PETROBRAS	TECHNICAL SPECIFICATION	N°: I-ET-3010.2Q-5147-413-P4X-001	
	CLIENT: MARLIM LESTE E SUL		SHEET: 1 of 22
	JOB: BASIC DESIGN – REVIT I		
	AREA: MARLIM LESTE E SUL		
	TITLE: ONCE THROUGH STEAM GENERATOR AND WASTE HEAT RECOVERY UNIT		ESUP
			INTERNAL

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Summary

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1. INTRODUCTION

This specification covers the minimum requirements of design, engineering, materials, fabrication, inspection, testing, preparation of shipment, installation, pre-commissioning and commissioning of the Once-Through Steam Generator and Turbogenerator Waste Heat Recovery Units, which will be installed in the exhaust of gas turbines driven power generation package.

2. NORMATIVE REFERENCES

All equipment shall comply with the requirements of this technical specification, applicable documents and standards stated below.

2.1 Classification

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

2.2 Codes and Standards

The equipment shall comply with the following codes and standards as guidelines for design.

AISC 325	Steel Construction Manual
API RP14 C	Recommended Practice for Analysis, Design, Installation and Testing of Basic Surface Safety Systems for Offshore Production Facilities
API STD 530	Calculations of Heater Tube Thickness in Petroleum Refineries
API STD 521	Pressure-Relieving and Depressuring Systems
API STD 560	Fired Heaters for General Refinery Service
API STD 673	Centrifugal Fans for Petroleum, Chemical, and Gas Industry Services
ASME B16.47	Large Diameter Steel Flanges
ASME B16.5	Pipe Flanges and Flange Fittings
ASME B31.1	Power Piping
ASME B31.3	Process Piping
ASME BPVC Section I	Rules for Construction of Power Boilers
ASME BPVC Section II	Boilers and Pressure Vessel Code: Material Specification
ASME BPVC Section V	Boiler and Pressure Vessel Code: Non-destructive Examination
ASME BPVC Section VIII-1	Rules for Construction of Pressure Vessels
ASME BPVC Section IX	Welding, Brazing, and Fusing Qualifications
AWS D1.1	Structural Welding Code - Steel
IEC 60092-502	Electrical Installation in Ships – Tankers – Special Features
IEC 61892	Mobile and Fixed Offshore Units – Electrical Installations
ISO 15156	Petroleum and natural gas industries — Materials for use in H_2S-containing environments in oil and gas production

2.3 Brazilian Government Regulation

NR-10	Brazilian Regulatory Standard – *Safety in Installations and Services with Electricity*.
NR-12	Brazilian Regulatory Standard – Machinery and Work Equipment Safety
NR 13	Brazilian Regulatory Standard - Boilers, Pressure Vessels, Pipes and Metallic Storage Tanks

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NR 26 Brazilian Regulatory Standard - Safety Signaling

NR-37 Brazilian Regulatory Standard - Safety and Health in Petroleum Platforms

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

2.3.2 PACKAGER/MANUFACTURER shall comply with any other government regulations stated in the Contract and not listed above

2.4 Applicable Documents

DR-ENGP-I-1.15	COLOR CODING
DR-ENGP-M-I-1.3	SAFETY ENGINEERING
I-DE-3010.00-5140-700-P4X-003	GROUNDING INSTALLATIONS TYPICAL DETAILS
I-ET-3000.00-1000-941-PPC-001	METOCEAN DATA
I-ET-3000.00-1000-100-P4X-001	MATERIAL SELECTION PHILOSOPHY
I-ET-3010.00-1200-200-P4X-115	REQUIREMENTS FOR PIPING FABRICATION AND COMMISSIONING
I-ET-3010.00-1200-200-P4X-116	REQUIREMENTS FOR BOLTED JOINTS ASSEMBLY AND MANAGEMENT
I-ET-3010.00-1200-251-P4X-001	REQUIREMENTS FOR BOLTING MATERIALS
I-ET-3010.00-1200-431-P4X-001	THERMAL INSULATION FOR MARITIME INSTALLATIONS
I-ET-3010.00-1200-451-P4X-001	REQUIREMENTS FOR SHELL AND TUBE HEAT EXCHANGER DESIGN AND FABRICATION
I-ET-3010.00-1200-540-P4X-001	REQUIREMENTS FOR PRESSURE VESSELS DESIGN AND FABRICATION
I-ET-3010.00-1200-800-P4X-002	AUTOMATION, CONTROL AND INSTRUMENTATION ON PACKAGE UNITS
I-ET-3000.00-1200-940-P4X-001	TAGGING PROCEDURE FOR PRODUCTION UNITS DESIGN.
I-ET-3010.00-1200-955-P4X-001	WELDING
I-ET-3010.00-1200-956-P4X-002	GENERAL PAINTING
I-ET-3010.00-1200-970-P4X-003	REQUIREMENTS FOR PERSONNEL QUALIFICATION AND CERTIFICATION
I-ET-3010.00-1200-970-P4X-004	NON-DESTRUCTIVE TESTING REQUIREMENTS FOR METALLIC AND NON-METALLIC MATERIALS
I-ET-3010.00-1200-970-P4X-013	COMPLIANCE WITH NR-13 AND SPIE REQUIREMENTS
I-ET-3010.00-1200-978-P4X-005	REQUIREMENTS FOR MATERIALS TRACEABILITY
I-ET-3010.00-5400-947-P4X-002	SAFETY SIGNALLING
I-ET-3010.00-1350-940-P4X-001	SYSTEMS OPERATION PHILOSOPHY

