PETROBRAS	**TECHNICAL SPECIFICATION**	**Nº:** I-ET-3010.2D-5412-583-P4X-001	
	CLIENT: AGUP		**SHEET** 1 of 46
	JOB: HIGH CAPACITY FPSO - GAS EXPORTATION ALL ELECTRIC		
	AREA: ATAPU 2 AND SÉPIA 2		
SRGE	**TITLE:** **FLARE SYSTEM**		INTERNAL
			ESUP

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DATE	19/08/2022	28/10/2022	02/12/2022	03/02/2022					
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APPROVAL	EGKA	CXM6	CXM6	CXM6					

SUMMARY

1 OBJECTIVE

1.1 This specification establishes the technical requirements to supply the High and Low-Pressure Flare System to be used in HIGH CAPACITY FPSO unit. The Flare System includes flare tips, wind and heat shields, ignition panels, pilots, pilots monitoring systems, burners, fuel supply control, staging skids, and everything else entailed, which, even if not described herein, is required for proper operation of the equipment.

2 NORMATIVE REFERENCES AND DESIGN SPECIFICATIONS

2.1 All equipment shall comply with the requirements of this technical specification and references stated below. All equipment parts and details not complying with any of these requirements shall be informed on a “Deviation List”. Otherwise, they will be considered as “Agreed”, and so required.

2.2 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 MANUFACTURER may revert to PETROBRAS for clarification.

2.3 All data shall be presented in International Standard’s Units.

2.4 CLASSIFICATION

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

2.5 CODES AND STANDARDS

The latest editions of the following codes and standards shall be used as design guidelines.

ISO-23251 (identical API-STD-521)	Petroleum, petrochemical, and natural gas industries - Pressure-relieving and depressuring systems
ISO-25457 (identical API-STD-537)	Petroleum, petrochemical, and natural gas industries - Flare details for general refinery and petrochemical service

API-RP-2A-WSD	Planning, Designing and Constructing Fixed Offshore Platforms - Working Stress Design
IEC 60079	Explosive atmospheres
IEC 61508 (all parts)	Functional safety of electrical /electronic /programmable electronic safety-related systems
IEC 61511 (all parts)	Functional safety – Safety instrumented systems for the process industry sector
IEC 60092 (all parts)	Electrical installations in ships
IEC 61892-1	Mobile and fixed offshore units - Electrical Installations – Part 1: General requirements and conditions
IEC 61892-6	Mobile and fixed offshore units - Electrical Installations – Part 6: Installation
IEC 61892-7	Mobile and fixed offshore units - Electrical Installations – Part 7: Hazardous Area
API RP 505	Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2
ASTM	For material specification
ASME-B-31.3	Process Piping
ASME-B-16.5	Pipe Flanges and Flanged Fittings NPS ½ Through NPS 24 Metric/Inch Standard
ASME-B-16.11	Forged Fittings, Socket-Welding and Threaded
ASME-B-1.1	Unified Inch Screw Threads (UN and UNR Thread Form)
ASME B1.20.3	Dry seal Pipe Threads (Inch)
AISC	For steel structures
AWS	For welding operations
AWS D1.1/D1.1M	Structural Welding Code - Steel

API-RP-14F	Recommended Practice for Design, Installation, and Maintenance of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class I, Division 1, and Division 2 Locations.
ISO 15156 – (all parts)	Petroleum and Natural Gas Industries - Materials for Use in H_2S-Containing Environments in Oil and Gas Production
ISO 21457	Petroleum, Petrochemical and Natural Gas Industries - Materials Selection and Corrosion Control for Oil and Gas Production Systems

2.6 GOVERNMENTAL REGULATION

NR 10	Brazilian Ministry of Labor (Ministério do Trabalho e Emprego – Norma Regulamentadora Nº 10, Segurança em Instalações e Serviços em Eletricidade)
NR 12	Brazilian Ministry of Labor (Ministério do Trabalho e Emprego – Norma Regulamentadora Nº 12, Segurança no Trabalho em Máquinas e Equipamentos)
NR 13	Brazilian Ministry of Labor (Ministério do Trabalho e Emprego – Norma Regulamentadora Nº 13, Caldeiras, Vasos de Pressão e Tubulação)
NR 26	Brazilian Ministry of Labor (Ministério do Trabalho e Emprego – Norma Regulamentadora Nº 26, Sinalização de Segurança *(Safety Signaling)*)
NR-37	Brazilian Ministry of Labor (Ministério do Trabalho e Emprego – Norma Regulamentadora Nº 37, Segurança e Saúde em Plataformas de Petróleo *(Health and Safety in Oil Platforms)*)

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

2.7 DESIGN SPECIFICATIONS

Coordination

I-ET-3010.00-1350-940-P4X-001	SYSTEMS OPERATION PHILOSOPHY
I-ET-3000.00-1200-940-P4X-001	TAGGING PROCEDURE FOR PRODUCTION UNITS DESIGN

I-ET-3A36.00-1000-941-PPC-001_F	METOCEAN DATA
I-ET-3A26.00-1000-941-PPC-001_F	METOCEAN DATA
Guideline	
DR-ENGP-I-1.15	COLOR CODING
DR-ENGP-M-I-1.3	SAFETY ENGINEERING
Arrangement Drawings	
I-DE-3010.2D-1200-942-P4X-002	GENERAL ARRANGEMENT
I-DE-3010.2D-1411-942-P4X-001	M-01 – FLARE SYSTEM – EQUIPMENT LAYOUT PLAN
Electrical	
I-DE-3010.00-5140-700-P4X-003	GROUNDING INSTALLATION TYPICAL DETAILS
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-3010.00-5140-741-P4X-004	SPECIFICATION FOR LOW-VOLTAGE GENERIC ELECTRICAL PANELS FOR OFFSHORE UNITS
Mechanical	
I-ET-3010.2D-1200-200-P4X-001	PIPING SPECIFICATION FOR TOPSIDE
I-ET-3010.00-1200-200-P4X-115	REQUIREMENTS FOR PIPING FABRICATION AND COMMISSIONING
I-ET-3010.00-1200-431-P4X-001	THERMAL INSULATION FOR MARITIME INSTALLATIONS
I-ET-3010.00-1200-956-P4X-002	GENERAL PAINTING
I-ET-3010.00-1200-956-P4X-003	THERMAL SPRAY COATING APPLICATION OF ALUMINUM

Instrumentation

I-ET-3010.2D-1200-800-P4X-001	INSTRUMENTATION ADDITIONAL TECHNICAL REQUIREMENTS
I-ET-3010.00-1200-800-P4X-002	AUTOMATION, CONTROL, AND INSTRUMENTATION ON PACKAGE UNITS
I-ET-3010.2D-1200-800-P4X-014	AUTOMATION INTERFACE OF PACKAGE UNITS
I-ET-3010.2D-5412-800-P4X-001	FLARE GAS RECOVERY SYSTEM - RELIEF SYSTEM

Naval

I-RL-3010.2D-1350-960-P4X-002	MOTION ANALYSIS

Piping and Instrumentation Diagram

I-DE-3010.2D-5412-944-P4X-003	HIGH / LOW PRESSURE FLARE

Process Data Sheet

I-FD-3010.2D-5412-583-P4X-001	FLARE (TA-5412001)

Safety

I-ET-3000.00-5400-98G-P4X-004	FLARE RADIATION AND GAS DISPERSION STUDY
I-ET-3010.00-5400-947-P4X-002	SAFETY SIGNALLING

Structure

I-DE-3010.2D-1354-140-P4X-001	FLARE TOWER – MAIN STRUCTURE – PART 1
I-DE-3010.2D-1354-140-P4X-002	FLARE TOWER - MAIN STRUCTURE – PART 2
I-DE-3010.2D-1354-140-P4X-003	FLARE TOWER - MAIN STRUCTURE – PART 3

Handling

I-ET-3010.2D-5266-630-P4X-001	TOPSIDE'S MECHANICAL HANDLING PROCEDURES

3 DEFINITIONS

3.1 Can: requirements are conditional and indicate a possibility open to the user of the standard.

3.2 May: indicate a course of action that is permissible within the limits of the standard (a permission).

3.3 Shall: is an absolute requirement, which shall be followed strictly in order to conform to the standard.

3.4 Unit: is defined as the FPSO (Floating Production Storage and Offloading), FSO (Floating Storage and Offloading), SS (Semi-Submersible) or Fixed Offshore Unit.

3.5 Package Unit or Package is defined as an assembly of equipment supplied interconnected, tested, and operating, requiring only the available utilities from the Unit for the Package operation.

