

**TECHNICAL SPECIFICATION**

Nº: I-ET-3010.00-1200-498-P4X-002

CLIENT: SRGE

SHEET: 1 of 24

JOB:

AREA:

TITLE:

**ELECTRIC PROCESS HEATERS**

INTERNAL

ESUP

**INDEX OF REVISIONS****REV.****DESCRIPTION AND/OR REVISED SHEETS**

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FORM OWNED TO PETROBRAS N-0381 REV.L.



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## 1 OBJECTIVE

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

This specification covers requirements for the design, materials, construction, inspection, testing and preparation for shipment of electric process heater intended for Molecular Sieve and TEG Regeneration Units.

It includes not only requirements for the ELECTRIC PROCESS HEATER itself, but also for all instruments, control panels, electrical accessories, as well as for associated pressure vessel within the scope of the package.

The ELECTRIC PROCESS 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 ELECTRIC PROCESS HEATERS for flammable fluids and for those installed in hazardous areas.

In addition to the requirements of this technical specification, SELLER shall follow all the requirements of the Exhibit I (Scope of Supply), as well as Exhibit III (Directives for Engineering Execution), Exhibit IV (Directives for Construction and Assembly), Exhibit V (Directives for Procurement), Exhibit VI (Directives for Planning and Control), Exhibit VII (Directives for Quality Management System) and Exhibit VIII (Directives for Commissioning Process).

The requirements herein listed are applicable to all players performing such related activities within the scope of this unit, including SELLERS, manufacturer, main SELLER, subSELLERS, suppliers, sub suppliers, integrators, constructors, and all technical personnel involved. Within the scope of this document, they are all referred to as being a SELLER.

## 2 NORMATIVE REFERENCES AND DESIGN SPECIFICATIONS

### 2.1 CLASSIFICATION

SELLER shall perform the work in accordance with the requirements of Classification Society. is responsible for submitting to the Classification Society all documentation in compliance with stated Rules.

### 2.2 CODES AND STANDARDS

2.2.1 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.

2.2.2 Other recognized standards may be used, provided it can be shown that they meet or exceed the requirements of the standards referenced below. Formal approval from PETROBRAS and from Classification Society is also required.

- |             |  |
|-------------|--|
| IOGP S-723  | - Specification for Electric Process Heaters   |
| API 521     | - Pressure-relieving and Depressuring Systems  |
| API RP 14FZ | - Recommended Practice for Design and Installation of Electrical Systems for Fixed and Floating Offshore |

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	Petroleum Facilities for Unclassified and Class 1, Zone 0, 1 and 2 Locations
API RP 14J	- Recommended practice for design and Hazard Analysis for Offshore Production Facilities
API RP 505	- Recommended Practice for Classification of location 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 BPVC SEC V	- Boiler and Pressure Vessel Code - Non-destructive Examination
ASME BPVC SEC VIII	- Rules for Construction of Pressure Vessels
ASME BPVC SEC IX	- Welding and Brazing Qualifications
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 60592	- Degrees of Protection Provided by Enclosures (IP Code)
IEC 61892	- Mobile and Fixed Offshore Units – Electrical Installations – All Parts
ISA 5.1	- Instrumentation Symbols and Identification
ISO 13702	- Control and Mitigation of Fires and Explosions on Offshore Production Installations
ISO 15156	- Materials for use in H <sub>2</sub> S containing environments in Oil and Gas Production – All Parts
ISO 21457	- Material selection and corrosion control for oil and gas production systems
TEMA	- Standards of the Tubular Exchanger Manufacturers Association
UL 1030	- Standard for Sheathed Heating Elements

### 2.3 GOVERNMENTAL REGULATION

Brazilian Government regulations are mandatory and shall prevail, if more stringent, over the requirements of this specification and other references herein.

- |         |   |
|---------|---|
| INMETRO | – Resolution nº 115, March 21 <sup>st</sup> 2022 and its annexes.   |
| NR 10   | – <i>Segurança em Instalações e Serviços em Eletricidade</i> (Safety in Electrical Facilities and Services)                                       |
| NR 13   | – <i>Caldeiras, Vasos de Pressão, Tubulações e Tanques Metálicos de Armazenamento</i> (Boilers, Pressure Vessels, Piping and Metal Storage Tanks) |
| NR 37   | – <i>Segurança e Saúde em Plataformas de Petróleo</i> (Safety and Health at Oil Marine Platform)  |

### 2.4 DESIGN SPECIFICATIONS

- |                               |  |
|-------------------------------|--|
| DR-ENGP-M-I-1.3               | - SAFETY ENGINEERING GUIDELINE   |
| DR-ENGP-I-1.15                | - COLOR CODING   |
| I-ET-3010.00-1200-251-P4X-001 | - REQUIREMENTS FOR BOLTING MATERIALS   |
| I-ET-3010.00-1200-540-P4X-001 | - REQUIREMENTS FOR PRESSURE VESSELS DESIGN AND FABRICATION                     |
| I-ET-3010.00-1200-970-P4X-013 | - COMPLIANCE WITH NR-13 AND SPIE REQUIREMENTS                                  |
| I-ET-3010.00-1200-955-P4X-001 | - WELDING  |
| I-ET-3010.00-1200-970-P4X-004 | - NON-DESTRUCTIVE TESTING REQUIREMENTS FOR METALLIC AND NON-METALLIC MATERIALS |
| I-ET-3010.00-1200-972-P4X-006 | - REQUIREMENTS FOR MANUFACTURING SURVEY INSPECTION                             |
| I-ET-3010.00-1200-978-P4X-005 | - REQUIREMENTS FOR MATERIALS TRACEABILITY                                      |
| 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-3010.00-1200-970-P4X-003 | - REQUIREMENTS FOR PROCEDURES AND PERSONNEL QUALIFICATION AND CERTIFICATION    |
| I-ET-3010.00-5140-700-P4X-002 | - SPECIFICATION FOR ELECTRICAL MATERIAL FOR OFFSHORE UNITS                     |

