall be provided with all necessary auxiliaries and instruments for safe, efficient and uninterrupted operation in a tropical marine environment.

Requirements related to equipment certified for hazardous areas are applicable for **HEATERS** for flammable fluids and for **HEATERS** installed in hazardous areas.

2 NORMATIVE REFERENCES

2.1 CLASSIFICATION

MANUFACTURER shall perform the work in accordance with the requirements of Classification Society.

MANUFACTURER is responsible for submitting to the Classification Society all documentation in compliance with stated Rules.

2.2 CODES AND STANDARDS

The following codes and standards include provisions which, through reference in this text, constitute provisions of this specification. The latest issue of the references shall be used unless otherwise agreed. Other recognized standards may be used, provided it can be shown that they meet or exceed the requirements of the standards referenced below:

- API RP 14 FZ Recommended Practice for Design and Installation of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class 1, Zone 0,1 and 2 Locations
- API RP 14 J Recommended Practice for Design and Hazard Analysis for Offshore Production Facilities
- API RP 505 Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class 1, Zone 0, Zone 1 and Zone 2
- API RP 551 Process Measurement
- ASME B16.5 Pipe Flanges and Flanged Fittings
- ASME B31.3 Process Piping
- ASME IX Boiler and Pressure Vessel Code; Welding and Brazing Qualifications
- ASME V Boiler and Pressure Vessel Code. Non-Destructive Examination
- ASME BPVC Section VIII Boiler and Pressure Vessel Code. Rules for construction of pressure vessels
- ASTM F 1940-07A Standard Test Method for Process Control Verification to Prevent Hydrogen Embrittlement in Plated or Coated Fasteners
- EPA AP 42 Compilation of Air Pollutant Emission Factors, Vol. 1: Stationary Point and Area Sources
- IEC 60079 Explosive Atmospheres
- IEC 60092-502 Electrical Installation in Ships – Tankers – Special Features
- IEC 60529 Degrees of Protection Provided by Enclosures (IP Code)
- IEC 61892-3 Mobile and Fixed Offshore Units – Electrical Installations - Equipment
- IEC 61892-6 Mobile and Fixed Offshore Units – Electrical Installations – Installation

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- IEC 61892-7 Mobile and Fixed Offshore Units – Electrical installations – Hazardous areas
- INMETRO Resolution 179, May 18-2010 and its annexes, and Resolution 89, Feb 23 2012
- ISA 5.1 Instrumentation Symbols and Identification
- ISO 13702 Control and Mitigation of Fires and Explosions on Offshore Production Installations
- ISO 12944-1 Paints and varnishes — Corrosion protection of steel structures by protective paint systems
- ISO 15156 Materials for Use in H₂S-Containing Environments in Oil and Gas Production
- NR-10 *Segurança em Instalações e Serviços em Eletricidade* (Safety in Electrical Facilities and Services/ Brazilian Labor Ministry Rules)
- NR-13 *Caldeiras e Vasos de Pressão* (Boilers and Pressure Vessels/ Brazilian Labor Ministry Rules)
- NR-17 *Ergonomia*
- NR-30 *Segurança e Saúde no Trabalho Aquaviário – Anexo II – Plataformas e Instalações de Apoio*
- TEMA Standards of the Tubular Exchanger Manufacturers Association


Government codes, regulations, ordinances or rules applicable to the equipment in Brazil shall prevail over the requirements of this specification, including reference codes and standards, only if more stringent.

2.3 REFERENCE DOCUMENTS

I-ET-3010.00-5400-947-P4X-002	SAFETY SIGNALING
I-ET-3000.00-1200-940-P4X-001	TAGGING PROCEDURE FOR PRODUCTION UNITS DESIGN
I-ET-3010.00-1200-540-P4X-001	REQUIREMENTS FOR PRESSURE VESSELS DESIGN
I-ET-3010.00-1200-540-P4X-002	REQUIREMENTS FOR PRESSURE VESSELS FABRICATION
I-ET-3010.00-1200-955-P4X-001	REQUIREMENTS FOR WELDING INSPECTION
I-ET-3010.00-1200-955-P4X-002	WELDING
I-ET-3010.00-1200-956-P4X-002	GENERAL PAINTING
I-ET-3010.00-1200-431-P4X-001	THERMAL INSULATION FOR MARITIME INSTALLATIONS
I-ET-3010.00-1200-956-P4X-003	THERMAL SPRAY COATING APPLICATION OF ALUMINUM
I-ET-3010.00-1200-956-P4X-002	GENERAL PAINTING
I-ET-3010.00-5140-700-P4X-002	SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS
I-ET-3010.00-5140-700-P4X-003	ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS
I-ET-3010.00-5140-741-P4X-003	POWER PANEL FOR THYRISTORIZED HEATER FOR OFFSHORE UNITS
I-ET-3010.00-5140-797-P4X-001	ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE
I-DE-3010.00-5170-797-P4X-001	ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM
I-DE-3010.00-5140-700-P4X-003	GROUNDING INSTALLATION TYPICAL DETAILS
I-ET-3010.00-1200-800-P4X-013	GENERAL CRITERIA FOR INSTRUMENTATION DESIGN

- Specific Documents to be supplied by PETROBRAS:

- SHELL & TUBE HEAT EXCHANGER SPECIFICATION
- ELECTRICAL HEATER DATASHEET
- FIELD INSTRUMENTATION

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- AUTOMATION, CONTROL AND INSTRUMENTATION ON PACKAGE UNITS
- HAZARDOUS AREA CLASSIFICATION
- METOCEAN DATA
- ACCELERATION DATA
- GENERAL ARRANGEMENT

2.4 CONFLICTING REQUIREMENTS

In case of conflicting information between this Technical Specification (hereinafter called ET) and the referred applicable standards, the most stringent requirement shall prevail.