3.6 Manufacturer: is defined as the responsible for project, assembly, construction, fabrication, test and furnishing of equipment or components internal to the Package.

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

3.8 Terms and definitions presented at ISO-23251 shall be considered on the present document besides the following:

3.9 Burner- is composed of a group of gas exit nozzles all fed by a single vertical pipe (burner stack or riser).

3.10 Burner stack (or riser) – is the vertical/tilted gas pipe which supports the burner and is fixed in the burner manifold. The burner stack keeps the flame high enough to maintain the radiation over the structures, service flare platform and pipes below admissible and/or designed levels.

3.11 Flare System - is all equipment herein described necessary to burn gas safely and properly, such as Burners, Pilots, Flare Ignition & Monitoring Panel, Flare Turndown Control System Panel, Flare Ignition, Pilot and Monitoring/Control Systems.

3.12 Gas exit nozzle – the orifices through which the gas is expelled to atmosphere.

3.13 Manifold or Burner Manifold - is the pipe (header) located on the flare supporting structure end (service flare platform), used to distribute the gas to the burners.

3.14 Repad – reinforcement pad

3.15 Turndown - is the maximum to the minimum gas flow limits ratio between which the gas shall be adequately burnt by the flare.

3.16 Abbreviations

CSS: Control and Safety System

dB(A): A weighted noise level measured in decibels

FPSO: Floating Production Storage and Offloading

PLC: Programmable Logic Controller

PSD: Process Shutdown System

QOV: Quick Opening Valve

SIL: Safety Integrity Level

4 SYSTEM COMPONENTS (SCOPE OF SUPPLY)

This specification describes the following components:

4.1 Burner Manifold

4.2 High and Low-Pressure Burners TIPs;

4.3 Windshields (if applicable);

4.4 Support and Access Structure for Burner Maintenance;

4.5 Retractable devices for flare dismantling;

4.6 Flare Ignition & Monitoring Panel;

4.7 Ignition Systems: pilot ignition system and flare ignition systems;

4.8 Heat shields over the burner manifolds;

4.9 Windproof Pilots;

4.10 Individual Pilot Flame Monitoring System by Thermocouples;

4.11 Individual Pilot Flame Monitoring System by Sound Signature;

4.12 Pilot burners backup fuel supply Control System;

4.13 HP Staging Manifold with Turndown Control System (QOVs, manual block and bypass valves, Buckling Pin Valves, Safety Pressure Transmitters, etc.) for High-pressure Flare System;

4.14 LP Staging Manifold with Turndown Control System (QOVs, manual block and bypass valves, Buckling Pin Valves, Safety Pressure Transmitters, etc.) for Low-pressure Flare System;

4.15 Flare Turndown Control System Panel (based on Safety PLC) in charge of HP and LP turndown control systems;

4.16 One portable radiometer;

4.17 Four radiometers installed, three observers at the most critical points on the top of process area and one at top of hose reel (bow side), permanently monitoring the flare radiation level; the position of the radiometers shall be defined during Detailing Engineering Design and approved by PETROBRAS;

4.18 Anemometer with wind speed and wind direction data acquisition in real time at the Unit Control System;

4.19 Flame Retention Device;

4.20 Lifting lugs.

5 PROCESS DESIGN DATA

5.1 The Flare Process Data Sheet I-FD-3010.1D-5412-583-P4X-001 - FLARE (TA-5412001) shall be used for the Flare System Design.

5.2 The Flare Tower will be 149 meters long.

6 GENERAL TECHNICAL REQUIREMENTS

6.1 The Flare parts and components will be installed outdoors, being exposed to the sea air and the radiation generated by its own operation.

6.2 Design, equipment, panels, materials, and labor for manufacturing of the Flare System shall be of high quality to ensure the efficiency and continuity of the service called for during the entire useful life of 30 years.

6.3 High-Pressure and Low-Pressure Flares shall be designed for continuous and emergency burning. Flare System’s parts and components shall endure continuous burning for an indefinite time, as well as emergency burning periods of at least 24 hours.

6.4 The flare Tip and related mechanical components shall be designed to operate and properly perform for the specified service conditions for a minimum of five years without the need for a downtime of the operating facility.

6.5 Materials, panels, and equipment shall be supplied fully tested, commissioned and ready to install.

6.6 The high and low-pressure flare systems shall be designed to operate simultaneously at their continuous burning design conditions.

6.7 The required radiation levels shall not be exceeded in any weather condition and in all continuous or emergency gas flow range at any point over the Unit where human presence is a possibility during operation and maintenance. The topside equipment specific radiation level limits, when specified by the equipment vendors shall also be respected.

6.8 All Flare systems parts shall be designed to have a MTBF (Mean Time Between Failures) of more than 5 (five) years and to remain fully operational under stormy weather conditions (wind velocity of 100 km/h).

6.9 Pilots shall be windproof and keep burning steady with rain and wind up to 160 km/h.

6.10 The Unit will have a single tower to support the Flare for burning both high and low pressure gas.

6.11 The windshield or other means of reducing the flame pull-down due to low pressure zones are mandatory in burners of high diameter.

6.12 The windshield and attachment of the windshield to the flare burner shall be designed for differential thermal expansion. The material of construction for the flare burner windshield and windshield supports shall be the same as the flare burner material.

6.13 The flare tips shall be provided with suitable lifting lugs.

7 RADIATION AND NOISE REQUIREMENTS

7.1 For the radiation calculations the Flare Manufacturer shall consider the cases described in the process datasheet I-FD-3010.2D-5412-583-P4X-001.

7.2 Radiation calculations shall include solar radiation flux of 789 W/m^2.

7.3 The radiation fluxes shall be calculated using weather conditions described in the METOCEAN DATA I-ET-3A36.00-1000-941-PPC-001_F and I-ET-3A26.00-1000-941-PPC-001_F, including case scenarios with wind velocity of 15, 10, 6, 0.5 m/s

(at 10m height) and wind directions forward-to-rear and rear-to-forward. A full radiation calculation report shall be submitted to Petrobras for approval. These wind velocities shall be corrected for the informed flare tower height according to the document DNV CLASSIFICATION NOTES No. 30.5.

7.4 Manufacturer shall guarantee that the maximum allowable total radiation fluxes (as per API STD 521) will not be exceeded at any point over the Unit where human presence is a possibility during occasional operations or maintenance.

7.5 The radiation calculations shall consider the modules and process equipment and modules heights, according to the General Arrangement Plan issued by the contractor during the detail engineering phase (a 3-model of the unit can be used). If any equipment requires a specific radiation level limit, the Manufacturer shall guarantee that total radiation flux at the equipment surface will not be exceeded.

7.6 The Flame length, and Flame distortion due to lateral wind, can be calculated by the API-521 (using Multipoint Brzustowski and Sommer approach), or other method published in scientific papers and validated by the industry. The use of proprietary models for radiation calculation is allowed when the manufacturer has an industrial scale flare test facility capable of evaluating and validating these models.

7.7 Flare radiation simulation as a single point source is not acceptable;

7.8 Air transmissivity shall be considered as 1.

7.9 Burners Fraction of Heat Radiated (F factor) considered in the calculations shall be informed for the different conditions.

7.10 The Flare Manufacturer Contractor shall recalculate the tower length only if the total calculated radiation fluxes over the unit where human presence is a possibility, exceeds the maximum allowable radiation permitted for personal as per API STD 521 table 12.

7.11 The anemometer and the four installed Radiometers shall have their readings stored in the platform control system computers. The radiometers will record the average radiation, from the flare at 5-minute intervals. When for two consecutive intervals the average recorded by the radiometer exceeds the limit of 1577 W/m^2 an alarm shall be started at the Platform Control Room.

7.12 Manufacturer shall guarantee a maximum noise level of 90 dB(A) for continuous gas burning on any point where human presence might happen during operation or maintenance over the Unit and 110 dB(A) for emergency gas burning. If necessary, the flare tower length can be extended to achieve this requirement with PETROBRAS approval.

7.13 MANUFACTURER shall consider when carrying this calculation out, the Unit linear and angular movements and accelerations. MANUFACTURER shall submit the calculation report to PETROBRAS approval.

8 MECHANICAL DESIGN CONSIDERATIONS

8.1 All burners TIPS shall be cast in single pieces of steel with the wall not thinner than ¼ inch. No welded joints or any other type of joints/connections are allowed in the burner TIP. Material shall be delivered in a solubilized condition in accordance with respective ASTM grade material.