- |                               |   |
|-------------------------------|---|
| I-ET-3010.00-5140-700-P4X-007 | - SPECIFICATION FOR GENERIC ELECTRICAL EQUIPMENT FOR OFFSHORE UNITS             |
| I-ET-3010.00-5140-700-P4X-009 | - GENERAL REQUIREMENTS 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-3010.00-5140-797-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                                   |
| I-ET-3010.00-1200-800-P4X-002 | - AUTOMATION, CONTROL AND INSTRUMENTATION ON PACKAGE UNITS                      |
| I-ET-3010.00-1200-940-P4X-001 | - TAGGING PROCEDURE FOR PRODUCTION UNIT DESIGN                                  |
| I-ET-3010.00-1200-940-P4X-002 | - GENERAL TECHNICAL TERMS   |

**Specific Documents to be supplied by PETROBRAS**

Electric Heater Process Datasheet

Material Selection Philosophy for Detailed Design

Field Instrumentation

Automation Interface of Package Units

Hazardous Area Classification

General Arrangement

Metocean Data

Motion Analysis

Key One Line Diagram

**2.5 CONFLICTING REQUIREMENTS**

In case of conflicting requirements between this technical specification and the referred applicable standards, the most stringent requirement shall prevail. In case of conflicting information between this Specification and other specific PETROBRAS's document, a formal technical query shall be issued to PETROBRAS, seeking clarification.



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### 3 DEFINITIONS AND ABBREVIATIONS

#### 3.1 DEFINITIONS

All terms and definitions are established in the latest revision of I-ET-3010.00-1200-940-P4X-002 – GENERAL TECHNICAL TERMS.

#### 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
VCI	-	Volatile Corrosion Inhibitors

### 4 GENERAL REQUIREMENTS

#### 4.1 BASIS FOR DESIGN

- 4.1.1 ELECTRIC PROCESS HEATERS shall be designed to be able to operate continuously and to develop the output power (duty) at rated voltage and frequency including variations under all the specified process conditions.
- 4.1.2 MANUFACTURER shall design the equipment for the maximum capacity and for the full range of process conditions stated on Electric Heater Process Datasheet [document supplied by PETROBRAS]. SELLER shall consider fluid characteristics, quantity and the redundancy of heaters according to datasheet.
- 4.1.3 All parts of ELECTRIC PROCESS HEATER, including sub-orders, shall be of “field proven” design and well within MANUFACTURER’s actual experience. “Field proven” design is defined as having a Reference List with satisfactory operation at least in 3 floating offshore installation units, operating under similar process conditions (pressure, flow, capacity, power and fluids) for a minimum of 24,000 hours.
- 4.1.4 SELLER is responsible for thermal, hydraulic, electrical and mechanical design and shall guarantee the process, electrical and mechanical performance. Heaters shall be designed to operate under continuous or cyclic (intermittent) temperature conditions in accordance with Process Datasheet. The design shall ensure minimum mechanical stress and fatigue strength of the heater elements for the expected operating conditions.
- 4.1.5 MANUFACTURER is responsible for the complete engineering package, including design, fabrication, inspection, testing, certification and preparation for shipment of the Electric Heaters.



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4.1.6 When multiple heater stages are present within the same bundle, allocation of elements to stages shall maintain even heating throughout the bundle at the identified duty points.

4.1.7 Heaters 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.

#### 4.2 OPERATION ENVIRONMENT

The equipment supplied shall be suitable for the environment and range of ambient condition defined in METOCEAN DATA [document supplied by PETROBRAS].

#### 4.3 MOTION REQUIREMENTS

The necessary design data and information on motion requirements are given in MOTION ANALYSIS [document supplied by PETROBRAS].

#### 4.4 DESIGN LOADS

In addition to Codes described loads and loads due to equipment motions defined in MOTION ANALYSIS [document supplied by PETROBRAS], the following loads shall be considered where relevant:

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

#### 4.5 EQUIPMENT LOCATION AND AREA CLASSIFICATION

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

#### 4.6 DESIGN LIFETIME

ELECTRIC PROCESS HEATERS shall be designed and fabricated to function continuously or in cyclic operation (as applicable) for a minimum service lifetime of 30 years.