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I-ET-3010.00-5140-700-P4X-001	SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS
I-ET-3010.00-5140-700-P4X-002	SPECIFICATION FOR ELECTRICAL MATERIAL FOR OFFSHORE UNITS
I-ET-3010.00-5140-700-P4X-003	ELECTRICAL REQUIREMENTS FOR PACKAGES 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-3010.00-5140-712-P4X-001	LOW-VOLTAGE INDUCTION MOTORS FOR OFFSHORE UNITS
I-ET-3010.00-5140-741-P4X-004	SPECIFICATION FOR LOW-VOLTAGE GENERIC ELECTRICAL PANELS FOR OFFSHORE UNITS
I-ET-3010.00-1200-800-P4X-002	AUTOMATION, CONTROL AND INSTRUMENTATION ON PACKAGE UNITS
I-DE-3010.2Q-1200-942-P4X-001	GENERAL ARRANGEMENT
I-DE-3010.2Q-1423-942-P4X-001	M-12 – POWER GENERATION – EQUIPMENT LAYOUT PLAN
I-DE-3010.2Q-1424-942-P4X-001	M-13 – POWER GENERATION – EQUIPMENT LAYOUT PLAN
I-DE-3010.2Q-1424-942-P4X-002	M-13B – POWER GENERATION – EQUIPMENT LAYOUT PLAN
I-DE-3010.2Q-5125-943-P4X-001	UTILITY FLOW DIAGRAM - HOT WATER SYSTEM
I-DE-3010.2Q-5125-944-P4X-002	TURBOGENERATOR WASTE HEAT RECOVERY "A"
I-DE-3010.2Q-5132-943-P4X-001	COMBINED CYCLE SYSTEM
I-DE-3010.2Q-5125-944-P4X-003	TURBOGENERATOR WASTE HEAT RECOVERY "B"
I-DE-3010.2Q-5125-944-P4X-004	TURBOGENERATOR WASTE HEAT RECOVERY "C"
I-DE-3010.2Q-5125-944-P4X-005	TURBOGENERATOR WASTE HEAT RECOVERY "D"
I-DE-3010.2Q-5132-944-P4X-001	BALANCE OF PLANT FOR COMBINED CYCLE POWER PLANT PACKAGE
I-DE-3010.2Q-5147-944-P4X-003	STEAM TURBOGENERATOR INTERCONNECTION
I-ET-3010.2Q-1200-200-P4X-001	PIPING SPECIFICATION FOR TOPSIDE
I-ET-3010.2Q-1200-200-P4X-004	REQUIREMENTS FOR PIPING SUPPORT
I-ET-3010.2Q-1200-200-P4X-005	MINIMUM REQUIREMENTS FOR PIPING MECHANICAL DESIGN AND LAYOUT
I-ET-3010.2Q-1200-200-P4X-006	REQUIREMENTS FOR PIPING FLEXIBILITY AND STRESS ANALYSIS
I-ET-3010.2Q-1200-800-P4X-014	AUTOMATION INTERFACE OF PACKAGED UNITS
I-ET-3010.2Q-1200-940-P4X-001	MATERIAL SELECTION PHILOSOPHY FOR DETAILED DESIGN

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I-ET-3010.2Q-5100-940-P4X-001	TECHNICAL SPECIFICATION – COMBINED CYCLE POWER PLANT PACKAGE
I-ET-3010.2Q-5147-332-P4X-002	TECHNICAL SPECIFICATION - STEAM TURBINE DRIVER FOR STEAM TURBOGENERATOR SET
I-FD-3010.2Q-5147-413-P4X-002	ONCE THROUGH STEAM GENERATOR AND WASTE HEAT RECOVERY UNIT
I-RL-3010.2Q-1350-960-P4X-002	MOTION ANALYSIS

2.5 Conflicting Requirements

As a general guideline, in case of conflicting requirements between this technical specification and other cited references, the most stringent shall prevail. If necessary, the CCPG PACKAGER/ MANUFACTURER may revert to PETROBRAS for clarification.

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
CCR	Central Control Room (located in the Hull Accommodation)
CCR-ATR	Central Control Room – Automation and Turbomachinery Room
Class	Classification Society
CRA	Corrosion Resistant Alloy
CSS	Control and Safety System
ESD	Emergency shutdown
FAT	Factory Acceptance Test
FPSO	Floating Production Storage and Offloading Vessel
GTG	Gas Turbine Generator
MT	Magnetic-Particle Testing
OPC UA	Open Platform Communications Unified Architecture
OTSG	Once Through Steam Generator
PAS	Package Automation System
PLC	Programmable Logic Controller
PSD	Process Shutdown System
PT	Liquid Penetrant Testing
P&ID	Piping and Instrument Diagram
RESD	Emergency Shutdown Relay
SS	Stainless Steel
STG	Steam Turbogenerator
TGCP	Turbo-generator Control Panel
WHRU	Waste Heat Recovery Unit

4. GENERAL

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This technical specification covers the minimum requirements for the design, material procurement, fabrication, inspection and testing, preparation for shipment and CCPG PACKAGER/ MANUFACTURER documentation requirements of FOUR sets of Once-Through Steam Generator (OTSG GV-TG-5147001A/D). This equipment (GV-TG-5147001A/D) has two sets of coils:

- One set to generate steam
- Another set to heat the hot water, which is P-GV-TG-5147001A/D - WASTE HEAT RECOVERY UNIT (WHRU)

OTSG is to be assembled in the exhaust gas duct of its respective gas turbine (TS-TG-5147001A/D - GAS TURBINE DRIVER FOR GAS TURBOGENERATOR SET). WHRU shall be positioned in the final portion of OTSG.

The once-through steam generator (OTSG) shall produce superheated steam for Steam Turbogenerator and to adjust the hot water temperature at the outlet of the WHRU, for further details of the operation and control of the OTSG and WHRU please see I-FD-3010.2Q-5147-413-P4X-002 – ONCE THROUGH STEAM GENERATOR AND WASTE HEAT RECOVERY UNIT. The waste heat recovery unit (WHRU) shall be used for heated water production.

Both the OTSG and WHRU shall be mounted on offshore FPSO unit, in safe area and in a marine tropical ambient having frequent rain storm.

Both of the OTSG and the WHRU shall be a vertical combined unit (by-pass /recovery coil) complete with all ancillary equipment built in it.

Additionally CCPG PACKAGER/ MANUFACTURER shall be responsible for all coordination and collection of all details, drawings and data to achieve optimum design and full submission of all documents requested.

Once Through Steam Generator and Waste Heat Recovery Unit Packages shall be provided with all necessary instruments to operate safely, adequately and without interruption.

4.1 Scope of Supply

The supplier of the OTSG and WHRU shall include in its scope of supply the equipment, instruments and what is necessary for a good design, construction, test and operation of the system.

CCPG PACKAGER/ MANUFACTURER shall be responsible for supplying complete and fully operational equipment in accordance with the requirements of this specification and I-FD-3010.2Q-5147-413-P4X-002 – ONCE THROUGH STEAM GENERATOR AND WASTE HEAT RECOVERY UNIT.