3 DEFINITIONS AND ABBREVIATIONS

3.1 DEFINITIONS

CAN: *Can* requirements are conditional and indicate the possibility of using the standard.

MAY: Indicates a course of action that is permissible within the limits of the standard (a permission).

SHALL: An absolute requirement which must be strictly followed in order to conform with the standard.

SHOULD: A recommendation. Alternative solutions having the same functionality and quality are acceptable.

MANUFACTURER: Company responsible for the project, assembly, construction, fabrication, test and furnishing of the equipment.


PURCHASER: The Company designated as such in the contract or purchase order.

CRITICAL SERVICE: Defined as a service where failure of the machine to operate correctly results in an unsafe condition that puts the lives of personnel at risk or jeopardizes equipment. Furthermore, it is a service where failure of the machine to operate correctly makes the plant or process unacceptable as a production unit. High criticality requires high quality and reliability equipment, stringent testing, and possible redundancy. Alternatively, three half-capacity machines shall be specified, two running in parallel with the third unit as a spare.

[document supplied by PETROBRAS]: Project's document to be furnished by PETROBRAS to MANUFACTURER, this document contain information to be used during equipment design and fabrication.

3.2 ABBREVIATIONS

API:	American Petroleum Institute
ASME:	American Society of Mechanical Engineers
ASTM:	American Society for Testing and Materials
CS:	Classification Society
EPA:	Environmental Protection Agency (USA)
FAT:	Factory Acceptance Test
FPSO:	Floating Production, Storage and Offloading
IEC:	International Electrotechnical Commission
ITP:	Inspection and Test Plan
ITR:	Inspection and Test Record
NDT:	Non-Destructive Testing
RT:	Radiographic Examination
SS:	Stainless Steel
TT:	Temperature Transmitter
TSA:	Thermal Spray Aluminum
UT:	Ultrasonic Examination

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VCI: Volatile Corrosion Inhibitors

4 GENERAL REQUIREMENTS

4.1 OPERATION ENVIRONMENT

The equipment shall be suitable for the environment and range of ambient conditions, including, atmospheric pressure, relative humidity, rainfall, dry-bulb air temperature (see *Note*), characteristic monthly values and wind velocities defined in latest revision of METOCEAN DATA report [document supplied by PETROBRAS].

Note: For dry bulb air temperature of electrical equipment, use the most critical conditions, among those defined by CS and the specific equipment documentation

4.2 DESIGN CONDITIONS

MANUFACTURER shall design the equipment for the full range of process conditions as specified in the Process Data Sheet ELECTRICAL HEATER [document supplied by PETROBRAS]. MANUFACTURER shall consider fluid characteristics, quantity of heaters and operation duty according to this Datasheet.

The MANUFACTURER is responsible for the thermal, hydraulic and mechanical design. The MANUFACTURER shall guarantee the process of the equipment and the mechanical performance. It shall be designed to operate under continuous and cyclic temperature conditions. The design shall ensure minimum mechanical stress and fatigue on the heater elements.

The supplier shall provide detailed mechanical and thermal design of the equipment. Pressure retaining parts shall be designed in accordance with the ASME BPVC Section VIII, including the heater bundle tubesheet, the offset sleeves (when applicable), as well as the welds connecting the tubesheet to the heating elements or to the offset sleeves (when applicable).

Regeneration Gas Heaters of Molecular Sieve Units shall be consisted of 2 (two) units and operate in duty / standby mode (2 x 100%). Alternatively, three half-capacity machines shall be specified, two running in parallel with the third unit as a spare.

4.3 EQUIPMENT LOCATION

The **HEATERS** shall be designed to be installed outdoors. Equipment location is according to the floating unit GENERAL ARRANGEMENT drawing [document supplied by PETROBRAS].


4.4 DESIGN LOADS

In addition to Code-described loads and loads due to FPSO motions defined in the latest revision of MOTION ANALYSIS specification [document supplied by PETROBRAS], the following loads must be considered where relevant:

- Equipment transportation and erection loads;
- Nozzle loads;
- Thermal loads;
- Wind loads;
- Weight loads.

4.5 DESIGN LIFETIME

MANUFACTURER shall design and fabricate the complete equipment to function in continuously or cyclic operating (as applicable) for a minimum service life of 25 years.

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5 EQUIPMENT SPECIFICATION

MANUFACTURER shall be responsible for supplying complete and fully operative items in accordance with the requirements of this specification and the referenced standards and specifications.

English language shall be used for all design and engineering documents, for drawings and for communication with PURCHASER.

Safety signaling shall be in Portuguese language and complying with I-ET-3010.00-5400-947-P4X-002 I-ET-SAFETY SIGNALING.

5.1 SCOPE OF SUPPLY

5.1.1 Heater Vessels

The scope of supply shall include, but not necessarily be limited to, the following:

- Complete heater vessels with all required nozzles; resistance bundles with active and spare heating elements; baffles, internals and so on;
- All required local instrumentation such as over temperature protection devices, gas detectors, pressure, flow and temperature indicators/ transmitters including respective process isolation valves, vent and drain valves as applicable;
- 1 (one) complete set of spare electrical resistances bundle for both heaters (supplied loose);
- Pressure safety valves;
- Heater power panel, complying with I-ET-3010.00-5140-741-P4X-003 - POWER PANEL FOR THYRISTORIZED HEATER FOR OFFSHORE UNITS;
- All required electrical equipment including grounding system and cable trays within the skid, cable glands, terminal boxes etc.;
- Complete required and necessary tests, including shop and field tests.