### 5 SCOPE

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

- 5.1.1 Complete heater associated pressure vessel.
- 5.1.2 Electric heater resistance bundles with active and spare heating elements, tubesheets terminal boxes, baffles and all required internals.
- 5.1.3 All required local instrumentation such as over temperature protection devices, gas detectors, heater power panel, complying with I-ET-3010.00-5140-741-P4X-003 - POWER PANEL FOR THYRISTORIZED HEATER FOR OFFSHORE UNITS;
- 5.1.4 All required electrical equipment including grounding system and cable trays within the skid, cable glands, terminal boxes etc.;
- 5.1.5 GENERAL MATERIALS
  - a. Earthing bosses and grounding devices;
  - b. Painting and thermal insulation;
  - c. AISI 316 nameplates in Portuguese;

- d. Spare parts recommended by CS and required for commissioning, pre-operation, start up and NR-13 testing;
- e. Consumables and special tools for assembly, disassembly, maintenance, commissioning and start up;
- f. Safety signaling, warning plates and labels in Portuguese;
- g. Lifting beams, spreader bars, slings, shackles etc. intended for transportation and installation on site.

#### 5.1.6 SERVICES

- a. Inspection, testing, including shop and field tests, and quality assurance;
- b. Commissioning supervision at job site;
- c. Non-destructive examination and functional tests;
- d. Operation and maintenance training;
- e. Packing, protection and marking for shipment;
- f. Preservation, conditioning and storage at job site;
- g. Total process and mechanical guarantee.
- h. Technical assistance for equipment installation, connection, commissioning and start-up;

## 6 GENERAL SPECIFICATION

### 6.1 MATERIALS SPECIFICATION AND CERTIFICATION REQUIREMENTS

- 6.1.1 Associated Pressure Vessel material shall be specified considering the philosophy stated at Material Selection Philosophy for Detailed Design [document supplied by PETROBRAS].
- 6.1.2 All materials exposed to fluids containing hydrogen sulphide shall follow the requirements of ISO 15156 for sour service.
- 6.1.3 Heater element sheath material shall be supplied as specification below:
  - 6.1.3.1 Molecular Sieve Regeneration heater - seamless Incoloy 800H (UNS N08810).
  - 6.1.3.2 TEG regeneration unit Reboiler - seamless Inconel 625 (UNS N06625).
- 6.1.4 The baffle support material shall be the same as the element sheath material.
- 6.1.5 Terminal boxes shall be made of grade 316 stainless steel.
- 6.1.6 For bolt materials apply the requirements of I-ET-3010.00-1200-251-P4X-001 – REQUIREMENTS FOR BOLTING MATERIALS.
- 6.1.7 Equipment subject to temperatures above 60°C or those that require heat conservation shall be thermally insulated according to I-ET-3010.00-1200-431-P4X-001 – THERMAL INSULATION FOR MARITIME INSTALLATIONS.
- 6.1.8 The material of the lifting lug attachments on the tubesheet shall be of same nominal composition as that of the tubesheet itself.
- 6.1.9 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. In order to ensure that the materials are in accordance with datasheets, 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.

## 6.2 PAINTING

- 6.2.1 The paint system shall be in accordance with I-ET-3010.00-1200-956-P4X-002 - GENERAL PAINTING.
- 6.2.2 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.
- 6.2.3 Color code adopted shall be in accordance with DR-ENGP-I-1.15 – COLOR CODING.

## 6.3 HAZARDOUS AREA

- 6.3.1 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 2 Group IIA temperature T3, unless they are automatically de-energized in case of confirmed gas in the equipment area, according to IEC 61892-1.

## 6.4 MAINTENANCE AND MECHANICAL HANDLING

- 6.4.1 Withdrawal spaces and clearances shall be provided for all removable pressure vessel internals.
- 6.4.2 All required maintenance lifting devices within the equipment limits shall be provided for safe and easy maintenance. Suitable lifting facilities shall be provided to allow bundle removal.
- 6.4.3 Tubesheets shall be provided with lifting lugs, pulling lugs or eyebolt on their outer face.
- 6.4.4 Terminal box covers weighing more than 25 kg shall be provided with hoisting attachments or be vertically hinged.
- 6.4.5 Lifting and pulling lugs or eyebolts on tubesheet shall be designed to support at least 150% of the weight of the heater bundle assembly including terminal box.

## 6.5 SAFETY REQUIREMENTS

- 6.5.1 Mandatory safety items as established in DR-ENGP-M-1.3 - SAFETY ENGINEERING, are to be considered complementary requirements, to the pertinent extent. In case of items in conflict with this document, PETROBRAS shall be consulted.

## 6.6 ELECTRICAL REQUIREMENTS

- 6.6.1 All electrical equipment and materials shall comply with the requirements of I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL FOR OFFSHORE UNITS, I-ET-3010.00-5140-700-P4X-007 - SPECIFICATION FOR GENERIC ELECTRICAL EQUIPMENT FOR OFFSHORE UNITS and I-ET-3010.00-5140-700-P4X-009 - GENERAL

REQUIREMENTS FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

- 6.6.2 Electrical installation shall comply with requirements of I-ET-3010.00-5140-700-P4X-003 - ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS.
- 6.6.3 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.
- 6.6.4 Grounding shall be in accordance with I-DE-3010.00-5140-700-P4X-003 - GROUNDING INSTALLATION TYPICAL DETAILS, IEC 61892-6, IEC 60092-502 and IEC 61892-7.
- 6.6.5 Electrical Heater shall be suitable for storage, service and installation on marine and petrochemical environment, complying with requirements related to these conditions defined in I-ET-3010.00-5140-700-P4X-009 – GENERAL REQUIREMENTS FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.
- 6.6.6 Electrical heater shall be protected by a suitable low insulation protection system to shut down the heater in the event of heater element failure to earth. These protections shall be according with documents I-ET-3010.00-5140-741-P4X-003 - POWER PANEL FOR THYRISTORIZED HEATER FOR OFFSHORE UNITS and KEY ONE LINE DIAGRAM.