The SCOPE OF SUPPLY shall include as a minimum the main equipment and services listed in the following list:

- Once-Through Steam Generator unit including heat recovery coil for steam generator, heat recovery coil for heating hot water and insulated housing;
- Exhaust gas diverter system (dampers) with air sealing system
- Exhaust gas damper valve assemblies with position switches;
- Exhaust duct from turbine outlet to damper valves;
- Exhaust duct from damper to silencer, unless silencer is integrated with WHRU;
- Exhaust duct from damper to OTSG;
- Exhaust duct from OTSG to WHRU;
- Exhaust outlet duct from WHRU (stack);
- Exhaust outlet duct from silencer (stack) unless silencer is integrated with WHRU;
- Exhaust silencer;
- Thermal insulation;
- Drains and venting connections;
- Grounding connections (for OTSG/WHRU supplier);
- Clips for thermal insulation as necessary for heat conservation and personnel protection;

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- Maintenance lifting beams and hoists;
- All required gaskets, bolting and seals for the total assembly of OTSG and WHRU, ducting and accessories, in according to I-ET-3010.2Q-1200-200-P4X-001 (PIPING SPECIFICATION FOR TOPSIDE);
- All necessary instruments, ancillaries and instrument support;
- OTSG Remote Panels;
- Inspection and observation doors or manholes;
- Complete design of all components in the scope of supply;
- Structural and thermal calculation;
- Drawings, documents and manuals for all items;
- The necessary studies as required by Classification Society;
- Certification by Classification Society;
- Postweld heat treatment, as applicable;
- Inspection, testing and the quality assurance of the equipment;
- Painting proper for offshore installations;
- Non-destructive examination, if applicable;
- Shop Hydrostatic test;
- Spare parts recommended for commissioning, pre-operation and start up;
- Spare parts recommended by the Classification Society;
- Consumables and special tools for assembly, disassembly, maintenance, commissioning and start up;
- Nameplates in Portuguese language made in AISI 316 and indelibly engraved;
- Safety signaling in Portuguese language;
- Packing, protection and marking for shipment for all items;
- Preservation, including equipment handling conditioning and storage at job site;
- Guarantee of both the OTSG and WHRU performance under the conditions described in the I-FD-3010.2Q-5147-413-P4X-002;
- Technical assistance with unit price for working and mobilization/demobilization;
- Training;
- Data books;
- Installation, operation and maintenance manuals in Portuguese language
- Commissioning supervision at job site during system assembly and turbogenerators full load test;
- Transportation.

4.2 Operation Environmental / Motion Requirements

4.2.1 Operational Environmental

The equipment supplied shall be suitable for the environment and range of ambient condition including, atmospheric pressure, relative humidity, rainfall, air temperature (dry bulb), sea spray and wind motions defined at the documents I-ET-3000.00-1000-941-PPC-001 - METOCEAN DATA. For more details, please see I-FD-3010.2Q-5147-413-P4X-002 – ONCE THROUGH STEAM GENERATOR AND WASTE HEAT RECOVERY UNIT.

4.2.2 Motion Requirements

The necessary design data and information on motion requirements are given in I-RL-3010.2Q-1350-960-P4X-002 – MOTION ANALYSIS.

PURCHASER shall inform to CCPG PACKAGER/ MANUFACTURER any data from the model tests, which contradicts the specified data. Any action on the revised data will be subject to agreement with the PURCHASER.

4.3 Calculations

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CCPG PACKAGER/ MANUFACTURER shall include the following calculations for approval:

- Thermal and mechanical design including dampers operations;
- Thermal fatigue and creep evaluation, as applicable;
- Vortex-induced vibration analysis, both in new, clean condition and in fouling condition;
- Thickness calculations at the design pressure for piping components;
- Maximum and minimum tube wall metal temperatures;
- Maximum and minimum fin tip temperature;
- Maximum and minimum tube film temperature;
- Turbine exhaust pressure drop calculations;
- Pressure Safety Valve sizing calculations;
- Nozzle reinforcement calculations;
- Wind and dynamic loading calculations;
- Lifting lug calculations;
- Motion calculations;

4.4 Design Requirements

MANUFACTURER/PACKAGER shall be responsible to submit to the Classification Society the documentation in compliance with Rules in force.

All elements of the package, including sub orders, shall be of field proven design and well within the manufacturer's actual experience.

4.5 Design Lifetime

CCPG PACKAGER/ MANUFACTURER shall design and fabricate the complete packages for a minimum lifetime of 25 years.

4.6 Manufacturer

Additionally PACKAGER shall be responsible for all coordination with manufacturers and collections of all details, drawings and data to achieve optimum design and full submission of all documents requested in the specification.

4.7 Material Selection

Materials shall be selected as predicted in I-ET-3010.2Q-1200-940-P4X-001 - Material Selection Philosophy for Details Design. Unless otherwise agreed, design of any part of the equipment with a life lower than 25 years counting on a subsequent substitution of equipment parts shall not be acceptable.

A material selection report for the unit shall be issued. The proposal shall describe a complete list of the materials of the main parts as well as inspection required.

All materials shall have a resistance to corrosion/oxidation from exhaust gases, high temperature and the external environment designed for a minimum lifetime of 25 years.

5. DESIGN DATA

5.1 General Conditions

CCPG PACKAGER/ MANUFACTURER shall design, fabricate, assembly, test and code stamp the tube bundle and related header system in accordance with codes and standards herein referenced.

The heat recovered from waste hot gases from gas turbine shall be used to produce superheat steam for Steam Turbine and used to heat water for utilities purpose.

Once-Through Steam Generator shall meet the full range of operational conditions specified in the process data sheet I-FD-3010.2Q-5147-413-P4X-002 – ONCE THROUGH STEAM GENERATOR AND WASTE HEAT RECOVERY UNIT.

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The OTSG section shall be fitted with one single inlet / outlet connection and shall be capable of operate, even in transient conditions such as normal/emergency startups and shutdowns, under the entire feedwater temperature range (including cold startup conditions).

Waste Heat Recovery Unit shall meet the full range of operational conditions specified in the process data sheet I-FD-3010.2Q-5147-413-P4X-002 - ONCE THROUGH STEAM GENERATOR AND WASTE HEAT RECOVERY UNIT.

All metal surfaces in contact with the exhaust gas shall be at least 10°C above the acid dew point of the exhaust gases.

The OTSG and WHRU shall be capable of start-up and continuous operate in dry run conditions (i.e., without water inside the tubes) at the maximum gas turbine exhaust gas temperature for a minimum service life of 100,000 hours. Besides the capability of continuous dry run operation, the OTSGs shall also be capable of performing cold and hot startups under dry conditions, over the entire range of feedwater temperatures.

The Manufacturer shall ensure that the arrangement of both the OTSG and WHRU assembly guarantees effective evaporation and drainage by gravity of the water inside tubes when switching to dry-run condition.

Bundle passes shall be designed for uniform heat distribution and equal flow distribution without the use of flow controllers.

CCPG PACKAGER/ MANUFACTURER shall define the utility requirements and consumption both of the OTSG and the WHRU. This information shall be included in the quotation.

The Once-Through Steam Generator and Waste Heat Recovery Unit shall be designed for easy removal and reinstallation of the tube bundle without disturbing the casing, insulation and exhaust piping. Slip-on flanges shall not be used.