5.1.2 General Materials

- Vessel supports / saddles;
- Earthing bosses and grounding devices;
- Painting;
- AISI 316 nameplates in Portuguese;
- Spare parts recommended by CS and required for commissioning, pre-operation, start up and NR-13 testing;
- Consumables and special tools for assembly, disassembly, maintenance, commissioning and start up;
- All raw materials;
- Safety signaling, warning plates and labels in Portuguese, if applicable;
- Lifting beams, spreader bars, slings, shackles etc. intended for transportation and installation on site.

5.1.3 Complete documentation, including at least:

- Detailed drawings of vessels;
- Calculation Report for vessel and bundle, according to ASME BPVC Sec VIII and TEMA R;

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- Detailed drawings of heating bundles (including information of dissipation surface, power, current, current/diameter (A/mm) and power/area (W/cm²);
 - Detailed data-sheets;
 - Resistive elements connection diagrams;
 - Calculation report of lead resistive elements lead cables;
 - Verification of equal distribution of spare elements among phases and stages;
 - Welding procedure;
 - Information of minimum acceptable heated fluid flow;
 - Test Reports, including at least:
 - Insulation resistance measurement;
 - Temperature measurement inside power terminal box at rated load (including information of maximum acceptable operation temperature for all components inside terminal box);
 - Temperature measurement of heated fluid at several points inside vessel, at full load (including information of maximum acceptable operation temperature);
 - Functional tests of controls;
 - Functional tests of alarms;
 - Functional tests of protective devices;
 - Output power control;
 - Suitable actuation of controls and protections in case of failure in blower;
 - Terminal box internal temperature data (design and limits);
 - Terminal box internal thermographic report at rated load;
 - Output power measurement, comparing with control load adjustment;
 - Check of torsional torque of electrical connections;
 - All documents required by Brazilian Regulation NR-10;
 - All documents required by Brazilian Regulation NR-13;
 - Documents required in I-ET-3010.00-5140-741-P4X-003 - POWER PANEL FOR THYRISTORIZED HEATER FOR OFFSHORE UNITS;
 - Certification by CS;
 - Certificate reports for all electrical equipment suitable to operation in hazardous areas;
 - Packing, Transportation, Assembly, Disassembly, Operation, Maintenance and Storage Manuals;
 - Spare part list recommendation for two years continuous operation;
 - Technical assistance for equipment installation, connection, commissioning and start-up;
- Other items may be included in Manufacturer scope of supply, according to PETROBRAS documentation.

5.1.4 Services

- Inspection, testing and quality assurance;
- Commissioning supervision at job site;
- Non-destructive examination;
- Operation and maintenance training;

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- Packing, protection and marking for shipment;
- Preservation, including equipment handling, conditioning and storage at job site;
- Total process and mechanical guarantee.

5.2 MECHANICAL AND PIPING

5.2.1 General

The **Heaters**, including all ancillary equipment, shall be assembled to the maximum extent possible, aligned and pre-checked at the MANUFACTURER's shop, allowing shipment to the installation site with minimum field work.

5.2.2 Pressure Vessels

5.2.2.1 Design

All pressure vessels shall be designed according to ASME section VIII and I-ET-3010.00-1200-540-P4X-001 - REQUIREMENTS FOR PRESSURE VESSELS DESIGN.

Heater vessel shall have one flanged end where the heater bundle is attached, and the fixed end shall be a semi-ellipsoidal or hemispherical end cap.

Pressure vessels shall comply with the requirements of NR-13 whenever applicable.

The dimensions of all nozzle flanges shall meet ASME B16.5 or B16.47 standard.

5.2.2.2 Connections/ Flanges

For nozzles < 2" in nominal diameter, forged steel couplings may be used. Couplings shall be at least class 6 000#, for socket weld.

Nozzles having a nominal diameter > 2" shall be flanged, except when specified for butt weld in the piping.

The minimum nominal diameter of nozzles intended for any purpose shall be 3/4".

Flanges having a nominal diameter < 1-1/2" may be of the following types:

- long welding neck flange;
- welding neck flange with a neck sch. 160 or XXS.

Flanges having a diameter from 2" to 12", inclusive, shall be forged steel welding neck type.

Nozzles in general may be forged, as an option, considering the high pressure level.


5.2.2.3 Weld Design

All welds subjected to pressure loads shall be butt welded, full penetration and allow radiography. All shell reinforcements, integral or not, shall have the same P-number as the shell.

MANUFACTURER shall follow the requirements of I-ET-3010.00-1200-955-P4X-001 – WELDING. Additional requirements are indicated in item 5.4.3.

5.2.2.4 Fabrication

Pressure vessels shall be fabricated according to I-ET-3010.00-1200-540-P4X-002 - REQUIREMENTS FOR PRESSURE VESSELS FABRICATION.

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5.3 MAINTENANCE AND MECHANICAL HANDLING

Package design shall allow replacement, if applicable, or plugging of any failed resistance element.

Withdrawal spaces and clearances shall be provided for all removable vessel internals. Suitable lifting facilities shall be provided to allow bundle removal.

All required maintenance lifting devices within the equipment limits shall be provided for safe and easy maintenance.

All lifting gear shall be subject to load testing, witnessed by PETROBRAS representative and CS.

5.4 ELECTRICAL

5.4.1 General

All electrical equipment and materials shall comply with the requirements of I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

Outdoor electrical equipment shall be certified for hazardous areas, according to Hazardous Areas Classification [document supplied by PETROBRAS]. Outdoor electrical equipment which shall be kept operating during emergency shutdown ESD-3P or ESD-3T shall be certified for installation in hazardous areas Zone 1 Group IIA temperature T3.