## 7 EQUIPMENT SPECIFICATION

### 7.1 PRESSURE VESSEL

- 7.1.1 Associated pressure vessel shall be designed and fabricated in accordance with I-ET-3010.00-1200-540-P4X-001 – REQUIREMENTS FOR PRESSURE VESSELS DESIGN AND FABRICATION.
- 7.1.2 Associated pressure vessels shall comply with the requirements of NR-13 and I-ET-3010.00-1200-970-P4X-013 - COMPLIANCE WITH NR-13 AND SPIE REQUIREMENTS.
- 7.1.3 Associated pressure vessel weldments shall be according to the requirements stated in I-ET-3010.00-1200-955-P4X-001 – WELDING.
- 7.1.4 **SELLER** shall provide detailed mechanical and thermal design of the equipment.


### 7.2 HEATER BUNDLE

#### 7.2.1 HEATER ELEMENT AND TUBESHEET

- 7.2.1.1 **SELLER** shall inform the total quantity of tubular heater elements per bundle (actives and spares).
- 7.2.1.2 Tubular heater elements shall be constructed from 80/20 NiCr resistance wire surrounded by compacted magnesium oxide powder (MgO).
- 7.2.1.3 Heater element end terminals shall be sealed to prevent damage due to moisture and hydrocarbon ingress.
- 7.2.1.4 For cyclic or intermittent service, as molecular sieve regeneration, and for flammable gas heating the method for sheath element to tubesheet joint shall be by means of a strength weld. The weld procedure shall be in accordance with ASME Code and I-ET-3010.00-1200-955-P4X-P4X-001 – WELDING.
- 7.2.1.5 For non-cycle service and non-flammable gas, the method for sheath element to tubesheet joint shall be seal welding, strength welding or using bite coupling. Bite

coupling shall be certified by a third party to an industrial standard. This shall be previously approved by PETROBRAS during bid phase.

- 7.2.1.6 For TEG Regeneration System, the heating elements shall be withdrawable, assembled separately, to allow individual replacement, without disturbing the normal operation. Withdrawable heating elements are not acceptable for molecular sieve regeneration heating.
- 7.2.1.7 Each heater shall have at least 10% unconnected spare elements. Spare heater elements shall be installed, but not connected. All spare elements shall be fitted. The wires shall be sufficient length to connect the element to any busbar in the event shall be furnished but not installed inside the Power Terminal Box.
- 7.2.1.8 Spare elements shall be provided with conductors, terminals, and fixings to connect to any heater stage, or to a dedicated heater stage if bus links are used.
- 7.2.1.9 Spare heater elements shall be identified and wired to a dedicated earth terminal inside the terminal box.
- 7.2.1.10 The bundles of all heaters (operational and spare) shall be identical, interchangeable and have an equivalent load balanced between phases.
- 7.2.1.11 Sheath's elements shall be directly connected to the tubesheet and to the power terminal box. The use of offset sleeves or standpipe is not acceptable.
- 7.2.1.12 **SELLER** shall confirm the heat flux (watt density) of the heater under normal operating conditions and the maximum design heat flux.
- 7.2.1.13 The heater element tubesheet shall be designed in accordance with ASME Code.
- 7.2.1.14 In order to prevent the overheating of the terminal box and damage to the insulators on the element terminals, an inactive unheated element length shall be provided between the Ex e terminal box and the heater shell inlet nozzle. This unheated element length shall be based on the maximum allowable temperature inside the terminal box.
- 7.2.1.15 Unheated element lengths shall also be provided where there is restricted process fluid flow.
- 7.2.2 BAFFLE AND BUNDLE SUPPORT**
- 7.2.2.1 **SELLER** shall supply suitable and sufficient supports (baffles), based on TEMA requirements, to prevent any bending of heater elements, any flow induced vibration and to guarantee the continuous flow within the vessel, preventing overheating on the elements.
- 7.3 POWER TERMINAL BOX**
- 7.3.1 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. Power terminal boxes with Ex d protection in accordance with IEC 60079-1 are not acceptable by PETROBRAS.
- 7.3.2 The power terminal box shall have with protection degree IPW-56 or higher, where W means saline, hot and dump atmosphere.