Each Gas Turbogenerator (GTG) shall be capable of operating via internal bypass (i.e., independently from its corresponding OTSG / WHRU) without causing overheating of trapped water inside OTSG and WHRU coils, even during plant emergency shutdowns, when heating medium circulation pumps are stopped. For this purpose, each OTSG/WHRU shall be fitted with an automatic, single-row blade type, on-off damper (Upper Damper), to be located at an upper portion of the main gas path, downstream of the OTSG and WHRU coils. Besides that, another automatic, double-row blade type control damper with intermediate sealing air (Lower Damper) shall be installed at the lower portions of both the internal bypass and the main gas path, upstream of the OTSG and WHRU coils. Lower Damper main/bypass sections shall be mechanically interlinked for intrinsically safe operation. A system with automatic damper(s) shall be installed, which is used when the OTSG and WHRU is out of operation simultaneously. The damper(s) shall be fitted with solenoid(s) to force damper(s) in open position (see I-DE-3010.2Q-5125-943-P4X-001 - UTILITY FLOW DIAGRAM - HOT WATER SYSTEM).

It shall be ensured a complete seal of gas exhaust to OTSG when the gas turbine is operating and both of the OTSG and the WHRU is not. In case of ESD-2, when hot water demand ceases, or ESD-3P, where TG continues to operate and WHRU does not, water overheating is not allowed.

The system that automatically controls both the generation of superheated steam and the temperature heating water and isolates both the OTSG and the WHRU from Turbogenerators gas exhausts shall be easy to operate, easy to maintain and shall withstand the operating conditions described in I-FD-3010.2Q-5147-413-P4X-002 – ONCE THROUGH STEAM GENERATOR AND WASTE HEAT RECOVERY UNIT.

The manufacturer shall evaluate the gas recirculation in the exhaust during the by-passing event to avoid the water overheating into the tube bundles.

Both of the OTSG and the WHRU arrangement shall be selected to minimize the backpressure to the gas turbine and keep the maximum backpressure lower than the maximum backpressure allowed by the turbogenerator (trip).

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The drainage system for the OTSG and WHRU package, including all auxiliary and ancillary equipment shall be designed and supplied by the PACKAGER/ MANUFACTURER, who shall acknowledge the location of all those points requiring occasional draining as well as their process data, including eventual chemical cleaning disposal. CCPG PACKAGER/ MANUFACTURER shall consider in its scope of supply all necessary piping, piping accessories, valves, flanges and companion flanges and all necessary interconnections with FPSO drainage systems (oily, contaminated, chemical, pluvial etc).

The whole design shall prevent noise to exceed 85 dBA from 1 m of any part of the equipment accessible to workers, in any operation condition.

5.2 Equipment Location

The packages will be installed outdoors, on main deck, in the location defined on the drawings mentioned below.

The design of the exhaust system has been carefully considered in order to not restrict the access for maintenance by means of overhead crane and lifting gear. For more details see I-DE-3010.2Q-1200-942-P4X-001 - GENERAL ARRANGEMENT, I-DE-3010.2Q-1423-942-P4X-001 - M-12 - POWER GENERATION - EQUIPMENT LAYOUT PLAN, I-DE-3010.2Q-1424-942-P4X-001 - M-13 - POWER GENERATION - EQUIPMENT LAYOUT PLAN and I-DE-3010.2Q-1424-942-P4X-002 - M-13B - POWER GENERATION - EQUIPMENT LAYOUT PLAN.

The steel frame runs above the gas turbine throughout its length.

5.3 Design Loads

In addition to the loads described in CODES and STANDARDS sections and loads due to equipment motions defined on I-RL-3010.2Q-1350-960-P4X-002 – MOTION ANALYSIS, the following loads shall be considered where relevant:

- Equipment transportation and erection loads;
- Nozzle loads;
- Thermal loads;
- Wind loads (see I-ET-3000.00-1000-941-PPC-001 – METOCEAN DATA for wind data);
- Weight loads.

6. EQUIPMENT DESCRIPTIONS AND REQUIREMENTS

CCPG PACKAGER/ MANUFACTURER shall provide both the OTSG and the WHRU to be compatible with the gas turbine exhaust and shall be responsible for all interfaces and interference of both the OTSG and the WHRU to the gas turbine and to the steam turbine.

OTSG and WHRU shall be provided with an integral by-pass duct built in it. The by-pass shall be sized for the appropriate velocity and dimensional constraints.

OTSG and WHRU internal coils may have an API 560 style with header boxes. In this case tube sections can be removed individually instead of the entire bundle at once.

Manhole shall be provided in both transition pieces, downstream and upstream of both the OTSG and the WHRU, to allow cleaning and inspection of the entire duct system.

6.1 Water Quality Requirements

As per designer/supplier's requirements and internationally recognized standards for OTSGs.

6.2 Structural Requirements

All individual equipment items shall incorporate lifting lugs. For ducting sections, lifting lugs shall be provided for both vertical and horizontal lift orientations. In addition, lifting lugs shall also be provided to lift the fully assembled coil enclosure, i.e., the enclosure, the bypass duct, and the inlet and outlet transitions. Lifting lug markings and designs shall ensure that lugs installed to lift unit components cannot

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be inadvertently used to lift the assembled unit. Stacks and duct selection shall be provided with two lifting lugs

Both the OTSG and the WHRU shall be supported on a steel frame independently carrying the full weight of the tubes and headers. The frame shall permit lateral and vertical expansion of all parts of both the OTSG and the WHRU at temperatures that may exist at various sections in both the OTSG and the WHRU. OTSG and WHRU shall be supported to allow lateral as well as axial growth due to temperature changes.

All casing plate shall be sufficiently stiffened against internal design pressure, damage during transport, erection and vibration. Stiffening shall not interfere with expansion.

All structural steel attached to steel plates shall have continuous seal welds. The structure shall be designed to prevent flexing of the walls.

OTSG, WHRU, internal coils, and all duct pieces and major components shall include pad eyes suitable for single point lift to facilitate loading, unloading and erection.

If necessary, the bundle may be divided into parts, so that it can be removed by cargo handling equipment for maintenance.

Equipment deck mounting connections shall be designed to adequately resist all combined static and dynamically induced loads and thermal as well, including influence of roll, pitch, yaw and heave of the facility to which it is affixed, in addition to wind loading.

Inspection openings for inspection of the heat exchanger tubes and return bends and other critical components shall be provided. All openings shall be sealed to prevent leakage of exhaust gases and shall be watertight.

Duct supports shall remove all ducts loads to the gas turbine and the exhaust stack. The ducting and supports shall be designed to remain stationary when sections near the gas turbine are removed to provide access for maintenance.

6.3 Electrical Requirements

Electrical equipment and materials shall comply with requirements of I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL FOR OFFSHORE UNITS, I-ET-3010.00-5140-700-P4X-009 - GENERAL REQUIREMENTS FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS, I-ET-3010.00-5140-712-P4X-001 - LOW-VOLTAGE INDUCTION MOTORS FOR OFFSHORE UNITS, I-ET-3010.00-5140-700-P4X-007 - SPECIFICATION FOR GENERIC ELECTRICAL EQUIPMENT FOR OFFSHORE UNITS, I-ET-3010.00-5140-741-P4X-004 - SPECIFICATION FOR LOW-VOLTAGE GENERIC ELECTRICAL PANELS FOR OFFSHORE UNITS.