8.2 Special purpose or special design flare burners (high diameter, air assisted, and so on) for which the technology requires construction methods other than casting shall have its mechanical design calculation submitted for owner. This design calculation shall be complemented with thermomechanical simulations, through which all radiation/temperature design scenarios shall be simulated in order to obtain the thermal stresses distribution on all welds and components. For burners with barrel diameters of 36 in. and above, the minimum thickness of the flare burner barrel shall be 0.35 inch.

8.3 All welded joints of both high and low pressure burner, burner manifolds, distribution manifolds and all accessories shall be of full penetration, 100% inspected by radiography (ultrasound inspection is acceptable if the inspection procedure contemplates the materials and the joint set up) and 100% tested with dye penetrant. Threaded connections are not accepted.

8.4 Seamless pipes shall be used for low and high-pressure burner stacks as for manifolds too and shall be at least schedule 40S. Welded pipes can only be used with PETROBRAS approval and the use of steel plate parts is not acceptable. Manifolds caps shall be forged.

8.5 All welded connections among burner risers and burner manifolds shall be reinforced with double plate despite the flare burner fatigue analysis results. Any support of structures or other pipes on the gas pipe walls shall be protected and reinforced with double plate. The risers shall not have any intermediary weld between its tip and its end/ bottom.

8.6 The pilot-thermocouple-ignitor (both) column shall be designed and constructed so as to permit their entire substitution as a sole piece in one hour without any welding execution.

8.7 The pilot burner heads shall be a single cast piece, joining gas lines for pilots and FFG. At least, one complete spare set shall be supplied, entirely wired up to panel inlet terminal strip.

8.8 The arrangement design at the tower end shall be clean in order to permit the free circulation of the wind/air and to avoid flame disturbance. A low-pressure zone shall be avoided below the flare flames.

8.9 The flare tips shall be provided with suitable lifting lugs.

8.10 The types of burners shall be defined and clearly specified by the Manufacturer during the proposal's evaluation phase and shall be built according to the material table 1 of this specification.

8.11 Each Gas Burner connection flange, when applicable, shall have this protective heat shield encompassing the bolting. The Manifold for distribution of the gas to the burners shall each be protected by heat shield of SS310H of at least 1/8" thick plate. The heat shield shall be able to support the stress of a man walking upon it. The heat shields shall have a triangular section (Chinese hat type) in order to avoid oil drops accumulation

8.12 The design shall be such as to permit a ready replacement of the Burner Nozzles and Burners, following the requirements of item 22.13 of this specification. The connections between the stack burners and the flare headers shall be designed to prevent gas leakage mainly when under high thermal stresses. No threaded connections are allowed.

8.13 The high-pressure Flare Column shall be of the stand-alone (self-supporting) type, standing on its own pipes. Auxiliary beams can be used to transmit efforts to tower structure (see tower structural drawings).

8.14 Flare sizing shall consider:

a) the internal pressure,

b) the prevailing winds,

c) the Production Unit linear and angular movements and their accelerations whether in the production site or during transportation throughout the globe from the construction site to its definitive production site,

d) the access structure for maintenance efforts,

e) the thrust effect caused by the outlet of the gases,

f) its inherent weight,

g) the vibration,

h) thermal and movement fatigue. Complete fatigue analysis shall be reported to and approved by PETROBRAS

i) Others.

8.15 It shall also have over-thickness to offset corrosion to the extent of at least 3.0 mm, for equipment, components, and piping above the heat shield on service platform.

8.16 Temporary fastening structure for being installed only during the Production Unit transportation shall be designed and installed by the Flare Manufacturer.

8.17 The attachment of the Flare Column to the structure shall be detailed by Manufacturer and approved by PETROBRAS. Minimum #300 RF class flanges will be demanded by PETROBRAS on these connections.

9 FLARE SYSTEM DESIGN SCOPE

9.1 Design of the Flare System comprises, as a minimum, the following items:

9.2 Design of Process and Piping from the Flare Ignition & Monitoring Panel to the ignitor and pilot tips. Design of Process and Piping downstream of the Staging Manifold inlet to the burners. Due to maximum operation temperature allowable of piping

material class, the design shall include the evaluation of the necessity of thermal insulation, and its extent over gas piping, for keeping piping temperature bellow maximum value allowable. This evaluation shall consider the worse flare operation situation and that heat shields might have already been foreseen due to tower structural design as per item 8.2.1.

9.3 Detailed structural design of the Flare Panels

9.4 Instrumentation Design of the Flare Ignition Panel, the Flare System Panel, and all required logic, including control algorithms for interlocking with Flare Gas Recovery System and of the Turndown and Monitoring Control System for high and low pressure Flare, Pilot-Monitoring Systems, and pilot burners backup fuel supply control.

9.5 Electrical Design of Ignition Systems and electric cables for thermocouples.

9.6 Mechanical Design of all components, providing the ASTM specifications of all materials used in the flare system.

9.7 Thermal Design with evaluation of the maximum radiation levels at the exposed areas at the production Unit and on the Flare tower.

10 LOW-PRESSURE FLARE

10.1 MANUFACTURER shall guarantee a smokeless burning of RINGLEMANN 1 (Ringelmann scale) for all continuous burning cases.

10.2 The burner design shall be a non-pollutant type, with low NOx emissions. Combustion efficiency shall be greater than 98% to guarantee low HC emissions to atmosphere.

10.3 MANUFACTURER shall inform the expected combustion efficiency for high CO_2 burning cases.

10.4 Low-pressure flare system will be staged in order to guarantee best burning conditions, provided it complies with Unit restrictions and requirements: maximum space available in deck, maximum weight over flare tower structure, access, and maintenance platform dimensions, etc. It is mandatory the use of staging special valves (QOVs) for controlling the opening of stages. The maximum and minimum

gas flow rates per stage, the pressure and exit velocity limits shall be submitted to PETROBRAS approval.

10.5 The LP FLARE can be supplied as single stage burner if the technology proposed by the Manufacturer is capable of burning efficiently all the low pressure cases described in the I-FD-3010.2D-5412-583-P4X-00, including the smokeless continuous cases. This option shall be confirmed by Performance Tests

10.6 The use of High Radiation Burners for low pressure gas burning is acceptable, provided they can work in all conditions and restrictions predicted and required in this specification, such as: flow conditions cases, maximum radiation level, flare tower length of 149 m, combustion efficiency, smokeless burning, flame interference with platform equipment and platform operation, gas assistant availability, equipment, and piping footprint available.

10.7 Manufacturer can use a high-pressure gas for assistance provided the maximum rate as specified at I-FD-3010.2D-5412-583-P4X-001- FLARE (TA-5412001). For more details, see I-DE-3010.2D-5412-944-P4X-003 - HIGH/LOW PRESSURE FLARE.

10.8 Whenever a minimum assist gas flow has to be maintained for the burner cooling, protection and endurance, the Manufacturer shall clearly inform in the documentation. The absence of this minimum assist gas flowrate shall be alarmed at CSS HMI.

11 HIGH-PRESSURE FLARE

11.1 Burner manifolds have to be made of straight horizontal pipes, from which the burner stacks will be supported.

11.2 The burner design shall be a non-pollutant type, with low NOx emissions. Combustion efficiency shall be greater than 98% to guarantee low HC emissions to atmosphere.

11.3 MANUFACTURER shall inform the expected combustion efficiency for high CO_2 burning cases.

11.4 High-pressure gas burning flare system shall be staged in order to guarantee best burning conditions, provided it complies with Unit restrictions and requirements:

maximum space available in deck, maximum weight over flare tower structure, access, and maintenance platform dimensions, etc. In this case, it is mandatory the use of staging special valves (QOVs) for staging valves controlling the opening of stages. The maximum and minimum gas flow rates per stage, the pressure and exit velocity limits shall be submitted to PETROBRAS approval. The Flare supplier shall inform the diameters of all gas exit nozzles.

11.5 The use of High Radiation Burners for high-pressure gas burning is acceptable, provided they can work in all conditions and restrictions predicted and required in this specification, such as: flow conditions cases, maximum radiation level, flare tower length of 149 m, combustion efficiency, smokeless burning, flame interference with platform equipment and platform operation, gas assistant availability, equipment, and piping footprint available.

11.6 Flaring of the High Pressure Gas shall be effected through low-Radiation. Manufacturer shall inform to PETROBRAS the flare behavior and burning characteristics, and still guarantee all burning parameters and radiation requirements.

12 MATERIAL SELECTION

12.1 Material selection for flare system is a Manufacturer responsibility. PACKAGER/MANUFACTURER may use the same, similar or better material than listed in Table 1. However, in all cases PACKAGER/MANUFACTURER shall submit the detailed material list, including all equipment and their components, for PETROBRAS approval prior to start the manufacture activities. Manufacturer shall provide certificate for all materials specified for every piece of burner and manifolds.