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<p>7.3.3 The temperature inside the power terminal box shall be within the limits stated on the EX-certification and shall not exceed 70° C. <b>SELLER</b> shall inform in datasheet the maximum expected temperature in normal operation condition at 100% electrical power.</p> <p>7.3.4 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. The anti-condensation heater shall be controlled from the power and control assembly and shall be in operation when the process heater is de-energized.</p> <p>7.3.5 The power terminal boxes shall be able to receive three core or single core cables, and besides the characteristics plate they shall have a high temperature warning indication.</p> <p>7.3.6 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.</p> <p>7.3.7 The element leads (electrical cables) and the cable lugs to connect the resistive elements to incoming power cables shall be sized considering the number of cables inside of the power terminal box (derating grouping factor, to be informed by <b>SELLER</b>) and the internal temperature (derating temperature factor, to be informed by <b>SELLER</b>) when the heater is operation in full load condition.</p> <p>7.3.8 The field emergency pushbutton to turn off the heater shall not be installed on the power terminal box. This pushbutton shall be supplied by <b>SELLER</b> and shall be installed in safe area close to heaters neighborhood (area with safe access in case of accident in heaters) and with identification.</p> <p>7.3.9 The internal connections within the main terminal box shall be made by copper and of sufficient size, strength, and configuration to enable a solid connection of the supply cables without excessive stress on the conductors.</p> <p>7.3.10 For heating element entrance into terminal box, the manufacturer shall provide removable non-magnetizing material plate (panel back plate).</p> <p>7.3.11 Earth terminals shall be provided inside and outside the terminal box.</p> <p>7.3.12 Terminal box cable entries shall not be top entry. Manufacturer shall be able to provide removable non-magnetizing drilled and undrilled material plates for installation of cable glands. The hazardous area certification shall clarify about drilling cable gland plate at field.</p> <p><b>7.4 INSTRUMENTS</b></p> <p><b>7.4.1 GENERAL</b></p> <p>7.4.1.1 The equipment shall be provided with local indicators, transmitters and other instruments required for operation and monitoring, in accordance with I-ET-3010.00-1200-800-P4X-013 – GENERAL CRITERIA FOR INSTRUMENTATIONS PROJECTS, I-ET-3010.00-1200-800-P4X-002 - AUTOMATION, CONTROL AND INSTRUMENTATION ON PACKAGE UNITS, the respective process datasheet, P&amp;ID and the latest revision of FIELD INSTRUMENTATION and Automation Interface of Package Units specifications [documents supplied by PETROBRAS].</p> <p>7.4.1.2 All instruments shall be Ex d IIA T3 in accordance with IEC 60079 and shall have minimum ingress protection IP-56 in accordance with IEC 60529 and shall be installed in accordance with API RP 551.</p> <p>7.4.1.3 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.</p>				



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- 7.4.1.4 Control and safeguarding instrumentation shall be segregated according to reference documents.
- 7.4.1.5 Due to high temperatures occurring inside the Power Terminal Boxes (up to 70°C), is not allowed to install transmitters inside it. The design shall foresee remote sensors that withstand these operational temperature limits to be placed inside to monitoring the Power Terminal Boxes
- 7.4.1.6 The casings or enclosures of all field instruments shall be made of stainless-steel ASTM A 351 Gr. CF8M. Aluminium alloy (including copper-free alloys) will not be acceptable. See I-ET-3010.00-1200-956-P4X-002 for painting.

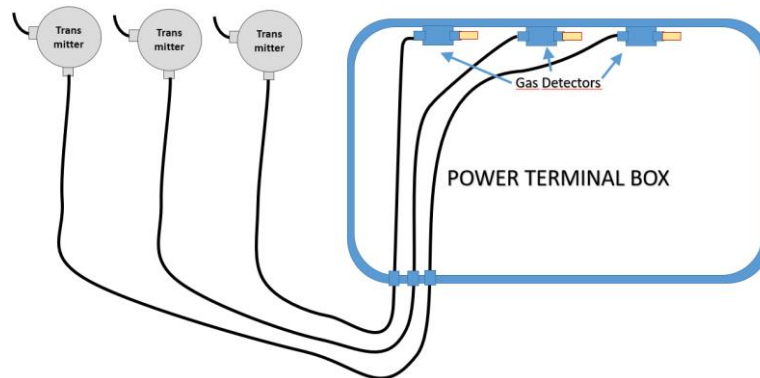
**7.4.2 OVER-TEMPERATURE PROTECTION DEVICES**

- 7.4.2.1 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 and ensure the EX-T- Class rating;
  - Inside the terminal box, based on maximum allowable temperature for cable conductor, as well as for cable insulation material;
  - On the sheaths of heater elements (tubes), a minimum of two over-temperature sensing devices shall be provided per heater element stage, 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 sheath temperature;
  - On the outlet nozzle of the Heater Vessel, to control the heated fluid temperature.
- 7.4.2.2 The temperature sensors shall be connected to temperature transmitters, (see also item 7.4.1.5), which shall have 4~20mA+Hart output. Signal from transmitter shall be connected to equipment panel and shall be used in order to shut down the Heater in case of over-temperature. **SELLER** shall inform the over-temperature setpoint value for each sensor.
- 7.4.2.3 The method of sealing the temperature detector sheaths or thermowells to the tubesheet shall be the same as that of the heater element sheaths. The heater element temperature detector sheath or thermowell material shall be the same as the heater element sheath material
- 7.4.2.4 Temperature detectors shall be Type K thermocouple elements or PT 100 devices.

**7.4.3 GAS DETECTORS**

- 7.4.3.1 The heaters shall be supplied with Process Fluid Breach Detection, this detection shall be thru gas detection inside Power Terminal box.
- 7.4.3.2 For ELECTRIC HEATERS for flammable gases, **SELLER** shall provide 3 (three) gas detectors (suitable to flammable CH<sub>4</sub> 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.
- 7.4.3.3 As per item 7.4.1.5, These detectors shall have remote sensors to place transmitters outside of the Power Terminal Boxes, while sensor are placed inside terminal boxes in a most probable gas propagation cloud.