Electrical installations inside the package and the voltages to be supplied for electrical loads (motors, heaters, control panels, etc.) shall comply with requirements of I-ET-3010.00-5140-700-P4X-003 - ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS.

Grounding installations inside the package shall comply with requirements of I-ET-3010.00-5140-700-P4X-001 - SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS and I-DE-3010.00-5140-700-P4X-003 - GROUNDING INSTALLATIONS TYPICAL DETAILS.

6.4 Thermal and Hydraulic Design

The heat duties shown on the technical specification I-ET-3010.2Q-5100-940-P4X-001 - COMBINED CYCLE POWER GENERATION PACKAGE item 5 shall be the required performance of a single OTSG and WHRU. The maximum pressure drop on the gas turbine exhaust gas due to both the OTSG and the WHRU package and other components listed on item 4.1 shall be no more than 2.5 kPa or as otherwise noted on the process data sheet.

The rates of volumetric heat release and the heat flux density in the coils shall not exceed those values previously adopted and confirmed by SUPPLIER in similar installations. The adopted values shall be informed in Detail Data Sheet.

INTERNA

The liquid side of the heat recovery system shall be designed for sufficiently high fluid velocity to avoid "hot spots" in the heating coil. For the ONCE THROUGH STEAM GENERATOR, an erosion evaluation shall be performed for the steam at highest fluid velocity case.

The heat recovered will be used for two applications: to produce superheat steam for Steam Turbine and utility water heating.

The limiting pressure available for the tube bundle shall adjust the ducting sizing to meet the allowable exhaust pressure drop. The exhaust gas pressure drop through the equipment shall not limit the power available from gas turbine. For additional information see I-ET-3010.2Q-5100-940-P4X-001 - TECHNICAL SPECIFICATION – COMBINED CYCLE POWER PLANT PACKAGE

CCPG PACKAGER/ MANUFACTURER shall indicate any temperature restrictions for the equipment proposed in his proposal.

6.5 Heat Recovery Coil

6.5.1 Tube Supports

The heat recovery coil shall include sufficient supports to ensure that it does not suffer from thermal distortion and vibration during operation or mechanical damage from reasonable handling during shipment, installation or replacement.

Tube supports shall be provided for each tube and shall be suitable for the maximum exhaust gas temperature of gas turbine.

Tube loads shall not be supported on the fin tip surface.

CCPG PACKAGER/ MANUFACTURER shall:

- Select the tube supports materials;
- Design (geometry and thickness) tube supports;
- Consider, in the tube support mechanical design, loads of tube and accessories added to hot fluid weight and the allowable coils movement and loads;
- Consider, in the tube support mechanical design, when applicable, friction loads due to tube expansion and contraction in transient conditions (start-up and shut-off);
- Consider coil test hydrotest conditions in the mechanical design;
- Consider corrosion allowance in the mechanical design;
- Tube support shall allow free thermal expansion of tubes during normal operation;
- Supply the detailed drawings of tube support.

6.5.2 Tubes and Tube Bundles

The tube bundles of both OTSGs and WHRUs shall be made of Incoloy 800 (only for those tube bundle sections/rows exceeding 510 degC) and Incoloy 825 (for all other sections/rows). Alternative CRA materials shall be prior submitted for PETROBRAS approval.

The tube coil design shall consider uniform heat and feed distribution.

Tubes between headers and return bends shall be continuous lengths of seamless pipe with no interim circumferential welds.

The minimum clearance between adjoining tubes shall be 12mm including fin height.

The minimum distance from fin tips to the waste heat recovery unit wall or surface of the wall insulation or refractory shall be 19mm. Fins shall be minimum 1.3mm thick with a maximum height of 25mm and no more than 1 fin for every 5mm shall be applied.

Each horizontal or vertical row shall have a minimum of four tubes, or the number of tubes equal to the number of passes, whichever is greater.

WHRU Tubes shall not be longer than 6 meters in length. For tube sizes OD 50 mm and less, Schedule 80 is required for low alloy steels.

INTERNA

Return bends shall be of the same material as the tubes. They shall match or be taper bored to match the I.D. of the connected tubes. Metal backing rings in completed coil assemblies shall not be acceptable. Rolled return or header connections shall not be allowed.

Minimum tube wall thickness shall not be less than the nominal thickness of sch. 40 pipe. Tubes shall be selected from standard pipe sizes available. Tubes shall be designed for a minimum life of 100,000 hours using API STD 530 or other technical recognized referenced for calculation of heater tube thickness.

The design of tube banks and shell shall be such that the possibility of exhaust gas bypassing coil is minimized.

Minimum fluid velocity in any segment inside tube shall be no less than 0.61 meters per second. There shall be no fluid "dead spots" or low velocity areas exposed to high temperatures exhaust gases.

The design temperature of tubes shall be the calculated maximum tube metal temperature using API Standard 530 including fouling plus a minimum temperature allowance of 4°C.

CCPG PACKAGER/ MANUFACTURER shall design the area of heat exchange with a suitable excess to account for fouling, unless otherwise state in the process data sheet.

The tubes shall be accessible for inspection, cleaning, and/or repair.

Drains and vents shall dispose safely without causing damage to equipment or persons.

CCPG PACKAGER/ MANUFACTURER shall:

- Select the tube coil materials;
- Define the tube diameter;
- Calculate the tube wall thickness;
- Analyze tube coil flexibility;
- Determine the allowable loads (forces and moments) on terminals;
- Supply a complete detailed design of tube coils, headers, crossovers, drains and vents, issuing bevel and welding specification, inspection and testing procedures, etc;
- Analyze tube wall thickness, considering, where applicable, hoop and longitudinal stresses and strains due to internal or external pressure, dead loads, space between supports, allowable loads and movements in terminal, etc.

6.6 Plenum

The plenum section, if applicable, for the heat recovery unit shall be of a double wall design, consisting of an outer shell, a thermal insulation barrier, and an inner liner.

The outer shell shall be weatherproof and completely seal welded, with the exception of the bundle flange.

CCPG PACKAGER/ MANUFACTURER shall verify that his casing design is sufficient to withstand the maximum exhaust gas pressure of gas turbine.

Design thermal growth (of coil, exhaust components, etc) shall be based on the temperature differential between minimum ambient temperature and design outlet temperature as stated in the process data sheets.

All access doors (minimum size 600mm diameter) shall be provided in the plenum above and below the coil to allow inspection and cleaning of all heat transfer surfaces without removing the coil section from the plenum.