Table 1 - Recommended minimum quality materials

SERVICE	MATERIAL
Piping and accessories, Instrumentation (junction boxes, conduits) and Manifold [1,3]	SS 310H (UNS S31009)[2]
Flare tip and any device that may be eventually in contact with the flame up to 1.0 m below the burner	ASTM A351CK20 (UNS J94202)

Burner risers/stack, flare tip runners, thermocouple wells, flare heat shield, pilot and flame-front pilot ignition lines [1]	SS 310H (UNS S31009)[2]

(1) Any flare system part above the flare tower end (service flare platform floor) and in contact with the main gas flow

(2)This stainless steel shall be manufactured with Nb (10 x Cmin.);

(3)For piping materials see B50 piping spec – I-ET-3010.1Y-1200-200-P4X-001.

12.2 The use of carbon steel is limited to a project temperature of 350°C.

12.3 The materials of flare system shall be able to handle the process fluids with H_2S and CO_2. The requirements of ISO 15156 shall be complied.

12.4 Manufacturer shall isolate dissimilar materials to avoid galvanic corrosion.

12.5 In the construction of burners, burner tip or head ends of the pilot-monitoring-ignition soldered joints is not allowed.

13 FLARE SERVICE PLATFORM

13.1 A service platform shall be constructed at the end of the flare supporting structure (tower). Though flare manufacturer is not responsible for the design, he is the responsible for supplying PETROBRAS with all the documentation and information necessary for design, construction and installing this item at the flare tower.

13.2 The service platform arrangement shall provide enough space for combustion air movement. The air shall reach all flames, even the ones at the center of all flames, allowing the combustion air coming from their sides and from below.

13.3 The burner tips shall be high enough above the service platform floor for allowing the combustion air coming from below (htip > 3m).

13.4 The floor shall be grated to allow vertical air movement, which contributes for combustion and for cooling of the floor itself. Underneath the floor grate, two layers of metal screen heat shield of SS316L shall be installed for shading the service platform structure and the boom structure from the flame radiation. The metal screens and the grate shall be installed in attached sections not heavier than 35 kg for easy removal.

13.5 As a general rule, the arrangement shall be clean for avoiding recirculation zones promoted by the wind on the leeward side of the structures and of the flare parts. Recirculation zones can cause flame impingement on the structures and on the flare itself, which can cause their premature destruction. The arrangement shall be clean and open sighted from all directions. The wind shall travel all across the burner forest considering the flames obstruction as well.

13.6 The expected radiation flux on top of the service platform floor shall not be higher than 50,000 W/m^2.

13.7 Several 70-cm-wide access corridors for accessing all burners and pilot-ignition-T/C columns shall exist around the entire service platform and among different groups of burners.

13.8 The entire flare service platform edge shall be protected with an elevated vertical plate for preventing tools and parts from falling down. This structure shall be “Windstorm Shake Proof” and have a long life at the offshore environment and resist to the extreme thermal radiation fluxes.

13.9 For handling of Flare Tips, it will be necessary a special portable structure to be installed on top of flare tower in order to allow their maintenance. SELLER shall issue a detailed procedure for this operation considering solutions available in the market and shall be installed lashing points and pad eyes described in the procedure. The total load capacity and stresses expected on the top of Flare Tower for this maintenance shall be foreseen and present in a structural calculation report. For more details, please refer to I-ET-3010.2D-5266-630-P4X-001.

13.10 An access structure for maintenance of the pilots, ignition and thermocouple tips supported on the flare headers shall be supplied and considered during the flare design.

13.11 All Flare flanges and connections shall be less than 1.5 meters above the flare operation/maintenance platform´s floor level.

14 PIPING

14.1 Flare Manufacturer shall use I-ET-3010.2D-1200-200-P4X-001 - PIPING SPECIFICATION FOR TOPSIDE and I-ET-3010.00-1200-200-P4X-115 - REQUIREMENTS FOR PIPING FABRICATION AND COMMISSIONING for piping, valves, and materials.

14.2 Each QOV installed in the Flare turndown control system shall have its own Buckling Pin Valve (BPV) protection in a bypass line. The set of QOV and BPV shall have a piping arrangement using two manual isolation valves (full bore) and one by-pass manual valve (full bore) for maintenance purposes only. The isolating valves shall be locked open during normal operation. The manual valves shall have proper interlock system in order to prevent missing operational maneuver.

14.3 QOVs, BPVs and Manual Valves shall be provided with limits switches linked to the Flare Gas Recovery System Panel. The status (open/close position) of these devices shall be available at Unit SOS.

14.4 All the flare's branch connections shall be through an extruded butt-welding /reducing butt-welding tees, or socket welding - forged steel fittings. The use of connections or branches as "Stub-in" branch, "Shaped Nipple", "fabricated Tees", "Lateral" (straight or reducing), "Flat closure" are all not acceptable.

14.5 The use of Plain End for the pilot ignition and the pilot gas line are not acceptable as well. They shall be of socket welding fitting (coupling) type.

14.6 All flanged service and pilot gas connections shall be kept at the same height (flare tips flanges).

14.7 The Strainers in the pilot gas line are in the scope of supply. The drain pots and drain valves to the piping ignition lines and the pilot gas lines are in the scope of supply. For the drain pots and drain valves to the piping ignition lines and the pilot gas lines that are below the service flare platform floor, it shall be in SS316. For materials above the flare tower end (service flare platform floor) refer to Table 1.

14.8 Above the service platform, the piping materials selection and assembly details shall follow the requirements established in B50 piping spec from I-ET-3010.2D-1200-P4X-001.

15 FLARE IGNITION AND MONITORING SYSTEM

15.1 For instrumentation and automation, Flare System Package classification shall refer to I-ET-3010.2D-1200-800-P4X-014 - AUTOMATION INTERFACE OF PACKAGE UNITS and shall follow the package requirements according to I-ET-3010.00-1200-800-P4X-002 - AUTOMATION, CONTROL, AND INSTRUMENTATION ON PACKAGE UNITS, and shall be in accordance with the I-ET-3010.00-1350-940-P4X-001 - SYSTEMS OPERATION PHILOSOPHY.

15.2 Flare Ignition & Monitoring Panel (PN–TA–5412001-01)

a) The Flare Ignition & Monitoring Panel shall be of the rack type, standalone (self-supported) structure and contain the required instruments, equipment and accessories required for operation of the ignition system only.

b) The panel shall be suitable for operation in a classified area according to IEC, Group IIA, T3 and Zone 2 and shall have IP 56 level of protection (weatherproof) and sealed at its entrances and exits with cable glands or sealing units.

c) The flare operator shall be sheltered by the panel from the rain, sunshine, and flare total radiation. It shall be able to properly operate the system under difficult environmental conditions. Therefore, the Flare Ignition & Monitoring Panel shall have a roof, a partial lateral wall, or any other solution, which might be discussed during Detailing Engineering Design.

d) Special attention shall be taken to make sure that during the operation of the transformer/ignitor, there shall be no interference with the operation of any electronic instruments. The electronic and electrical instruments shall therefore be located 600 mm away from it.

e) Separated terminal strips shall be forecast in the flare panel for gathering interface signals. All panel inlets/outlets shall be delivered properly plugged. This panel mounted instruments casings shall be earthen to the panel structure and the latter in its turn shall be connected to the metallic structures.

f) The panel shall have interface signals with CSS. The signals themselves and their requirements are described in I-ET-3010.2D-1200-800-P4X-014 - AUTOMATION INTERFACE OF PACKAGE UNITS.

g) The Flare Ignition & Monitoring Panel shall be also interconnected to the Unit CSS - Control and Safety System and SOS – Supervisory Operation System in order to allow operator at Central Control Room (CCR) send remote command for pilots flare ignition.

h) All logic carried out by PN-5412001 shall be accessible read-only to Petrobras. Writing and editing shall have means of access control via password.

15.3 Ignition System

a) The flare system shall have a complete four ignition systems installed and ready for use. The all of ignition systems (A), (B), (C) and (D) are at scope of supply of flare manufacturer.

b) The first and the second one (A and B type) will function as the main systems while the Flare Gas Recovery System Compression Unit (UC-5412001) is in operation.

c) In case of the Flare Gas Recovery System Compression Unit (UC-5412001) is not operating and the flare system is working as an open flare, the C and D type shall be available for use.