7.4.3.4 The gas sensors placed inside Power terminal box shall withstand its maximum temperature, and for these ones shall be allowed to use IR, catalytic, electrochemical with expected lifespans of 5 years on operation conditions. See suggested sketch bellow at Figure 1:



**Figure 1 - Gas Detectors Sketch suggestion**

7.4.3.5 The set Sensor plus Transmitter shall comply with following response time requirements:

T50 < 15 seconds

T90 < 30 Seconds

7.4.3.6 Gas detectors shall be arranged in a voting logic, so that:

- 1oo3 detection - an alarm shall be generated both at the supervisory system and at the dehydration unit HMI;
- 2oo3 detection - interlocking actions shall be taken inside the dehydration unit package.

#### 7.4.4 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.

### 7.5 CERTIFICATION REQUIREMENTS FOR HAZARDOUS AREA

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

7.5.2 All materials and equipment proper to be used in hazardous areas, shall have Conformity Certificates complying with INMETRO Portaria n° 115, March 21<sup>st</sup>, 2022, and its annexes and shall be approved by Classification Society. In this way, **SELLER** 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.

### 7.6 SPECIFIC REQUIREMENTS

7.6.1 The equipment shall be designed to operate under cyclic (intermittent) or continuous temperature conditions, in accordance with Process Datasheet [document supplied by PETROBRAS] and in either case shall be controlled by a thyristors panel.

7.6.2 The resistive elements shall have rated voltage according to Process datasheet [document supplied by PETROBRAS]. Besides the variations defined in I-ET-3010.00-5140-700-P4X-



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009 - GENERAL REQUIREMENTS 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.

7.6.3 The maximum electrical demand and configuration shall be according to Process Datasheet [document supplied by PETROBRAS].

7.6.4 The electrical system distribution is IT system (isolated neutral distribution). Electrical heater configuration shall be implemented by delta connections. Electrical Y connection is not acceptable, since this kind of connection allows neutral floating point and variation of operational voltage between phase and neutral point, jeopardizing heating elements lifetime because of overvoltage above the acceptable limits. Other different electrical heater connection (considering fully power and grounding heater and electrical system connections) shall be submitted to PETROBRAS for analysis, since lifetime of heating elements are guaranteed.

## 8 NAMEPLATES

8.1.1 **SELLER** shall attach a corrosion resistant SS 316 nameplates on each item of equipment (vessel and terminal box) in an accessible location, fastened with corrosion resistant pins. The nameplates shall be in Portuguese language and at least 1.5 mm thick.

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

- Petróleo Brasileiro S.A. – PETROBRAS;
- Purchase order number;
- Manufacturer and year of build;
- Service;
- Tag number;
- Serial number;
- Main data for design, operation and testing (Power, Pressure, Capacity, Temperature, Flow rate), as applicable;
- Specific requirements;
- Installation identification;
- Power rating, voltage, phases, phase number and frequency and other electrical data, as applicable;
- Design code;
- NR 13 class (for pressure vessels);
- Empty, operation and test weight.

8.1.3 The process heater main terminal box identification and label plate shall include additionally to item 8.1.2 the following data:

- Model
- Heater elements connection;
- IP rating or NEMA enclosure rating;
- Maximum and Minimum ambient air temperature.
- Rated fault current;
- Rated input current;
- Weight;
- Space heater voltage;
- Space heater rated current.



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#### Notes:

- 1) Space heater information may be provided on a separate space heater terminal box nameplate.
  - 2) All technical data shall be shown in International System units (SI).
- 8.1.4 Nameplates for pressure vessels shall be according to I-ET-3010.00-1200-540-P4X-001 REQUIREMENTS FOR PRESSURE VESSELS DESIGN AND FABRICATION.

## 9 TAG NUMBERING AND SAFETY SIGN

### 9.1 TAGGING

- 9.1.1 Tagging of all instruments, electrical, telecommunications mechanical and piping items, including valves, shall be carried out. Tag numbers shall be according to I-ET-3000.00-1200-940-P4X-001- TAGGING PROCEDURE FOR PRODUCTION UNITS DESIGN.
- 9.1.2 Tag numbers for remaining ancillary equipment shall be given after purchase order placement.

### 9.2 SAFETY SIGN

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.

## 10 INSPECTION, TESTING AND COMMISSIONING

### 10.1 GENERAL

- 10.1.1 **SELLER** shall submit an inspection and testing program of all supplied equipment to PETROBRAS's approval, prior to work start in accordance with document schedule.
- 10.1.2 Unless otherwise stated, all inspections and tests shall be performed at MANUFACTURER shop in the presence of PETROBRAS's representative and CS surveyor, as applicable.
- 10.1.3 Inspections and tests are integral part of the order which will not be considered complete until such these activities have been carried out in full.
- 10.1.4 Mechanical Completion is the 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's requirements. **SELLER** shall deliver relevant documentation to prove that these inspections and checks have been completed.
- 10.1.5 **SELLER** shall submit an Inspection and Test Plan (ITP) with the bid. A full function test of completed package shall be performed.
- 10.1.6 PETROBRAS shall identify all the required witnessed inspections on a marked up copy of the ITP and reserves the right to inspect the equipment anytime during fabrication to ensure that material and workmanship are in accordance with this specification.
- 10.1.7 **SELLER** 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.
- 10.1.8 **SELLER** 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.