Electrical installation inside the PACKAGE shall comply with requirements of I-ET-3010.00-5140-700-P4X-003 - ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS.

Equipment, accessories, piping and structures shall be grounded according to IEC 61892-6 and 60092-502 and I-DE-3010.00-5140-700-P4X-003 - GROUNDING INSTALLATION TYPICAL DETAILS. For installations in hazardous area, the grounding requirements of IEC 61892-7 shall also be met. Package skid shall have 2 diagonally opposed earthing bosses.

The electrical interfaces of the equipment shall comply with I-ET-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE and I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM.

5.4.2 Specific Requirements

The equipment shall be designed to operate under cyclic or continuous temperature conditions, in accordance with Process Data Sheet ELECTRICAL HEATER [document supplied by PETROBRAS] and in either case shall be controlled by a thyristors panel.


The maximum electrical demand and configuration shall be according to Process Data Sheet ELECTRICAL HEATER [document supplied by PETROBRAS].

Each vessel shall have one resistors bundle with at least 10% unconnected spare units and a power terminal box with protection degree IPW-56 or higher, where W means saline, hot and dump atmosphere. The bundles shall be identical, interchangeable and have the load balanced between phases.

The resistive elements shall have rated voltage according to Process Data Sheet [document supplied by PETROBRAS]. Besides the variations defined in I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS, they shall withstand continuous voltage variations of + 6, -10% according to IEC 61892-1 with no reduction to the lifetime. Deviations from these requirements shall be approved by PETROBRAS.

5.4.3 Heater Elements and Power Terminal Box

Tubular heater elements shall be constructed from 80/20 NiCr resistance wire surrounded by compacted magnesium oxide powder (MgO). Elements shall be seamless incoloy 800H sheath. MANUFACTURER shall inform the total quantity of tubular heater elements per bundle. During manufacture of the individual tubular

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heater elements, each element shall be dried in a high temperature oven and subsequently sealed to prevent damage due to moisture and hydrocarbon ingress.

For cyclic service, the method for sheath element to tubesheet joint shall be by means of a strength weld. The use of welded offset sleeves to connect the tubesheet to the power terminal box is only acceptable after specific approval from Petrobras. Mechanical bushing with "bite" couplings is acceptable for non-cyclic service. The Manufacturer shall include the method in his quotation for PETROBRAS approval.

The Manufacturer shall supply suitable and sufficient supports to prevent any bending of heater elements and any flow induced vibration.

In order to prevent the overheating of the terminal box and damage to the insulators on the element terminals, there shall be a distance between the Ex e terminal box and the heater shell flange and an inactive element length after the tubes enter the heater shell. The use of heat shields in between the flange and the terminal box is acceptable.

The bundles shall be designed to prevent the ingress of heated fluid into the terminal box in case of failure of a welded junction or a sealing device. The medium and the maximum allowable heat flux shall be specified by the PURCHASER on the process data sheet. The Manufacturer shall confirm the heat flux of the heater under normal operating conditions and the maximum design heat flux.

Spare heater elements shall be installed, but not connected. All spare elements shall be fitted. The wires of sufficient length to connect the element to any busbar in the event shall be furnished but not installed inside the Power Terminal Box.

The Manufacturer shall provide with the quotation information regarding the repair procedure in case of a faulty heater element. The repair practice shall be suitable to be performed on board and shall not invalidate the Ex certification.

The Power terminal box shall be suitable for use in the environment described in this ET and shall comply with I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

The power terminal boxes shall be fitted with sunshades, with anti-condensation heaters (fed from external 220Vac 2phases ungrounded) controlled by thermostats and with thermal cutouts to guarantee that the limit of the temperature class T3 will not be exceeded.

They shall be able to receive three core or single core cables, and besides the characteristics plate they shall have a high temperature warning indication.

The construction of power terminal box shall comply with the requirements of the relevant parts of IEC 60079. The power terminal box shall have type protection Ex e in accordance with IEC 60079-7.

The Power terminal boxes with Ex d protection in accordance with IEC 60079-1 are only acceptable after specific approval by Petrobras.

The temperature inside the power terminal box shall be within the limits stated on the Ex certification. Manufacturer shall inform in Data Sheet, the maximum expected temperature inside terminal box in normal operation.


Considering that the substantial power cable derating that is normally applied, adequate cable termination space shall be provided for the power cabling. Cable details shall be confirmed during detailed design based on the actual heater parameters.

The element leads (electrical cables) and the cable lugs to connect the resistive elements to incoming power cables shall be sized considering the amount of cables inside of the power terminal box (derating grouping factor, to be informed by Manufacturer) and the internal temperature (derating temperature factor, to be informed by Manufacturer) when the heater is operation in full load condition.

The field emergency pushbutton to turn off the heater shall not be installed in the Power terminal box. This pushbutton shall be supplied by Manufacturer and shall be installed in safe area close to heaters neighborhood (area with safe access in case of accident in heaters) and with identification.

The internal connections within the main terminal box shall be copper and of sufficient size, strength, and configuration to enable a solid connection of the supply cables without excessive stress on the conductors.

For heating element entrance into terminal box, the manufacturer shall provide removable non-magnetizing material plate (panel back plate).

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The heater shall be protected by a suitable earth fault protection system wired to shutdown the heater in the event of heater element failure to earth. This protections shall be carried out by thyristorized power panel.

5.4.4 Auxiliaries Terminal Boxes

The terminal boxes for auxiliary cables shall be separate from the main terminal box and have covers which can be accessed without opening the cover of the main terminal box. The degree of protection shall be at least IP 56 as defined in IEC 60529.