A - Sparking Pellets Type

i. The system is based on the pellets or small rockets propelled by compressed air. The pellet is sent in high velocity through a small diameter pipe from the platform to the flare tip where it is ignited close to the flare burners. A large cloud of sparks ignites the flaring gas. A certain delay will have to exist between the Quick Opening Valve opening (flaring gas delivery) and the pellet dispatch because a gas-air mixture cloud has to exist near the flare tip.

ii. The system shall be manually or automatically ignited (when the UC-5412001 is out of operation). Remote ignition from Central Control Room (CCR) shall also be foreseen.

B - Continuous Electric Sparking Type

i. The system has several high energy sparking devices at the flare tip (burners). The sparking device can either run continuously or be started only when the Quick Opening Valve opens. However, enough reliability

shall be demonstrated on the starting of the non-continuous option and enough endurance shall be demonstrated by the continuous one. This system shall have interface with Flare Gas Recovery System Relief Panel (PN-5412001) and CSS-PSD.

C - Electro-electronic Type

i. A third ignition system shall be provided and use electricity as energy source to ignite the pilot.
ii. This ignition system shall automatically re-ignite the pilots until the flare monitoring systems detect the presence of flame on the pilot tip.
iii. The pilots shall be ignited from manual or automatic command from the Flare System Ignition & Monitoring Panel (PN-TA-5412001-01 - FLARE IGNITION & MONITORING PANEL). Remote pilot ignition from Central Control Room (CCR) shall also be foreseen.
iv. The spark plug shall be installed away from the flame zone.

D - Flame Front Type

i. The Ignition System shall be of the flame front type. Instrument air, fuel gas and power electricity shall be available.
ii. The fuel gas shall be mixed with the instrument air to permit ignition inside a combustion chamber. If compressed air and fuel gas are required at a lower pressure than they are supplied, the Manufacturer shall supply the necessary pressure reduction valves. A hand-operated needle valve shall be installed downstream the pressure reduction valve in the air line.
iii. Fuel gas feed line shall be automatically blocked in case the pressure drifts to a value considered as being unsafe (an alarm shall be generated for local and remote indication for this event).
iv. The mixture of gas and air shall be set alight by means of a spark plug actuated through a push-button and energized by a high voltage transformer. A sight-glass shall be provided for observing the ignition, which shall be installed close to push-button so that the operator can observe the ignition and press the button without displacement.
v. The transformer casing shall have lamps to indicate "energized" and "de-energized", and a push-button for ignition.

vi. A flame propagation manifold with the necessary three-way fire-safe valves shall be installed in the Flare Ignition & Monitoring Panel, to allow the operator to direct the flame towards each pilot he wishes to light up. The arrangement of these valves shall be such as to make it impossible for the flame front to be blocked.

vii. Drains with proper access shall be installed to drain water resulting from each ignition process. Drains shall be provided not only for the lowest point in the FFG (Flame Front Generator) line, but for every low point of accumulation (gooseneck). Drains shall be installed inside the Flare Ignition & Monitoring Panel and have easily access to operation.

viii. The Flare Ignition & Monitoring Panel shall clearly indicate, written in a SS steel plate attached to the flare panel, the pressures necessary to achieve ideal mixture of gas and air and other main instructions for the operators. Rotameters shall be furnished to indicate volumes of gas and air necessary to achieve ideal mixture of gas and air.

ix. Provision shall also be made for a piezoelectric ignition system to be used in case of electric power shortage on the production Unit.

15.4 Pilot System

d) The number of pilots for each burner shall be in accordance with API STD 537. For special applications such as low LHV burners more pilots may be required.

e) The pilots shall be fixed heat release, self-inspirating, pre-mix burners.

f) All pilots shall be remotely supervised from CSS' HMIs (through Flare Ignition & Monitoring Panel) and they shall also be manually/automatically re-ignited from the Flare Ignition & Monitoring Panel.

15.5 Pilot Monitoring System

a) The pilot monitoring signal shall be available in the CSS.

b) All pilots shall be monitored by two pilot monitoring systems, (i) thermocouples and (ii) sound signature.

(i) – Thermocouples

Two thermocouples shall be installed for each pilot flame. The thermocouples shall not be in direct contact with the pilot flame for long lasting design (more

than 2 years campaign). However, the flame detection time interval shall be smaller than 2 minutes.

(ii) – Sound Signature

The Sound pilot monitoring system consists of an acoustic sensor and a signal processor. The acoustic sensor receives pilot sounds through the flame front generator (FFG) line. The acoustic data are conveyed from the sensor to the signal processor. The signal processor then analyzes the acoustic data and signals the pilot flame status - either on or off.

Individual acoustic sensors shall be installed for each pilot flame in its corresponding FFG line close to the Flare Panel. The distance between the pilot flame and the acoustic sensor in the FFG line shall not be greater than 105 meters.

16 FLARE TURNDOWN CONTROL SYSTEM

16.1 The Flare Turndown Control System based on a staged manifold will be performed by the Flare Panel Safety PLC. It will be based upon the monitoring of HP gas flow, and pressure measured at the HP header.

16.2 The Flare Gas Recovery System Relief Panel (PN-5412001), based on safety programmable logic controller (Safety PLC), is responsible for controlling and safety interlocking the Flare System, and shall be used to command the stage on-off valves (QOVs) and acquire flare monitoring data, in order to anticipate the QOVs opening when a sudden gas pressure increase occurs at the production plant, promoting adequate burning conditions.

16.3 These QOVs shall be of quick-opening type, not expending more than 3 (three) seconds (to be confirmed during detailed engineering design phase) travelling between fully closed to fully open positions. The Flare Turndown Control System Panel shall be responsible for data availability and remote actuation at Unit CSS - Control and Safety System.

16.4 All instruments and controls shall be suitable for marine environmental according to the same standards and requirements applicable for the project. Flare

Manufacturer shall ensure that the equipment is properly certified for the specified classification.

16.5 Flare Manufacturer shall assume total responsibility for the instrumentation, control, design, engineering, operational philosophy, and the Safety PLC based control and safeguarding systems. These are part of Flare Manufacturer´s scope, unless specified otherwise.

16.6 Flare Gas Recovery System Relief Panel (PN-5412001) Package classification shall be in accordance with I-ET-3010.2D-1200-800-P4X-014 - AUTOMATION INTERFACE OF PACKAGE UNITS, and I-ET-3010.00-1200-800-P4X-002 - AUTOMATION, CONTROL, AND INSTRUMENTATION ON PACKAGE UNITS. This Panel shall be in charge of the proper and safe operation of the stage on-off valves (QOVs) and it shall be interconnected to the Unit CSS - Control and Safety System and SOS - Supervision and Operation System.

16.7 Flare Turndown Control System Panel (PN-TA-5412001-02) shall be installed indoor, in air conditioned area, at Automation & Electrical Panels Room (AEPR).

16.8 Flare Turndown Control System Panel shall be in charge of controlling both HP and LP Staging Manifolds.

16.9 Minimum Safety Requirements

a) The flare turndown control function shall be understood also as a safety function, and it shall be implemented according to IEC-61508/61511 SIL requirements.

b) For the HP and LP Staging Manifold, the flare turndown control/safety loops (SIFs - Safety Instrumented Functions) shall be implemented according to SIL requirements as defined in safety analysis to be carried out during detailed engineering design phase.

c) SIL requirements shall apply to the flare turndown control system as indicated below:

- Safety pressure transmitters (initiators);
- Logic solver, including I/O cards, network, power supply and processors;
- Application program;

- All final elements, e.g., QOV/actuator sets, with respective solenoid control cabinets, if applicable;

- All appurtenances necessary to build the system.

16.10 During Detailed Engineering Design phase, Flare Manufacturer shall present for PETROBRAS approval all documentation in order to certify that SIL requirements were achieved. The Safety Requirements Specification (SRS) shall include all Safety Instrumented Functions (SIF's).

Note 1: Each QOV set shall have a Buckling Pin Valve (BPV) as a backup and this BPV shall be considered as an independent layer of protection with high reliability and shall comply with PFD (Probability of Failure on Demand) equal to 10^{-2}.

Note 2: Process design calculations shall be undertaken by Flare Manufacturer during detailed engineering design phase in order to define the Flare turndown control system response times that are sufficiently short to prevent unacceptable process conditions. Flare turndown control system response times shall be defined in that phase and shall be considered for selection of the stage on-off valves (QOVs).

16.11 Flare Turndown Control System shall be fail-safe.

16.12 Logic Solver Main Requirements

a) In order to guarantee SIL reliability, an independent safety programmable electronic system (Safety PES), based on Safety PLC, shall be supplied, designed, and installed in compliance with the required safety integrity level (SIL).

b) The logic solver shall be in charge of both HP and LP Staging Manifold Turndown Control Systems.