## 10.2 PERSONNEL QUALIFICATION AND CERTIFICATION

10.2.1 Qualification and certification for procedures and personnel shall be in accordance with I-ET-3010.00-1200-970-P4X-003 – REQUIREMENTS FOR PROCEDURES AND PERSONNEL QUALIFICATION AND CERTIFICATION.

## 10.3 QUALITY AND INSPECTION

10.3.1 **SELLER** shall provide documented schedules with the estimated completion dates. These schedules shall be issued by the same time the drawings are submitted for approval, as indicated in the agreed document schedule.

10.3.2 PETROBRAS reserves the right to inspect all items at any time during fabrication to ensure that the materials and workmanship are in accordance with this specification and all applicable documentation.

10.3.3 **SELLER** is responsible for the overall compliance of the Unit when it comes to the CLASS requirements, including certificates, work examinations and tests, as well as final inspection activities and shipment.

10.3.4 In addition to PETROBRAS inspection, equipment such as valves and fittings, etc. shall be subject to all CLASS authority and may range from a review of **SELLER**'s quality manual to a physical survey of **SELLER**'s shop or end products.

10.3.5 The CLASS inspector shall have the right to request inspections or examinations to ensure that the equipment complies with the relevant CLASS requirements. If examination reveals any deficiencies, **SELLER** shall bear the full cost of repair or replacement when necessary. Any repair work shall be approved by PETROBRAS. The subsequent examination necessary to ensure the satisfactory manufacture of the equipment in question will be on behalf of the **SELLER**.

10.3.6 Except if approved by PETROBRAS inspector, all equipment shall be presented for inspection in an unpainted state. **SELLER** shall provide notice to the inspector to witness the specified tests at least 2 (two) weeks in advance for Brazilian MANUFACTURER and 3 (three) weeks for foreign MANUFACTURER.

10.3.7 Manufacturing Survey Inspection shall be performed according to I-ET-3010.00-1200-972-P4X-006 – REQUIREMENTS FOR MANUFACTURING INSPECTION.

10.3.8 Traceability of material shall comply with I-ET-3010.00-1200-978-P4X-005 – REQUIREMENTS FOR MATERIALS TRACEABILITY.

## 10.4 WELDING AND WELDING INSPECTION

10.4.1 Welding shall be carried out with procedures and welders qualified in accordance with Design Code and additional requirements stated in contractual technical specifications. Welding shall not be performed before qualified welding procedures specification have been approved.

10.4.2 Welding repairs shall be in accordance with I-ET-3010.00-1200-955-P4X-001 – WELDING.

10.4.3 Details of all major weld repairs and heat treatment shall be recorded and reported to PETROBRAS for previous approval.

10.4.4 Welding inspection shall be according to the Design Code and additional requirements stated in I-ET-3010.00-1200-540-P4X-001 – REQUIREMENTS FOR PRESSURE VESSEL DESIGN AND FABRICATION.

### 10.5 NDT

10.5.1 NDT shall be according to the ASME Code and I-ET-3010.00-1200-970-P4X-004 – NON-DESTRUCTIVE TESTING REQUIREMENTS FOR METALLIC AND NON-METALLIC MATERIALS.

### 10.6 TESTING

10.6.1 The integrity of the sheath to tubesheet joint shall be hydrostatically tested in the presence of PETROBRAS's surveyors. The Hydrostatic testing shall be carried out in accordance with I-ET-3010.00-1200-540-P4X-001 – REQUIREMENTS FOR PRESSURE VESSEL DESIGN AND FABRICATION.

10.6.2 Electric Heaters working with flammable fluids shall be tightness tested with helium gas. The Helium concentration shall be at least 10%. Test pressure shall be 2 bar minimum (but never higher than the hydrostatic test pressure). Sensitivity shall be agreed with the PETROBRAS. No leak shall be acceptable.

10.6.3 For non-flammable fluids, a pneumatic test using a soap-water solution shall be performed to identify any leak.

### 10.7 FACTORY ACCEPTANCE TEST (FAT)

10.7.1 The following tests shall be included in **SELLER** scope:

- 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;
- All applicable NDTs;

- Hydrostatic Testing;
- Helium Tightness Testing.

10.7.2 **SELLER** shall prepare a FAT procedure and submit it to PETROBRAS's approval.

10.7.3 FAT will be witnessed by PETROBRAS's representatives. **SELLER** 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. **SELLER** shall invite CS surveyor for FAT.

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

### 10.8 ASSEMBLY ASSISTANCE AND COMMISSIONING REQUIREMENTS

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

10.8.2 **SELLER** 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 PETROBRAS.

10.8.3 Site Acceptance Test (SAT) shall be witnessed by PETROBRAS surveyors and shall include at least:

- a. Megger test for cables;
- b. Power Terminal box internal temperature measurement with stable full load;
- c. Power Terminal box infrared register (cables, bars, elements' connections, cable glands plate and bundle plate) at stable full load;
- d. Operation of temperature sensors, transmitters, controls and protections;
- 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. Tests of power panel, according to I-ET-3010.00-5140-741-P4X-003 - POWER PANEL FOR THYRISTORIZED HEATER FOR OFFSHORE UNITS;
- o. Review of calibration certificate issued by laboratory certificated by RBC (All Instruments);
- p. Review of hazardous area equipment certificates (All instruments);
- q. Loop Test (All instruments).

10.8.4 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.