WHRU bundle cover shall be bolted to allow tube bundle removal. WHRU bundle cover shall allow the closing of the WHRU's casing while bundle is removed for maintenance, and in this way permitting the GTG to operate without the WHRU bundle.

The plenum shall be designed with internal baffling, as required, to evenly distribute the hot gas over the surface of the heating coil and eliminate low flow areas within the plenum.

6.7 Ductwork

INTERNA

Maximum prefabrication of both the OTSG and the WHRU is preferred in order to minimize field erection labor.

All fasteners (bolts, nuts and washers) shall follow the requirements of I-ET-3010.00-1200-251-P4X-001 - REQUIREMENTS FOR BOLTING MATERIALS.

Ductwork insulation design, supply, and installation shall be of responsibility of the PACKAGER/ MANUFACTURER. The exhaust ductwork shall be insulated to ensure that the external surface temperature of the ducting does not exceed the limit of 60°C for personnel protection. The requirements of thermal insulation shall follow the I-ET-3010.00-1200-431-P4X-001 (Thermal Insulation for Maritime Installations). To prevent corrosion under insulation, only non-hygroscopic insulation material shall be used. In order to avoid damages during transportation and erection, insulation shall be carried out after final installation in place.

The external insulation and jacketing shall be anchored (or shall be fixed) properly to withstand the climatic conditions described in I-ET-3000.00-1000-941-PPC-001 - METOCEAN DATA.

Ducting after the thermal exchange area shall be made of plate steel with a minimum thickness of 4.8 mm, supported by structural steel, and shall be externally insulated.

OTSG inlet ducting shall comprise the complete ducting from the gas turbine exhaust flange to the OTSG inlet flange (or plenum) and the ducting to the bypass stack.

The ducts between the OTSG and the WHRU shall comprise the complete duct from the OTSG outlet flange (or plenum) to the WHRU inlet flange (or plenum)

The exhaust gas ducting shall comprise the complete ducting from the WHRU outlet flange to the stack.

The silencer ducting shall comprise the complete ducting from the silencer outlet flange to the bypass stack.

Ducting, including bends and inlet plenum shall have a design pressure not less than 380 mm of water column.

Guide vanes shall be designed to avoid resonance and the formation of eddies in the exhaust stream. Attachment to ducting shall be by welding and allowance shall be made for differential thermal expansion.

Ducting shall be sufficiently stiffened against mechanical vibration and distortion. Stiffening shall not restrict the free expansion of the ducting in any direction.

All ducting shall be designed such that the free cross-sectional area provides stable gas flow and acceptable pressure loss.

Transition pieces between duct sections of different cross-sectional areas shall be provided as necessary. These shall be designed with the objective of preventing flow detachment from the duct wall and providing the most economical pressure loss.

Diverging sections shall be designed commensurate with maintaining gas flow uniformity across the cross-sectional area. If necessary, guide vanes shall be used to maintain flow uniformity.

Duct supports, expansion joints, brackets, nuts packing, pipe supports, etc., shall be provided as required.

Provision to continuously drain all rainwater that enters the stack during periods of shutdown or inactivity of the unit shall be made. CCPG PACKAGER/ MANUFACTURER shall propose a suitable method for PURCHASER review and acceptance.

CCPG PACKAGER/ MANUFACTURER shall further provide a detailed, step-by-step written procedure for the installation/erection of the exhaust gas ducting system. Such procedure shall be submitted to the PURCHASER for review.

Duct supports shall be placed along the unit to remove all duct loads towards the gas turbine exhaust / exhaust stack flange. The ducts shall be supported to allow lateral as well as axial grow due to temperature changes. Ducts shall be sufficiently rigid to avoid vibration.

The duct system shall be arranged so that the minimum number of changes in direction is made.

INTERNA

The housing drainage design shall ensure that water does not stand inside the unit at any time. The drainage system shall be designed such that exhaust gas is not allowed to be drawn into the stream through the drain piping.

Stack height shall be sufficient to meet the Local Environmental Control Legislations requirements and shall be confirmed on Detailing design by SUPPLIER, due to interference of the exhaust gases on the Helideck.

Inspection openings shall be provided and also a 2" nozzle on the exhaust stack, fitted with blind flange, for future emissions monitoring.

Stack design shall prevent rain ingress into the gas turbine exhaust manifold.

To prevent exhaust gases from leaking into the acoustic enclosure, all drains from the exhaust manifold shall terminate in a water trap with sufficient height to maintain a water column not less than the maximum exhaust back pressure.

Ducting shall be designed to withstand distortion under the maximum expected back pressure without leaking.

CCPG PACKAGER/ MANUFACTURER shall specify outlet stack support requirements that will be imposed on the silencer outlet flange.

All required supporting system (including spring supports, structure, etc.) shall be supplied (on-skid elements) and specified with all design requirements, as loads, position, etc. by CCPG PACKAGER/ MANUFACTURER for all items inside his scope of supply.

6.8 Expansion Joint

Expansions joints manufactured of metal bellows shall be provided to limit thermally induced forces and moments to values acceptable to the turbine, three-way diverter valve and silencer manufacturers, if applicable.

Expansion joint shall be supplied with flow liners.

All expansion joints shall be shipped with removable braces to hold the expansion joint in the cold installed position.

The expansion joint shall be capable of both axial and lateral deflection.

Expansions joints shall be of high temperature fabric multi-layered and reinforced. The fabric shall be protected internally by insulation and metal sleeves. External protection shall be by stainless steel wire mesh and a ventilated rain shield. All metal parts in contact with the expansion joint fabric shall have rounded edges. The expansion joints shall be designed for continuous operation under the most severe operating conditions, and for ease of maintenance.

Expansion joints shall be provided in the exhaust gas ducting, as necessary. The fabric type as described above may be applied or, alternatively, the joints may be of the steel-bellows type with inner sleeves and shall be insulated externally to prevent the temperature of the metal in contact with the exhaust gas falling below the dew point of the exhaust gas.

Expansion joint at heat recover coil shall not be allowed.

6.9 Exhaust Gas Diverter Valves

6.9.1 General

The exhaust gas ducting from each turbine shall include diverter valve to control exhaust gas flow to the heat recovery section.

The diverter valves shall be designed for continuous operation at any position between the fully opened or closed position using a single pneumatic actuator. The dampers shall be able to modulate enough to supply only 10% of the heat generated by the turbine when it is operating at 100% load.

Dampers supports shall allow free movement along damper axis due to duct thermal expansion. The dampers shall also be provided with a manual device allowing its manual operation.

The dampers bearings and shafts gaskets shall be designed to allow easy removal and reinstallation.

The diverter valves positioned on the bypass and on the waste heat recovery inlet shall have a mechanical interlock connecting the valves. The interlock shall insure that both valves cannot close simultaneously.