16.13 The logic solver shall comply with the risk reduction factor (RRF) required by safety analysis, at least SIL-1 requirements. Safety PES shall consist of:

a) Redundant CPUs (processors) with special hardware features for functional safety, a special operating system and embedded functions for failures control, communication boards, I/O boards, memory boards, power

suppliers, racks, etc.;

b) Library with approved safety function blocks;

c) Special configuration tool for SIF parameters;

d) Tool to confirm that the download application software is identical to the source application software;

e) Safety users´ manual describing instructions on how to use the actual equipment in order to build safety applications that comply with IEC 61508.

16.14 In order to obtain both characteristics of high availability and high reliability (safety), redundant controllers shall be the core of Flare Gas Recovery System and Flare Turndown Control System Safety PES.

16.15 Safety PES SIL certification is mandatory and preference shall be given to equipment assessed by an independent organization that has been approved by Brazilian accreditation body (INMETRO) or the equipment is certified by TÜV, Exida or similar.

16.16 Flare Manufacturer shall supply all Safety PES hardware, application software, programming, configuration, cabinets, wiring, parts and materials for a fully functional system, whether or not specifically itemized in this specification. A fully functional system in this specification also includes a fully functional, programmed and configured Safety PES interface available for communication to CSS. The interface with CSS shall be kept to the minimum necessary for CSS safety actions/monitoring execution.

16.17 The Safety PES shall be able to communicate with CSS, without impact on the Safety PES logics.

16.18 Safety PES shall include hardware and software diagnostic facilities. Logic voted inputs and/or redundant outputs may be used in order to achieve SIL reliability. Safety PES for SIL applications shall demonstrate a minimum safe failure fraction of 90%.

16.19 Each analog input channel shall have resources for detecting signal failure when exceeds the 4 to 20mA range. It is recommended the use of channels in distinct input and output modules to connect the redundant initiators and/or actuators.

16.20 The components of Safety PES shall be provided with built-in redundancy or fault tolerance so that a single card failure shall not cause a loss on Flare Gas Recovery System and Flare turndown control system functionality.

16.21 Component parts of the Safety PES shall be arranged such that a loss of signal or power causes a safe failure.

16.22 The signals that shall be sent to CSS through network shall be defined during Detail Engineering Design, in strict accordance between PETROBRAS and Flare Manufacturer.

16.23 Instrumentation minimum requirements

a) Main characteristics of Quick Opening Valves (QOV): pneumatic actuator, tight shut-off, fail open and equipped with 2 (two) limit switches (open and close). It shall open in a time not superior to 3 (three) seconds (to be confirmed during detailed engineering design phase).

Note 3: In order to meet SIL requirements, it shall be demonstrated to PURCHASER by MODULE SUPPLIER that each QOV (including solenoid valve and actuator) is suitable for use in the safety instrumented functions considering the requirements defined in IEC 61508/61511, including Minimum Hardware Fault Tolerance of final elements. Technical data of valve manufacturer and safety certificate issued by a recognized entity, such as TÜV, Exida and similar, related to QOVs` reliability, failure data, and similar shall be presented to PURCHASER in order to proof the adequacy of the specified QOV for the safety application.

Note 4: The QOV back-ups (Buckling Pin Valves) shall be taken into account as an independent layer of protection with high reliability and shall comply with PFD (Probability of Failure on Demand) equal to 10^{-2}. These safety devices – BPVs - (similar to safety relief valves) shall not be taken into account as a Hardware Fault Tolerance for the QOVs. Flare Manufacturer shall inform PETROBRAS the technical data regarding the QOV back-ups (Buckling Pin Valve) in order to proof the PFD is achieved.

b) Actuators shall be properly sized to operate the QOV under the maximum specified operating conditions. Actuator configuration and selection shall be such that the actuator is suitable to be applied in the SIL loop as defined.

c) Safety pressure transmitters (initiators) shall have failure diagnosis features and be dedicated to Flare Gas Recovery System duty only and, therefore, separated, and independent from other field devices.

16.24 Tests

a) Flare Manufacturer shall be responsible for performing all the required tests associated to the automation, control, and instrumentation of the package as a whole, including Factory Acceptance Tests (FATs) and Site Acceptance Test (SAT).

b) Prior to execution, Flare Manufacturer shall submit for PETROBRAS approval the planning and test procedures for FAT as well as for SAT.

c) Testing, performance validation, verification and commissioning activities shall demonstrate that the Safety Requirement Specification designed for the Flare Gas Recovery System and Flare turndown control system has been reached.

d) Flare Gas Recovery System and Flare turndown control system shall be fully tested in specific period of time (proof test interval) in order to detect and correct dangerous failures to maintain the required performance. These tests shall cover all equipment that are part of the Flare Gas Recovery System and Flare turndown control systems.

e) Flare Manufacturer shall present a detailed maintenance/inspection plan to be executed during Unit lifetime in order to keep the SIL reliability.

f) All electronic modules or components utilized within the PES system shall be functionally tested in prior to system assembly.

g) There shall be documented test procedures to verify the whole Flare Gas Recovery System and Flare turndown control system, including the initiators and final elements.

h) Flare Manufacturer shall be responsible for providing personnel, material, necessary equipment and instruments for all the tests, independent of the place where they are carried out, until the final commissioning and acceptance of the Unit by PETROBRAS.

i) Any component of hardware or software failed during a test shall be re-tested as necessary to prove rectification has been completed satisfactorily.

j) The devices shall have self-diagnosis features to detect on-line failures. Input signals line monitoring and partial stroke test routine shall be available.

16.25 Safety Requirements Specification

a) During the detailed engineering design phase, Flare Manufacturer shall generate a Safety Requirements Specification (SRS). The SRS shall define the technical requirements needed to SIF implementation, in order to guarantee tolerance against spurious fails and SIL reliability.

b) The SRS shall include the following information:

- Process description and summary of the documented hazard scenarios generated from the hazard analysis process;
- Descriptions of functions performed by the SIFs;
- SIL calculations for each SIF;
- Flare Gas Recovery System and Flare turndown control system process measurements with their normal operating ranges and applicable trips points;
- Safe state of the process for each identified SIF;
- Response time requirements for the Flare Gas Recovery System and Flare turndown control system to bring the process to safe state;
- Requirements for overrides, inhibits and manual shutdowns, including how they will be reset;
- Considerations for process common cause failures such as corrosion, plugging, power supply etc.;
- Considerations regarding Flare Gas Recovery System and Flare turndown control system, requirements for proof test, procedures etc.;
- Special start-up requirements and Flare Gas Recovery System and Flare turndown control system restart considerations;
- Interfaces to Unit CSS and SOS;
- Requirements for proof test interval;

- Required testing frequencies, PFD and spurious MTTF.

c) Safety integrity data for all instruments, QOVs and devices shall be informed.

17 ELECTRICAL REQUIREMENTS

17.1 All flare electrical system and the electrical source available shall comply with I- ET- 3010.00-5140-700-P4X-003 – ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS.

17.2 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-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 and I-ET-3010.00-5140-741-P4X-004 - SPECIFICATION FOR LOW-VOLTAGE GENERIC ELECTRICAL PANELS FOR OFFSHORE UNITS.

17.3 Electrical equipment shall be certified according to hazardous areas classification. Electrical equipment installed in external safe areas, that shall be kept operating during emergency shutdown ESD-3P or ESD-3T shall be certified with the type of protection EPL suitable for installation in hazardous areas Zone 2 Group IIA temperature T3, according to IEC 61892.

17.4 The thermosensor junction boxes, extension wires, conduits, seal shall be in heat resistant material because they are subjected to extreme thermal radiation fluxes. The junction boxes above the flare service platform floor shall have a door and have an additional plate on top for shielding the junction boxes from the thermal radiation. All wire connectors shall be made in ceramic material, which shall resist the extremely high temperature.

17.5 For junction boxes please refer to I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL FOR OFFSHORE UNITS.

17.6 Just underneath the service platform floor, a single large junction box shall connect all wires connecting the flare panel to the flare. This junction box shall be easily accessible.

17.7 For cables on the flare tower, refer to I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL FOR OFFSHORE UNITS.

17.8 All electrical connections for all kind of equipment shall be suitable for operation in a classified area according to IEC 61892-1, Group IIA, T3 and Zone 2 and shall have IP 56 level of protection (weatherproof), as well all junction boxes.

17.9 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.