5.5 INSTRUMENTATION

5.5.1 General

The equipment shall be provided with local indicators, transmitters and other instruments required for operation and monitoring, in accordance with the respective process data sheet, P&ID and the latest revision of FIELD INSTRUMENTATION specification [document supplied by PETROBRAS].

All instruments shall be Ex d IIA T3 in accordance with IEC 60079 and shall have minimum ingress protection IP-56W in accordance with IEC 60529 and shall be installed in accordance with API RP 551.

Any new instrument cabling shall be led to the package limits in order to make the signals available for connection with the FPSO automation and monitoring systems.

Control and safeguarding instrumentation shall be segregated according to reference documents.

5.5.2 Over-Temperature Protection Devices


The Heater set shall have temperature sensors in order to measure the temperature at least in the following locations:

- On the tubesheet (flange), in order to protect the terminal box against over temperature (for heaters for flammable fluids);
- Inside the terminal box (for heaters for flammable fluids);
- On the sheaths of heater elements (tubes), in order to protect the elements against over temperature. These sensors shall be welded or clamped to the sheaths of the elements that are connected to different phases and shall be located in an area of highest anticipated sheath temperature;
- On the Heater Vessel, in order to control the heated fluid temperature.

The temperature sensors shall be connected to temperature transmitters, which shall have 4~20mA+Hart output. Signal from transmitter shall be connected to equipment panel and shall be used in order to shutdown the Heater in case of over-temperature. MANUFACTURER shall inform the over-temperature setpoint value for each sensor.

5.5.3 Gas Detectors

For HEATERS for flammable gases, MANUFACTURER shall provide a gas detector (suitable to gas fluid) to monitor the atmosphere inside of power terminal box. The gas detector shall have 4~20mA output signal with diagnostic capabilities and shall comply with maximum power terminal box inside temperature, as indicated on its certificate. Signals from gas detector shall trip the related Heater.

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5.6 MATERIALS

5.6.1 GENERAL

The Materials shall be according to ELECTRIC HEATER PROCESS DATASHEET [document supplied by PETROBRAS].

Material selection for the equipment shall be performed in accordance with ISO 21457. As a minimum they shall conform to the following:

- Heater elements sheaths: Seamless Incoloy 800H;
- Offset sleeve (if applicable): Seamless Incoloy 800H;
- Tubesheet and shell: compatible with the service.

All materials exposed to hydrocarbons containing hydrogen sulphide must follow the requirements of ISO 15156 for sour service.

Repair by welding or by plugging shall be undertaken only when permitted by the material specification and shall only be applied with the procedures specified.

Details of all major weld repairs and the heat treatment shall be recorded and reported to PETROBRAS.

5.6.2 MATERIAL CERTIFICATION

In order to ensure that the materials of construction are in accordance with data sheets, all certificates shall contain the following information:

- Name of manufacturer
- Purchase order number and issue date
- Identification number of certificate and issue date
- Material specification(s)
- Material charge, batch or heat number
- Mechanical properties recorded from test results
- NDT methods and results
- Heat treatment records.


5.7 PAINTING AND THERMAL INSULATION

The process heaters shall be suitable for use in a CX atmosphere, according to ISO 12944-1. Condensation and solar radiation shall be taken into account.

The vessel coating shall be in accordance with GENERAL PAINTING I-ET-3010.00-1200-956-P4X-002. In case TSA is required, the coating shall be in accordance with I-ET-3010.00-1200-956-P4X-003 - THERMAL SPRAY COATING APPLICATION OF ALUMINUM.

Thermal insulation shall be designed and applied in accordance with I-ET-3010.00-1200-431-P4X-001 - THERMAL INSULATION FOR MARITIME INSTALLATIONS.

To avoid corrosion underneath insulation, only non-hygroscopic insulation material shall be selected. The use of asbestos or materials containing asbestos is prohibited.

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5.8 NAMEPLATES

MANUFACTURER shall attach SS 316 nameplates on each item of equipment in an accessible location, fastened with corrosion resistant pins.

Nameplate shall display, as a minimum, the following information (in Portuguese):

- Petróleo Brasileiro S.A. – PETROBRAS;
- Purchase order number;
- Manufacturer and year of build;
- Tag number.
- Service;
- Serial number;
- Main design, operation and test data (pressure, capacity, temperature, flow rate), as applicable;
- Specific requirements;
- Installation identification;
- Power rating, voltage and other electrical data, where applicable;
- Design code;
- Empty, operation and test weight.

Nameplates for vessels shall be according to I-ET-3010.00-1200-540-P4X-001 - REQUIREMENTS FOR PRESSURE VESSELS DESIGN, and shall also include sufficient information to enable the calculation of leakage emissions, according to the standards established in EPA AP 42 (see item 2.2 – Codes and Standards).

5.9 TAGS AND SAFETY SIGNS

5.9.1 TAGGING

Tagging of all instrumentation, electrical, mechanical, and piping items, including valves, shall be carried out, as defined in I-ET-3000.00-1200-940-P4X-001 – TAGGING PROCEDURE FOR PRODUCTION UNITS DESIGN. Tag numbers for remaining ancillary equipment shall be given after Purchase Order placement.

5.9.2 SAFETY SIGNS

All safety signs shall be in Portuguese, and their layout, size, colors, fonts, materials etc. shall meet the requirements of I-ET-3010.00-5400-947-P4X-002 - SAFETY SIGNALLING.


6 CERTIFICATION REQUIREMENTS

6.1 GENERAL

MANUFACTURER shall be responsible for all required certification of the equipment.

MANUFACTURER, through the independent certifying authority, shall supply all certificates related to the materials, inspections, tests and qualification activities detailed in the approved Quality Plan.