The diverter valves shall not allow more than 1% total mass flow leakage, across the full range of exhaust gas flow, at the design temperatures. Additional sealing devices such as air blowers shall be provided to block the 1% mass flow that may leak through diverter valves when in closed position.

In order to minimize warpage, binding and leakage, the diverter frame, blade(s) and shafting shall, insofar as practical, be produced from materials having similar expansion coefficients.

CCPG PACKAGER/ MANUFACTURER shall provide the calculated backpressure for both the OTSG and the WHRU when turbine exhaust is in full load operation.

The units shall have interlocking between the position of modulating dampers and the start-up of the turbo-generator.

6.9.2 Seals

The diverter seals shall be fabricated of materials that are not adversely affected by the temperature, composition and corrosive or erosive environment of the exhaust gas system.

The design and construction of the diverter seals shall consider the differential expansion of the various components, including the blade(s), shaft, frame and seals.

6.9.3 Blades, Shaft Bearings, and Packing Glands

The pivot shaft shall be of a one-piece design and manufactured of solid stainless steel.

The bearings may be of either ball or sleeve type, and shall be selected on the basis of the pivot shaft temperature and the ambient conditions at the installation. Bearing shall be lubrication free, and suitable to operate whilst exposed to the temperature of the exhaust gases.

Bearing shall be mounted outboard of the packing gland, to avoid exhaust gas contamination and overheating in the event of packing gland failure. Safe access to the lubrication point shall be provided. Bearings mounting shall allow easy access for replacement.

The use of Polyamide or any other synthetic cage material design is not allowed.

6.9.4 Actuator

The actuator shall be double-acting piston type and shall be suitable to operate whilst exposed to high temperatures around it.

Each diverter valve actuator shall be supplied with solenoid valves, positioners, air supply filter/regulators, pressure gauges for supply, input, and output to actuator, and limit switches to indicate when the diverter valves are closed or open, and automatically control the process heating water temperature, according I-DE-3010.2Q-5125-944-P4X-002/005 - TURBOGENERATOR WASTE HEAT RECOVERY note 10.

6.10 Instrumentation and Controls

6.10.1 Interface with FPSO Control and Safety System

All instrumentation equipment and interface with FPSO automation and control design shall comply with I-ET-3010.00-1200-800-P4X-002 – AUTOMATION, CONTROL, AND INSTRUMENTATION ON PACKAGE UNITS.

Both the OTSG and the WHRU are part of COMBINED CYCLE/ COGENERATION PLANT (UG-5132001) and shall follow its package classification as defined in I-ET-3010.2Q-1200-800-P4X-014 - AUTOMATION INTERFACE OF PACKAGED UNITS and I-ET-3010.00-1350-940-P4X-001 - SYSTEMS OPERATION PHILOSOPHY. Additionally hardwired and network signals from both the OTSG and the WHRU and CSS shall be according to I-ET-3010.2Q-1200-800-P4X-014 - AUTOMATION INTERFACE OF PACKAGED UNITS under COMBINED CYCLE/ COGENERATION PLANT as well as in I-DE- 3010.2Q- 5125- 944- P4X- 002 - TURBOGENERATOR WASTE HEAT RECOVERY "A", I-DE-3010.2Q-5125-944-P4X-003 - TURBOGENERATOR WASTE HEAT RECOVERY "B", I-DE-3010.2Q-5125-944-P4X-004 -

INTERNA

TURBOGENERATOR WASTE HEAT RECOVERY "C", I-DE-3010.2Q-5125-944-P4X-005 - TURBOGENERATOR WASTE HEAT RECOVERY "D".

6.10.2 Internal Control and Safety Requirements

CCPG PACKAGER/ MANUFACTURER shall be responsible for providing all necessary instruments, valves, device, associates accessories (including, but not limited to, tubings and thermowells) and control and safety strategies for both the OTSG and the WHRU system, in order to operate adequately and without interruption and to ensure safe operations.

CCPG PACKAGER/ MANUFACTURER shall develop the control and safety strategies for both the OTSG and the WHRU system taking into account at least the following aspects and requirements:

All requirements and recommendations mentioned in this specification, specially item 6 and its sub items.

Damper valves shall be modulated in order to achieve the specified temperature set point, referred to the temperature at the outlet pipeline or connection. A temperature transmitter shall be located in the outlet piping or connection of the WHRU.

Damper valves shall fail to the position of routing all exhaust gas to the silencer.

When the OTSG is out of operation the WHRU operation shall modulate the divert valves to the silencer.

When the OTSG is operating, the WHRU operation shall modulate the steam extraction valves from the steam turbine.

Water flow inside the heating coils shall be established prior to performing any action.

The external shutdown signal (ESD-3P or ESD-3T) shall lead both the OTSG and the WHRU system to safe condition.

OTSG and WHRU control and safety interlocking strategies shall also provide status, alarm, malfunction, and shutdown signals to the combined cycle / cogeneration plant control panels. This information shall be confirmed and updated by CCPG PACKAGER/ MANUFACTURER and shall be provided to PURCHASER at BID stage;

Where necessary, on hot spots, monitoring transmitters (4-20 mA) shall be included in the WHRU.

6.10.3 Other Requirements

Draft gauge connections (50mm, 150#, RF with blind flanges) shall be installed at the inlet and outlet of the plenum and in the ductwork at the upstream and downstream sides of both diverter assemblies.

Thermowell connections (50mm, 150#, Carbon Steel) shall be installed at the inlet and outlet of the plenum section.

All switches and sensors shall be suitable for high temperature applications.

All instrument connections shall be clear of thermal insulation.

The pipe sleeves shall be seal welded to exhaust gas containing surfaces, to prohibit leakage to the atmosphere.

OTSG Remote Panel shall fully comply with requirements of I-ET-3010.00-5520-888-P4X-001 - AUTOMATION PANELS.

6.11 Design and Fabrication

6.11.1 Pressure Vessels Design

For all intents and purposes throughout this specification, pressure containing parts of the WHRU and OTSG will be referred to as “Pressure Vessel” or “Vessel”.

The facing and holes of all nozzle flanges shall be in accordance with standard ASME B16.5 or B16.47.

Each vessel shall have its own support and shall not be supported by piping even in the case of small vessels.

6.11.1.1 Material requirements

Materials shall be selected as predicted in I-ET-3010.2Q-1200-940-P4X-001 - Material Selection Philosophy for Details Design.

INTERNA

The use of cast parts shall be kept to a minimum and this has to be submitted at all times to PURCHASER previous approval.

Corrosion allowance shall be minimum 2.5mm for chrome alloy coil materials and minimum 1.27mm for corrosion resistant alloy coil materials.

All welds made on coils shall follow integrally the I-ET-3010.00-1200-955-P4X-001 – Welding and it shall be 100% inspected using radiography and/or UT according to I-ET-3010.00-1200-955-P4X-002 – Requirements for Welding Inspection.