18 PURGE SYSTEMS

18.1 The flare headers will be provided with a purge system that can operate with nitrogen or low-pressure fuel gas to ensure continuous purging of the flare system. Besides, the high pressure flare tip shall be provided with fluidic seals to reduce purge gas requirements. Since pressure drop in low pressure flare system is critical, this requirement is not mandatory. Manufacturer shall guarantee that available purge gas flowrate and flare systems backpressure are not exceed as stated in I-FD-3010.2D-5412-583-P4X- 001.

19 PAINT AND COLOR

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

19.2 Flare system shall be coated with TSA according to I-ET-3010.00-1200-956-P4X-003 THERMAL SPRAY COATING APPLICATION OF ALUMINUM.

19.3 The Burners made with SS 310H are excepted from being coated as well as other equipment and components of same material.

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

20 MOTION REQUIREMENTS

20.1 The necessary design data and information on motion requirements are given in I- RL- 3010.1Y-1350-960-P4X-009 - MOTION ANALYSIS.

21 OPERATION REQUIREMENTS

21.1 The equipment supplied shall be suitable for the environment and range of ambient condition including, atmospheric pressure, relative humidity, rainfall, air temperature (dry bulb), characteristics monthly values and wind motions defined at the document I-ET-3A36.00-1000-941-PPC-001_F - METOCEAN DATA and I-ET-3A26.00-1000-941-PPC-001_F – METOCEAN DATA.

22 ADDITIONAL INFORMATION IN TECHNICAL PROPOSAL

22.1 The data here demanded shall be delivered during proposal phase and resubmitted, with complete technical details, during the Manufacturer's flare system design.

22.2 The Flare Manufacturer shall demonstrate deeply knowledge of the technology and prove to have already supplied at least five (5) equipment/burners like those being proposed to compose the ATAPU 2 & SEPIA 2 flare system.

22.3 FLARE RADIATION

22.3.1 Manufacturer shall supply, for all the burning conditions, continuous and emergency, described in the data-sheet I-FD-3010.2D-5412-583-P4X-001, the flare total radiation fluxes (W/m^2) over the Unit. Solar radiation has to be included in the calculations (789 W/m^2). The proposal shall inform the complete inlet serial data considered in order to obtain that radiation values (wind speed and direction, flow rate, gas low heating value, distances, etc.). The radiation profiles shall include the following radiation levels as a minimum:

- 500 $BTU/h.ft^2$
- 1000 $BTU/h.ft^2$
- 1500 $BTU/h.ft^2$

- 2500 BTU/h.ft^2

22.3.2 The Flare supplier shall inform the diameters of all gas exit nozzles, which will be verified during the Acceptance Tests.

22.4 DISPERSION OF UNBURNT GASES

22.4.1 Studies shall consider all the safety requirements in accordance with I-ET-3000.00-5400-98G-P4X-004 - FLARE RADIATION AND GAS DISPERSION STUDY.

22.5 GRAPH OF FLOW X PRESSURE

22.5.1 The Flare manufacturer proposal shall include the pressure drop versus flow rate curve for each flare tip and the minimum flow rate and pressure for safe burning and for smokeless burning Ringelmann 1 (continuous case).

22.5.2 The proposal shall include the Gas Flowrate x Pressure curve for the Turn-down control system, indicating the control valves opening pressures and flow, the flow rates per stage, the minimum flow rate and minimum pressure for safe burning and for smokeless burning.

22.6 PURGING

22.6.1 The minimum purging gas flow rates shall be indicated for the high and low-pressure system, as well as the minimum requirements to be complied with by this mentioned gas.

22.7 STRESSES

22.7.1 The weight of the various components of the system shall be reported for the tower and Unit structural designing purposes.

22.7.2 The magnitude of the thrust effect caused by the discharge of the low and high-pressure gas shall also be indicated.

22.8 DIMENSIONS

22.8.1 Manufacturer shall report the dimensions of the various parts and the diameter of the piping with a preliminary layout drawing with tips location.

22.9 MATERIALS

22.9.1 ASTM specifications for the materials used in the various components shall be informed.

22.10 PILOTS

22.10.1 Number of required pilots, and fuel gas consumption.

22.11 IGNITION

22.11.1 Report of fuel gas and instrument air consumption.

22.12 TURNDOWN CONTROL

22.12.1 The turndown control arrangement drawings.

22.13 MAINTENANCE AND ERECTION

22.13.1 Report the weight and size of the largest and heaviest component to be transported in one piece to the end of the tower. MANUFACTURER shall submit for PETROBRAS approval the outlines of the future flare maintenance and repair plan.

22.14 NOISE LEVEL

22.14.1 Manufacturer shall indicate the noise level for continuous and emergency cases. Manufacturer shall highlight all points over the Unit where noise levels are between 82 and 90 dB(A) for continuous burning condition, and over 110 dB(A) for emergency conditions. Levels shall be indicated in form of isopleths.

22.15 HEAT SHIELD

22.15.1 Heat shield specification, location with material specification, dimensions, mesh, material properties.

22.16 OPERATION UNDER STORM CONDITIONS

22.16.1 Manufacturer shall inform maximum wind conditions for stable operation of flame without extinguishing for both continuous and emergency conditions.

22.17 INSPECTION AND TESTS SCHEDULE PLAN

22.17.1 Manufacturer shall provide an inspection and tests schedule plan.

22.18 INDEX OF DRAWINGS AND DOCUMENTS

22.18.1 An index of drawings and documents shall be provided.

22.19 MANUFACTURER PLANT TEST PLAN

22.19.1 Manufacturer shall provide in the proposal at least the following:

- A complete description of the test facilities (location, capabilities, etc);
- The main technical characteristics of the experimental apparatus;
- The composition of the test gas and its Wobbe index compared with the cases described in the Datasheet I-FD-3010.2D-5412-583-P4X-001;
- The present flare test program.

22.20 FLARE BURNERS ARRANGEMENT

22.20.1 Manufacturer shall provide the flare burners arrangement drawing with at least a perspective, one top and two side views. All pipes, supports, floor, structure, and handrails shall be represented.

22.21 PIPING

22.21.1 Provide P&ID, including inlet and outlet connections (rating, size, etc).

23 FLARE DESIGN TECHNICAL DOCUMENTS

23.1 The Flare system design shall, as a minimum and in addition to the roll described in the Flare Material Requisition, be composed of the technical documents here listed.

23.2 Technical reports shall reproduce and collect all the information provided by PETROBRAS or not, used during the calculations.

23.3 The vendor shall provide full calculation reports, including radiation plots over the unit, inputs and outputs for the calculations, utilities consumption (nitrogen, fuel gas, instrument air, service air, treated water, power consumption)

23.4 Procedures and/or plans specified below shall be submitted to PETROBRAS for approval before the beginning of the corresponding activity:

- Equipment mechanical drawings;
- Inspection and test plan;
- Material quality certificates;
- Welding plan;
- Certificates of consumable quality with guaranteed property, as required (see AWS);
- Welding procedure qualification records;
- Welders/welding operators' qualification records;
- Report indicating procedures and inspectors and/or qualified non-destructive testing operators.

23.5 Thermal Radiation Study

23.5.1 A Thermal radiation study shall be supplied to PETROBRAS. This study has to show the maximum radiation fluxes over the process plant, as indicated in this Technical Specification. All these informed radiation fluxes shall be part of the Flare Manufacturer guarantee.

23.5.2 All these radiation levels have to be informed for, at least, two wind conditions: (i) wind blowing from the bow toward the flare tower, and (ii) wind blowing from the flare tower toward the stern.

23.5.3 Flare Tower: The maximum total radiation fluxes along the flare tower have to be informed by the Flare Manufacturer at every meter. Such data will be used in the flare tower structural design and in the definition of the heat shield extent.

23.6 Flare Gas Atmospheric Dispersion Study

23.6.1 Flare gas atmospheric dispersion study for different wind velocities and weather conditions shall be made, in accordance with I-ET-3000.00-5400-98G-P4X-004.

23.7 Flare system material temperature study

23.7.1 Flare system material temperature study shall prove that in any operational condition, the pipes, valves, vessels, instruments, or any flare system material shall work all the time between the material temperature limits.

23.8 Mean time between fails report

23.8.1 MTBF Calculation Report for operational conditions.

23.9 Flare maintenance plan

23.9.1 A detailed flare maintenance plan has to be designed and proposed by the MANUFACTURER and approved by PETROBRAS.

23.10 Flare system gas distribution and pressure loss study

23.10.1 The gas pressure loss from the Flare K.O. Drums to the flare shall be calculated and the gas flow rate distribution among the flare stages shall be demonstrated for all the opened flare stage combination.