For pressure containing parts of equipment and main components, MANUFACTURER shall attest material properties and chemical composition by means of appropriate certificates.

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All materials and equipment proper to be used in hazardous areas, shall have Conformity Certificates complying with INMETRO Portaria n° 179, May 18th 2010 and its annexes and Portaria n° 89, Feb 23rd 2012 and shall be approved by Classification Society. In this way, the Manufacturer shall provide the Conformity Certificates considering both internal and external components to be installed at power terminal box. A Nameplate with information about Conformity Certificates shall be provided.

6.2 CLASS CERTIFICATION

For the vessels and other applicable components of the PACKAGE, a CS Certificate of compliance with Rules requirements shall be supplied.

7 INSPECTION, TESTING AND COMMISSIONING

7.1 GENERAL

MANUFACTURER shall submit an inspection and testing program of all supplied equipment to PURCHASER's approval, prior to work start in accordance with document schedule.

Unless otherwise stated, all inspections and tests shall be performed at the MANUFACTURER workshop in the presence of PETROBRAS representative and CS surveyor as applicable.

Inspections and tests are an integral part of the order which will not be considered complete until such inspections and tests have been carried out in full. PURCHASER shall issue an Inspection Release Certificate (IRC) after completion of these inspections and tests only.

7.2 MECHANICAL COMPLETION

Term used to indicate satisfactory completion of fabrication scope of work, including basic inspection and checks carried out to demonstrate that the equipment has been fabricated correctly and according to PETROBRAS requirements. MANUFACTURER shall deliver relevant documentation to prove that these inspections and checks have been completed.

7.3 INSPECTION

MANUFACTURER shall submit an Inspection and Test Plan (ITP) with the bid.

PETROBRAS shall identify all the required witnessed inspections on a marked up copy of the ITP.

PETROBRAS reserve the right to inspect the package equipment anytime during fabrication to ensure that material and workmanship are in accordance with this specification.


MANUFACTURER shall ensure that all the witnessed inspection requirements by CS are met and due notice is given. The notification period for such inspections shall be mutually agreed upon during the kick-off meeting.

MANUFACTURER shall provide notice in advance to the surveyor to witness the specified tests at least 2 (two) weeks for Brazilian MANUFACTURERS / Sub-Suppliers and 3 (three) weeks for foreign MANUFACTURERS / Sub-Suppliers.

7.4 HYDROSTATIC TESTING

All applicable equipment shall be hydrostatically tested in the presence of PETROBRAS surveyors, including:

- All vessels;

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- All fabricated retaining pipework to ASME B31.3.

The equipment shall be drained of water and dried after hydrostatic testing.

7.5 HELIUM TIGHTNESS TESTING

For Heaters for flammable gas, after the hydrostatic test, the Heater shall be tightness tested with helium gas in order to verify the sheath element to tubesheet joint. The test shall be in accordance with ASME V, Article 10. The Helium concentration in the test gas shall be 10% minimum, and the acceptance criteria shall be 1×10^{-4} cm³/s. Test pressure shall be 2 bar, minimum (but never higher than the hydrostatic test pressure).

7.6 NDT EXAMINATION

Final non-destructive examinations, for acceptance purposes, shall be carried out after completion of any post weld heat treatment (when applicable) and before painting, hydrostatic testing etc.

7.7 ELECTRICAL

Testing shall be witnessed by PETROBRAS surveyors and shall include at least:


- Megger test for cables,
- Power Terminal box internal temperature measurement with stable full load;
- Power Terminal box infrared register (cables, bars, elements' connections, cable glands plate and bundle plate) at stable full load;
- Operation of temperature sensors, transmitters, controls and protections;
- Operation of gas detectors and transmitters;
- Elements resistance measurement (including spares);
- Total resistance measurement (each phase with elements connected);
- Elements isolation measurement;
- Check of torque of electrical connections;
- Terminal box protection degree test (type test reports are acceptable);
- Check of non-magnetizing properties of cable glands plate and bundle elements plate;
- Visual inspection of connections, terminals and cables;
- All tests in accordance with the reference standards and documents;
- Tests of power panel, according to I-ET-3010.00-5140-741-P4X-003 POWER PANEL FOR THYRISTORIZED HEATER FOR OFFSHORE UNITS.

7.8 INSTRUMENTATION

Testing shall be witnessed by PETROBRAS surveyors and shall include at least:

- Review of calibration certificate issued by laboratory certificated by RBC (All Instruments);
- Review of hazardous area equipment certificates (All instruments);
- Loop Test (All instruments).

7.9 EQUIPMENT INSPECTION

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Unless waived by PETROBRAS, the following inspections and checks shall be witnessed by PETROBRAS surveyors:


- Verification of materials of construction of the package units (vessels etc.) for conformity with the requirements of the specification;
- Verification that piping, fittings and valves conform to specification of materials and fabrication;
- Radiographic, dye penetrant, magnetic particles, ultrasonic inspection of welds on the pressure retaining parts of the equipment;
- Approval of the relief valve settings and witness of their testing after setting;
- Review of ITR's;
- A visual check of the assemblies package noting:
 - That the thickness of pressure retaining parts meets or exceeds the quoted design thickness;
 - Any repairs;
 - Dry-film thickness quoted;
 - General appearance, materials, workmanship and surface finish standard are acceptable;
 - Dimensional check: alignment to be demonstrated.
- Final dimensional and visual examination of the equipment (prior to assembly of the bundle to the shell);
- Hydrostatic Test of the equipment;
- Helium tightness test of the equipment;
- Final Preservation and preparation for shipment.