## 11 PREPARATION FOR SHIPMENT

### 11.1 MARKING

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

11.1.2 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

### 11.2 PACKING AND PRESERVATION

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

11.2.2 The equipment preparation shall be suitable for 24 months outdoor storage, in its original sealed packaging, with VCI pads, from the time of shipment.

11.2.3 Packaging design shall be submitted to PETROBRAS for approval.

11.2.4 Desiccant shall be provided in terminal boxes.

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

11.2.6 Moisture indicators shall be provided and fitted to the packaging.

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

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

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



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## 12 DOCUMENTATION

### 12.1 DOCUMENTS AT PROPOSAL

- 12.1.1 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, without any technical deviation.
- 12.1.2 Any exclusion and/or alternative to what is specified in the Material Requisition and its annexes, including the use of the **SELLER**'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.
- 12.1.3 The Deviation List mentioned above shall contain for each requirement that the **MANUFACTURER** intends to change at least the following:
- a. The document's description, code and section that contain the requirement;
  - b. 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;
  - c. The **MANUFACTURER**'s proposal.
- 12.1.4 The proposal shall include the following information as minimum but not limit to, for **PETROBRAS**'s approval:
- a. Overall dimensions of main components;
  - b. List of similar installations ("field proven" evidence);
  - c. Bundle weight and bundle removal space (handling area dimensions);
  - d. The design heat flux (power [watt] density);
  - e. Sheath element to tubesheet join method;
  - f. Material of construction of main components;
  - g. General arrangement drawing or a sketch, showing the main dimensions of the heater (at least terminal box dimension, Insert length, active length, element diameter, construction materials, number of active and spare elements);
  - h. Factory and field tests procedures and planning;
  - i. Repair or applicable 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.
  - j. Material and special tools lists;
  - k. Commissioning, storage, packing typical requirements;
  - l. Typical electrical interface connections;
  - m. One-line electrical diagram;
  - n. Terminal box internal temperature data (design and limits of main internal components, like electrical cables, connectors, screws, nuts, washers, copper busbars, cable glands, ceramic insulators etc) and evidence that all components withstand the maximum operating temperature at 100% electrical power operation of the power box;
  - o. Typical conformity certification (INMETRO Portaria nº 115, March 21st, 2022, and its annexes;

- p. Typical Packing, Transportation, Assembly, Disassembly, Operation, Maintenance and Storage Manuals;
- q. Spare part list recommendation for two years continuous operation;
- r. Technical assistance for equipment installation, connection, commissioning, and start-up;
- s. Typical operation and maintenance manual

## 12.2 DOCUMENTS FOR APPROVAL

MANUFACTURER's documentation shall include the following information as minimum but not limit to:

- a. Detailed drawings of associated pressure vessels;
- b. Mechanical Calculation Reports for associated pressure vessel and bundle, according to ASME BPVC Sec VIII and TEMA R;
- c. Thermal Calculation Report;
- d. Detailed drawings of heating bundles (including information of dissipation surface, power, current, current/diameter (A/mm), heat flux (watt density) (W/cm<sup>2</sup>) and expected sheath temperature;
- e. Detailed datasheets;
- f. Resistive elements connection diagrams;
- g. Complete dimensional drawing of terminal boxes, containing all copper bars, connectors, cable glands, screws, nuts, washers, electrical cables, holes and necessary assembly torque;
- h. Calculation report of resistive elements lead cables;
- i. Verification of equal distribution of spare elements among phases and stages;
- j. Terminal boxes internal temperature data (design and limits of internal components), to withstand the maximum operating temperature at 100% electrical power operation of equipment;
- k. Welding procedures;
- l. Information of minimum acceptable heated fluid flow;
- m. Description of the alarm and shutdown facilities to be provided;
- n. One-line electrical diagram;
- o. Test Reports, including at least:
  - Hydrostatic and leak tightness tests;
  - Insulation resistance measurement;
  - 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);

- Output power measurement, comparing with control load adjustment;
- Check of torque of electrical connections;
- p. All documents required by Brazilian Regulation NR-10, a dedicated NR-10 file complete with all applicable documentation;
- q. All documents required by Brazilian Regulation NR-13, a dedicated NR-13 file complete with all applicable documentation;
- r. Documents required in I-ET-3010.00-5140-741-P4X-003 - POWER PANEL FOR THYRISTORIZED HEATER FOR OFFSHORE UNITS;
- s. Certification by CS;
- t. Certificate reports for all electrical equipment suitable to operation in hazardous areas;
- u. Packing, Transportation, Assembly, Disassembly, Operation, Maintenance and Storage Manuals;
- v. Spare part list recommendation for two years continuous operation;
- w. Complete conformity certification (INMETRO Portaria nº 115, March 21<sup>st</sup>, 2022, and its annexes.) for all electrical and instrumentation equipment suitable to operation in hazardous areas;
- x. Operation and maintenance manual (English and Portuguese);
- y. Other items may be included in MANUFACTURER scope of supply, according to PETROBRAS documentation.

### 12.3 DOCUMENTS AT DATA BOOK

MANUFACTURER´s data book documentation shall include the information of item 12.1 as minimum but not limit to.

### 12.4 MANUALS

MANUFACTURER shall provide a complete operational and maintenance manual. Maintenance manual shall include videos containing the way to remove and reinstall all electrical heater elements.