24 TESTS AND INSPECTIONS ROUTINES

24.1 Tests on the Flare System are divided into two different types, namely:

- Tests at Manufacturer´s Testing Facility;
- Tests at Unit.

24.2 When it is not possible to perform certain tests at the Testing Facility, they shall be run on the system as erected at Unit.

24.3 Supplementary tests to be run at Unit may be called for, even if the tests had already been performed at plant.

24.4 TESTS AT MANUFACTURER PLANT (ACCEPTANCE TESTS)

24.4.1 The following tests, inspection and control shall be performed and eye-witnessed by PETROBRAS at Manufacturer Plant:

- Visual inspection and dimensional checking of all equipment and accessories items.
- Control of certificate covering mechanical tests and chemical analysis of materials comprising the major components of the system.
- For non-descriptive examinations predicted by constructors or indicated on the Data Sheet, it is enough to check the respective certificates. In special cases, when required, the respective tests may be site witnessed.
- Performance test on operations of the Turndown Control System and Flare Panel.

24.4.2 A PETROBRAS representative shall witness these tests.

24.5 PERFORMANCE TESTS

24.5.1 A PETROBRAS representative shall witness these tests.

24.6 FLARE RADIATION TEST.

24.6.1 The flare radiation test shall be a full performance industrial scale test to verify the radiation emitted from the Flare Tip.

24.6.2 Gas flow rates

- The LP 1st stage flare tip shall be tested with the maximum continuous gas flow rate described in the Process Datasheet (I-FD-3010.2D-5412-583-P4X-001).
- The test gas flow rate shall be maintained for a period of 60 seconds plus the radiometers thermal stabilization time.

24.6.3 Gas composition

- The gas mixture used in the test shall have the same Wobbe Index (with ± 10% tolerance) of the continuous gas cases (LP and HP) as described in the I-FD-3010.2D-5412-583-P4X-001.

24.6.4 General remarks

- The radiation flux has to be measured at the same point and with the same radiometers. More than one radiometer may be used for simultaneously recording the radiation fluxes from different positions.
- A still camera, as a minimum, or movie camera, at the best, has to be used for recording flame images during the test. (A drone equipped with a recording camera can be used).
- The radiation flux, gas flow rates, gas temperature, wind speed and direction, ambient temperature, relative humidity, and atmospheric pressure shall be stored in real time in a computer and provided to Petrobras for further analysis.

24.7 FLARE IGNITION AND FLAME STABILITY TEST.

24.7.1 The Flare ignition and flame stability test is required to confirm the flare ignition and flame stability when burning high CO2 and low LHV gases.

24.7.2 Gas Flow Rates

- The LP pressure Tips shall be tested with the high CO2 (or lower LHV value) gas flow rate case as described in the I-FD-3010.2D-5412-583-P4X-001.
- The HP pressure tips shall be tested with the high CO2 (or lower LHV value) gas flow rate as described in the I-FD-3010.2D-5412-583-P4X-001.
- The test gas flow rate can be scaled-down using a similar Flare Tip with a small diameter but with the same design gas exit velocity and same gas composition.
- The test gas flow rate shall be maintained for a period of 30 seconds after the flow rate reaches the set point.

24.7.3 Gas composition

- The gas mixture used to be burned in the test shall have the same CO2 and similar LHV of the emergency cases as described in the I-FD-3010.2D-5412-583-P4X-001.

24.7.4 General remarks

- When using a gas assisted tip for burning high CO2 content gases, the test shall be done with the design assist gas flow rate OR the same design Wfg/Wag ratio (for a smaller diameter tip).
- Wfg – Flare gas flow rate (kg/h)
- Wag – Assist gas flow rate (kg/h)
- A still camera, as a minimum, or movie camera, at the best, has to be used for recording flame images during the test. (A drone equipped with a recording camera can be used).
- Due to the flame low temperature, and low visible light emission during the flame stability test (high CO_2 composition) the manufacturer shall record the test with an Infrared Camera.
- The gas flow rates, gas temperature, wind speed and direction, ambient temperature, relative humidity, and atmospheric pressure shall be stored in real time in a computer and provided to Petrobras for further analysis.

24.8 SMOKELESS BURNING TEST.

24.8.1 The smokeless test shall be a full performance industrial scale test to verify the smokeless performance of the Flare Tip when operating in continuous cases.

24.8.2 Gas Flow Rates

- The LP 1st stage flare tip shall be tested with the continuous gas flow rate described in the I-FD-3010.2D-5412-583-P4X-001.
- The test gas flow rate shall be maintained for a period of 60 seconds

24.8.3 Gas composition

- The gas mixture used to be burned in the test shall have the same Wobbe Index (with ± 10% tolerance) of the continuous gas cases (LP-X) as described in the I-FD-3010.2D-5412-583-P4X-001.

24.8.4 General remarks

- When using a gas assisted tip for burning high CO_2 content gases, the test shall be done with the design assist gas flow rate.
- Smokeless requirement is estimated as Ringelmann 1.0 or less at one flame length from the end of the visible flame. Smokeless combustion shall be determined via EPA Method 9 by a certified smoke reader.
- A still camera, as a minimum, or movie camera, at the best, has to be used for recording flame images during the test. (A drone equipped with a recording camera can be used).
- The gas flow rates, gas temperature, wind speed and direction, ambient temperature, relative humidity, and atmospheric pressure shall be stored in real time in a computer and provided to Petrobras for further analysis.
- The test gas flow rate shall be maintained for a period of 30 seconds after the flow rate reaches the set point.
- The smokeless and radiation performance can be checked in a single test point. In this case the minimum test duration period shall be 60 seconds after the radiometers thermal stabilization time.

24.9 TEST PROCEDURE.

24.9.1 The proposed composition of the tests gas mixture shall be informed with the calculated Molecular Weight, Low Heating Value and Wobbe index

24.9.2 The external gas source (e.g., Natural Gas) compositional analysis shall be informed and documented.

24.9.3 Test gas mixtures for all the test point shall be sampled and sent for compositional analysis in a lab.

24.9.4 Test instrumentation shall be properly calibrated, and the documentation of calibration be included in the test report.

24.9.5 A Flare test procedure shall be emitted, prior to the test, and submitted for Petrobras approval.

24.10 TEST REPORT.

24.10.1 A complete test report shall be emitted by the Flare Manufacturer.

- The test report shall contain the following information (as a minimum);
- Test point start and stop timestamps
- Test flare gas flowrate
- Test flare gas temperature
- Test flare gas compositional analysis
- Assist gas pressure
- Assist gas temperature
- Assist gas flow rate
- Assist gas compositional analysis
- Meteorological conditions, such as
- Ambient temperature
- Barometric pressure
- Wind speed and wind direction
- Relative humidity
- Visual determination of emissions will be based on EPA Test Method 9
- Photograph documentation of the test setup
- Photograph of the test point
- Radiometer measurements
- Video recordings of each test point shall be sent together with the test report.

24.11 TESTS AT UNIT

24.11.1 The acceptance tests on the Flare System shall be run at Unit and shall cover all operating systems and possible defects that could be tested, by mutual agreement with PETROBRAS.

24.11.2 Radiation Levels

- When system is in operation, radiation measurements shall be made at different representative points of the Unit. For these measurements, the radiometers installed on the top of the process area and at top of hose reel (bow side), shall be used, according to what is defined in item 4.
- The measurements shall be carried out for maximum continuous and emergency condition flowrate

24.11.3 Operation

- Tests shall be repeated on the functions of the Flare Ignition & Monitoring Panel and the Turndown Control System.

24.11.4 Leaking test

24.11.5 All flanged connections in the flare system have to be tested in order to prevent leakage in operation.

25 GUARANTEE

25.1 GUARANTEE SHALL COVER AT LEAST:

25.1.1 Reported radiation levels in accordance with the requirements of this Technical Specification.

25.1.2 Dispersion curves as reported during the flare system design, in accordance this Technical Specification, and the responsibility assumed in the Technical Proposal

25.1.3 Gas flow pressure loss through piping sized during the flare design and informed to PETROBRAS.

25.1.4 All information appearing in this Technical Specification.

25.1.5 Reliability of system.

25.1.6 Continuity, safety and quality of burning.

25.1.7 Noise issued by system when in operation.

25.1.8 The Flare System Design in accordance with this Technical Specification.

25.1.9 The Flare Manufacturer shall guarantee the radiation levels everyplace where human presence is a possibility during operation and maintenance or when equipment Manufacturers requires specific radiation level limits.