7.10 FAT

The following tests shall be included in MANUFACTURER scope:

- Pressure tests of vessels;
- Electrical continuity checks on all wiring and earthing for each resistive element;
- Electrical insulation and dielectric strength tests for each resistive element;
- Megger test for cables,
- Operation of temperature sensors, transmitters and controls;
- Operation of gas detectors and transmitters;
- Elements resistance measurement (including spares);
- Total resistance measurement (each phase with elements connected);
- Elements isolation measurement;
- Check of torque of electrical connections;
- Terminal box protection degree test (type test reports are acceptable);
- Check of non-magnetizing properties of cable glands plate and bundle elements plate;
- Visual inspection of connections, terminals and cables;
- All electrical tests in accordance with the reference standards and documents;
- Tests of power panel, according to I-ET-3010.00-5140-741-P4X-003 POWER PANEL FOR THYRISTORIZED HEATER FOR OFFSHORE UNITS;
- Functional checks on all instruments and valves.

MANUFACTURER shall prepare a FAT Procedure for the package and submit it to PETROBRAS approval.

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FAT will be witnessed by PETROBRAS representatives. MANUFACTURER shall advise PETROBRAS of the test schedule at least two (2) weeks for Brazilian Manufacturers/ Sub-Suppliers and 3 (three) weeks for foreign Manufacturers/ Sub-Suppliers before the scheduled test dates. MANUFACTURER shall invite CS surveyor for FAT.

Acceptance of the FAT will not be considered as the final acceptance test of the package unit.

7.11 ASSEMBLY ASSISTANCE AND COMMISSIONING REQUIREMENTS

MANUFACTURER is responsible for the field assembly supervision of the equipment, including assembly of components to be delivered loose.

MANUFACTURER shall be responsible for pre-commissioning and commissioning supervision of the equipment supplied. Final acceptance will be on satisfactory completion of commissioning tests as specified by the PURCHASER.

7.11.1 Electrical Equipment

Before the energization of the package at least the following tests shall be carried out:

- a) Electrical continuity checks on all wiring and earthing for each resistive element;
- b) Electrical insulation and dielectric strength tests for each resistive element;
- c) Megger test for cables,
- d) Operation of temperature sensors, transmitters and controls;
- e) Operation of gas detectors and transmitters;
- f) Elements resistance measurement (including spares);
- g) Total resistance measurement (each phase with elements connected);
- h) Elements isolation measurement;
- i) Check of torque of electrical connections;
- j) Terminal box protection degree test (type test reports are acceptable);
- k) Check of non-magnetizing properties of cable glands plate and bundle elements plate;
- l) Visual inspection of connections, terminals and cables;
- m) All tests in accordance with the reference standards and documents;
- n) Test of isolation monitoring devices.


During the first operating cycles, the following tests shall be performed as a minimum:

- a) Power Terminal box internal temperature measurement with stable full load;
- b) Power Terminal box infrared register (cables, bars, elements' connections, cable glands plate and bundle plate) at stable full load;
- c) Power measurement in 10% steps, from no-load to full-load;
- d) Measurement of current balance between phases at full load.

8 PREPARATION FOR SHIPMENT

8.1 MARKING

All items supplied according to this specification shall be marked for identification against a certificate or relevant test documentation. Marking shall be such that it will not damage or impair the component. Items

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that cannot be identified shall be rejected. Rejected items may be re-certified by carrying out all relevant testing, with prior approval of PETROBRAS.

As a minimum, the following identification shall be provided:

- Project Number
- Manufacturer's name
- Purchase Order Number
- Shipping Weight
- Item Number
- CS surveyor's stamp

8.2 PACKING AND PRESERVATION

The equipment shall be supplied tested, flushed, preserved and protected from corrosion.

The equipment preparation shall be suitable for 24 months outdoor storage from the time of shipment.

Packaging design shall be submitted to PETROBRAS for approval.

Desiccant shall be provided in terminal boxes.

VCI pads shall be installed into terminal boxes, vessel inlets / outlets, tubesheet and on both ends of tube bundle.

Equipment shall be packed in accordance with the packaging requirements of the country which the equipment is being shipped to.

MANUFACTURER shall provide the procedures for unpacking, handling and installation, as well as repacking and long-term storage requirements.

MANUFACTURER shall specify any limitations applicable to the transportation and installation phase.

9 MANUFACTURER RESPONSIBILITY


Any conflict between the requirements of this specification and related codes, standards, specifications etc. shall be presented in writing for PETROBRAS resolution prior to manufacturing.

MANUFACTURER shall assume sole contractual and total engineering responsibility for the equipment supplied.

MANUFACTURER responsibility shall also include but not limited to:

- Resolving all engineering issues and/ or problems relating to design and manufacture.
- Providing details as requested of any vendors relating to design and manufacturing.
- In all cases of conflict between this specification and applicable documents listed herein, the more stringent requirements shall prevail. In such cases, MANUFACTURER shall inform PURCHASER of the conflict and seek clarification.
- Installation at site by others, however, presence of supervision will be required.
- MANUFACTURER responsibility shall include Commissioning & Training for operation.
- Compliance by the MANUFACTURER with the provisions of this specification does not relieve the MANUFACTURER of his responsibility to furnish equipment and accessories of a proper mechanical design suited to meet the specified service conditions.

The technical proposal shall present the complete and detailed scope of supply and meet the requirements of all items of the respective Material Requisition (number and revision quoted) and its annexes,

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complemented by the Technical Clarification Circular Letters (number quoted), without any technical deviation.

Any exclusion and/or alternative to what is specified in the Material Requisition and its annexes, including the use of the MANUFACTURER'S standard and exclusive technology, shall be presented in a Deviation List, which will only be accepted by PETROBRAS during the clarification phase, preceding the proposal presentation.