Steels for pressure parts shall present a carbon content not exceeding 0.30 %, and for shell and head plates the carbon content shall not exceed 0.26 %. Steels having a carbon content exceeding the above limits may be used only in the following circumstances:

a) non-welded parts, such as blind flanges and manhole covers;

b) plates more than 50 mm in thickness.

The use of steels containing other alloy elements besides manganese and silicon and/or with tensile stress exceeding 485 MPa (70 ksi), nominal stress value given in the material specification, as well as the use of quenched and tempered steels shall be subject to PURCHASER previous approval.

When using austenitic stainless, only materials that are not susceptible to sensitization shall be used (low C steels, types L and ELC or stabilized steels).

6.11.1.2 Pressure vessels connections/flanges

For nozzles less than 2" in nominal diameter, forged steel couplings may be used. Couplings shall be at least class 6000#, for socket weld.

All nozzles having a nominal diameter of 2" or over, shall be flanged, except when specified for butt weld in the piping spec (see I-ET-3010.2Q-1200-200-P4X-001).

The minimum nominal diameter of nozzles intended for any purpose shall be 3/4". Flanges having a nominal diameter up to and including 1 1/2" may be of the following types:

a) long welding neck flange;

b) welding neck flange with a neck sch. 160 or XXS.

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

6.11.2 Pressure Vessels Fabrication

6.11.2.1 Welding

Welding shall be done following the requirements of I-ET-3010.00-1200-955-P4X-001 - Welding

6.11.2.2 Welding inspection

Welding Inspection shall follow the requirements of I-ET-3010.00-1200-955-P4X-002 (Requirements for Welding Inspection).

7. PAINTING

Paint system shall be according to I-ET-3010.00-1200-956-P4X-002 – GENERAL PAINTING.

Color code adopted shall be in accordance with DR-ENGP-I-1.15 – COLOR CODING.

8. THERMAL INSULATION

Thermal insulation shall be according to I-ET-3010.00-1200-431-P4X-001

Thermal insulation shall be considered to temperatures of 60ºC and above. All steam component insulation shall be with aerogel type material.

The CCPG PACKAGER / MANUFACTURER supplies fully internally insulated ductwork. That offers numerous advantages and time and cost savings to a project. Field insulation installation at the site is required only between the major ducting components and OTSG/WHRU.

9. NAMEPLATES

INTERNA

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

The nameplate information shall include, as a minimum, the following items in the Portuguese language:

- Tag number
- Manufacturer and year built
- Ancillary equipment's serial number and type
- Capacity, volume, flow rate, heat exchange rate, etc.
- Design code and Year edition
- Design temperature and pressure
- Maximum allowable working pressure

10. TAG NUMBERING

Tagging of all instruments, electrical, mechanical and piping items, including valves, shall be in accordance with latest revision of I-ET-3000.00-1200-940-P4X-001 - TAGGING PROCEDURE FOR PRODUCTION UNITS DESIGN.

Tags shall be supplied with description in Portuguese language, unless otherwise stated in the project data sheets.

All tag labels shall be made from SS 316.

Valves and instruments shall be tagged with the applicable number only.

Tagging of all instruments, electrical, mechanical and piping items, including valves, shall be carried out by PACKAGER/MANUFACTURER and confirmed by OWNER.

11. 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.

12. CERTIFICATION REQUIREMENTS

11.1 CLASS CERTIFICATION

For each package, a Classification Society Certificate of compliance with Rules requirements shall be supplied.

11.2 MATERIAL CERTIFICATION

CCPG PACKAGER / MANUFACTURER shall be responsible for obtaining all necessary certification of the equipment. The CCPG PACKAGER / 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.

All castings shall have the material designation embossed and engraved on each part.

13. INSPECTION AND TESTING

12.1 INSPECTION

CCPG PACKAGER / MANUFACTURER shall submit an Inspection and Test Plan (ITP) in the technical proposal.

PURCHASER shall identify all the required witnessed inspections on a marked up copy of the Inspection and Test Plan (ITP).

CCPG PACKAGER / MANUFACTURER shall be responsible to provide sufficient notice of testing/inspection to the respective classification society, such that a class certificate can be obtained.

All WHRU shall be subjected to inspections in manufacturer's shop by buyer/owner representatives.

12.2 TESTING

INTERNA

All WHRU coils shall be hydro tested in accordance with the ASME Code for a minimum duration of two hours.

WHRU coils of stainless steel shall be tested with water that does not exceed 100 ppm chloride content. After testing, the coil shall be immediately drained and dried internally.

Copies of all test records and data shall be available to buyer/owner representative including manufacturer's data sheet, hydrostatic test records, radiographic film, etc.

12.2.1 Factory Acceptance Test (FAT)

PURCHASER requires witnessed testing for each major sub-component in the Waste Heat Recovery Unit.

The following items (and their spares, if applicable) shall be mechanically tested to the fullest extent possible in the manufacturer's shop prior to their release for shipment:

- Safety Valves
- Package WHRU Hydrostatic Test (including bundle coil and headers)
- Dampers operations and leakage

Tests shall take the form of a mechanical test performed in accordance with a mutually acceptable code or standard.

Copies of all test records and data shall be available to PURCHASER including MANUFACTURER'S/CCPG PACKAGER'S data sheet, hydrostatic test records, radiographic film, etc.

12.2.2 Field Testing

PURCHASER may elect to conduct performance tests on any or all components of the Waste Heat Recovery Unit. CCPG PACKAGER / MANUFACTURER shall ensure that all instrumentation or test points required for testing are provided with the equipment. Test standards shall be in accordance with those listed in this specification.

14. CCPG PACKAGER / MANUFACTURER RESPONSIBILITY

CCPG PACKAGER / MANUFACTURER shall assume total engineering responsibility for the complete package.

MANUFACTURER'S/CCPG PACKAGER'S responsibility shall also include but not be limited to:

- Resolving all engineering questions and/or problems relating to design and manufacture.
- Providing details as requested of sub-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, CCPG PACKAGER / MANUFACTURER shall inform PURCHASER of the conflict and seek clarification.
- Installation at site by others, however, presence of supervision shall be required.

Compliance by the CCPG PACKAGER / MANUFACTURER with the provisions of this specification does not relieve the CCPG PACKAGER / MANUFACTURER of responsibility to furnish equipment and accessories of a proper mechanical design suited to meet the specified service conditions.

Any exclusion and/or alternative to what is specified in this Technical Specification, including the use of the CCPG PACKAGER /MANUFACTURER's standard and exclusive technology, shall be presented in a Deviation List, subject to PETROBRAS acceptance during the clarification phase, together with the proposal presentation. Otherwise the requirements herein will be considered as "Agreed", and so required.

INTERNA