PETROBRAS acceptance of each item of the Deviation List will be through Technical Clarification Circular Letters, that will be issued to all MANUFACTURER.

The Deviation List mentioned above shall contain, at least, for each requirement that the MANUFACTURER intends to change:

- The document's description, code and section that contain the requirement;
- The reason for deviation, indicating the requirements that are different to MANUFACTURER's standard, and the costs, schedule and technical benefits/ impacts of the change;
- The MANUFACTURER proposal.

Remarks:

- Detailed drawings and description of the operation of instrumentation and controls, as well as the makes, materials and types of auxiliary equipment shall be provided. The MANUFACTURER shall provide a description of the alarm and shutdown facilities to be provided.
- The operation manuals shall contain, in addition to all necessary installation, operating and maintenance information, updated "as supplied" revision of data sheets.
- All information to be provided shall be clear. Manuals for operation and maintenance shall apply specifically to the units installed. MANUFACTURER is fully responsible for the contents of all Data sheets and documentation.
- Dedicated NR-13 file complete with all applicable documentation and certification to prove NR-13 compliance (if applicable).
- Dedicated NR-10 file complete with all applicable documentation and certification to prove NR-10 compliance.
- Cross-sectional drawings shall be provided with the spare parts list, where applicable.



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10 WEIGHT CONTROL

MANUFACTURER shall fill in the following attachment.

APPLICABLE TO: PROPOSAL PURCHASE AS BUILT

FOR: _____ UNIT / MODULE: _____

SITE: _____ SERVICE: _____

No REQ / TAG: _____ MANUFACTURER: _____

MODEL: _____ VENDOR: _____

SIZE / TYPE: _____ MAIN EQUIPMENT: _____

SERIAL No. _____ MANUFACTURER No: _____

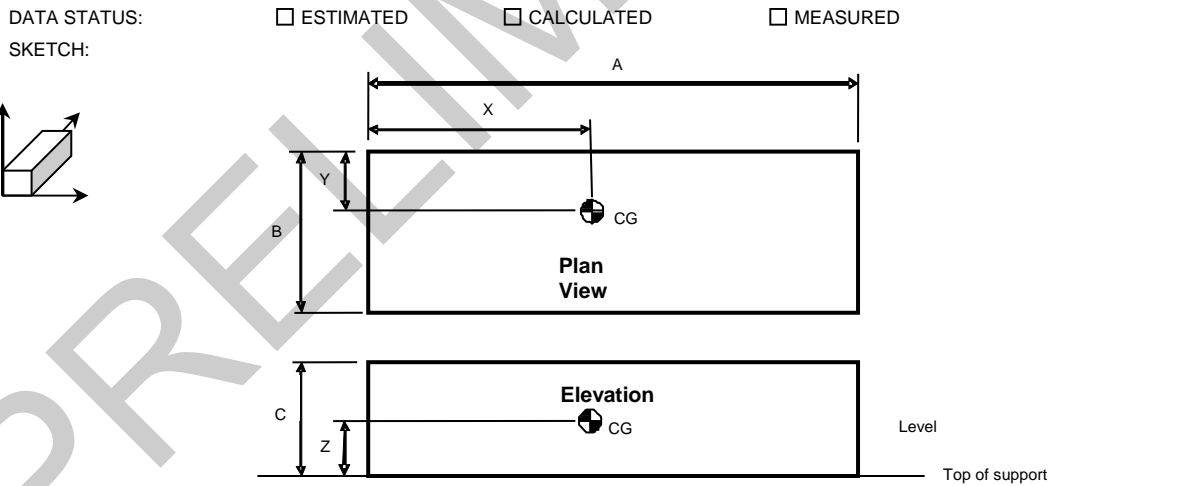
WEIGHT DATA

DATA STATUS: ESTIMATED CALCULATED WEIGHTED


EQUIPMENT WEIGHT: _____ ACCURACY: _____

DRY:	_____	k	_____	%	REMARKS: _____
OPERATING (NORMAL):	_____	g	_____	%	
OPERATING (MAXIMUM):	_____	k	_____	%	
TEST:	_____	g	_____	%	
MAX MAINTENANCE	_____	k	_____	%	
_____	_____	g	_____	%	

DIMENSIONS DATA



OVERALL DIMENSIONS:	DRY DIMENSIONS:	OPERATING DIMENSIONS:	MAINTENANCE DIMENSIONS:
A: _____ m	X: _____ m	X: _____ m	: _____ mm
B: _____ m	Y: _____ m	Y: _____ m	: _____ mm
C: _____ m	Z: _____ m	Z: _____ m	: _____ mm
	:	:	:

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NOTES

General:

- Vendor shall fill in all blank spaces in the weight control data sheet (fields and check boxes). All missing information will be considered as not applicable or not according to vendor's proposal.
- Vendor shall fill in data sheets for main and auxiliary equipment, furnished separately or on different skids. If necessary, manufacturer shall produce additional copies of the weight control data sheet.

Weight data:

- Accuracy of weight figures shall be $\pm 10\%$ in the proposal phase. After placing of the purchase order, the accuracy shall be refined to $\pm 3\%$.

Dimensional data:

- Manufacturer shall indicate equipment orientation.
- Any variation in center of gravity from dry to operating mode shall be noted.
- Manufacturer shall indicate with dashed lines on sketch and respective dimensions on the information table all maintenance areas required for assembly and disassembly of equipment.
- Accuracy of dimensions shall be $\pm 10\%$ in the proposal phase. After placing of the purchase order, the accuracy shall be refined to $\pm 3\%$.

PRELIMINARY