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	CLIENT: SRGE		SHEET: 1 de 11
	JOB: -		
	AREA: -		
	TITLE: **FLARE RADIATION STUDY**		ESUP INTERNAL

INDEX OF REVISIONS

REV.	DESCRIPTION AND/OR REVISED SHEETS
0	ORIGINAL ISSUE
A	REVISED WHERE INDICATED (items: 2.1, 3.2.4, 3.2.5, 4.1, 4.7.1, 4.7.6, 5.1, 7.1, 8.2, 9.4 and 10.2.2.)
B	REVISED WHERE INDICATED (Item 4.3)
C	REVISED WHERE INDICATED
D	TEMPLATE UPDATE

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DATE	NOV/11/22	MAR/24/23	APR/11/24	MAY/15/24	MAY/29/24	
EXECUTION	CX80	CLYZ	CX80	CX80	CX80	
CHECK	CLYZ	CX80	CLYZ	CLYZ	CLYZ	
APPROVAL	CXM6	CXM6	CXM6	CXM6	CXM6	

SUMMARY

1. INTRODUCTION

1.1. The Flare radiation study is an analysis to evaluate the effects of thermal radiation on monitoring points (observers - people, equipment, and structure) of an Offshore Stationary Production Unit (SPU). In addition to these monitoring points, other aspects considered critical to the safety of the Unit can be evaluated or for equipment integrity, such as those described in the scope of the study and contained in this Technical Specification.

1.2. This Technical Specification (ET) guides the development of the study and the preparation of its respective report.

2. OBJECTIVE

2.1. Define scope, methodology and criteria for carrying out the study for the executive project detailed engineering design and assisted operation (if applicable) of the Stationary Offshore Production Unit, hereinafter referred to as installation.

2.2. Guide the dynamics for the planning, development, and monitoring of the study by the parties involved and their final approval.

2.3. Define the standardization, content, and minimum requirements for submission of the study report.

2.4. This TS can be used optionally as a guide in the operation phase of the Installation due to the need for a review of the study.

3. ABBREVIATIONS and DEFINITIONS

3.1. Abbreviations

CFD – Computational Fluid Dynamics

CSI – Critical Safety Items

TS – Technical Specification

FEED – Front End Engineering Design

MSF – Main Safety Functions

HSE – Health and Safety Executive - Great Britain's independent regulator for work-related health, safety and illness

PFD - Process Flow Diagram

P&ID - Piping and Instrumentation Diagram

SIGEM - Sistema Integrado de Gerenciamento de Empreendimentos

SPU – Stationary Production Unit

3.2. Definitions

3.2.1. Case – It is one of the burning conditions described in the Flare Process Data Sheet considered at the point of interest or representativeness of points in the unit's production curve;

3.2.2. Flare Discharge - Predicted release of high and low pressure Flare gas directly into the atmosphere;

3.2.3. Study Consultant – Is responsible for the execution of the study of radiation, and may be a contracted company, either by the Designer or Petrobras, the Designer herself or even an internal workforce of Petrobras;

3.2.4. Fraction of Heat Radiated (F) – is the fraction of the heat released in a flame that can be transferred by radiation. Several factors may affect the irradiated fraction, such as: gas composition; flame type; air/fuel mixing status; soot formation;

3.2.5. Involved parts– Are the Designer, the Study Consultant and Petrobras involved in the preparation or monitoring the Flare Radiation study;

3.2.6. Designer - company responsible for the preparation of the engineering project in phases: conceptual project, basic project, FEED, or executive project, which may be Petrobras itself or company contracted to carry out the project.

3.2.7. All terms and definitions are established in the latest revision of I-ET-3010.00-1200-940-P4X-002 – General Technical Terms.

4. SCOPE OF THE STUDY

4.1. The Flare radiation study shall consider all burning cases listed in the flare process data sheet and technical specification for the various operating conditions, including continuous cases.

4.2. The study shall verify the adequacy of the height of the Flare structure to meet the maximum acceptable radiation levels in the various burning conditions described in the Flare Process Data Sheet.

4.3. As an acceptance criterion, the maximum permissible levels of radiation to be considered under the various conditions are those described in API-STD-521 table 12, transcribed bellow:

Permissible Design Level K kW/m² (Btu/h·ft²)	**Conditions**
9.46 (3000)	Maximum radiant heat intensity at any location where urgent emergency action by personnel is required. When personnel enter or work in an area with the potential for radiant heat intensity greater than 6.31 kW/m² (2000 Btu/h·ft²), radiation shielding and/or special protective apparel (e.g. a fire approach suit) should be considered. **Safety Precaution—It is important to recognize that personnel with appropriate clothing [a] cannot tolerate thermal radiation at 9.46 kW/m² (3000 Btu/h·ft²) for more than a few seconds.**
6.31 (2000)	Maximum radiant heat intensity in areas where emergency actions lasting up to 30 s can be required by personnel without shielding but with appropriate clothing. [a]
4.73 (1500)	Maximum radiant heat intensity in areas where emergency actions lasting 2 min to 3 min can be required by personnel without shielding but with appropriate clothing. [a]
1.58 (500)	Maximum radiant heat intensity at any location where personnel with appropriate clothing can be continuously exposed.
[a] Appropriate clothing consists of a hard hat, a long-sleeved shirt with cuffs buttoned, work gloves, long-legged pants, and work shoes. Appropriate clothing minimizes direct skin exposure to thermal radiation.	

Note: Always use the values of the most up-to-date version of the API standard mentioned above.

4.4. The study shall provide the incident radiation profile in the Flare support structure.

4.5. The study shall provide the temperature profile in the flare support structure continuous cases (continuous burning), and in the highest radiation emergency case.

4.6. The study shall calculate and inform the points of the Flare structure (height) where the temperature in the flare supporting structure is higher than the maximum allowable temperature informed in the TOPSIDES STRUCTURAL REQUIREMENTS technical specification for the project. This point will serve as a reference for determining the length of the structure that shall be protected with heat shield.

4.7. Radiation Results for equipment and personal.

4.7.1. Iso-radiation (isopleths) curves shall be drawn on the Unit Arrangement (Plant and Cut planes) to identify the radiation levels at the various points of the Installation. Additionally, tables with temperature and radiation values must be presented for each point of interest.

4.7.2. Solar radiation shall be included in calculations (789 W/m^2, ref. API 521), different value may be adopted as long as agreed with Petrobras.

4.7.3. The effect of the wind shall be considered, both in its variation of direction and velocity and its influence on the radiation to which the Installation will be subjected. The study shall use the Meteorological data informed in the referred METOCEAN.

4.7.4. The study shall evaluate and report the highest acceptable continuous gas burning flow, within the limits of radiation imposed, for the length of the given Flare structure. For this continuous burning condition, the gas to be considered is the same gas that would be compressed under normal process conditions.

4.7.5. Radiation analysis verifying the impact on platform structures. This analysis aims to determine the temperature that a calculated radiation-prone equipment can reach. As an example, the temperature increase of a pressure vessel and the upper face of a box shall be simulated.

4.7.6. The designer is responsible for contacting the Flare´s vendors to obtain more data on the burner for modeling purposes.

5. REFERENCE DOCUMENTATION

5.1. As inputs for the preparation of the study, the following documents shall be considered, in their most updated version and with status of RELEASED or RELEASED WITH COMMENTS BY PETROBRAS in INTEGRA or another electronic document management system defined in contract. The revision of each document to be used shall be clearly indicated in the analysis report.

- Technical Specification of meteoceanographic data (METOCEAN DATA);
- Flare technical specification;
- Flare Process data sheet;
- Updated Installation 3D model and/or arrangement design (2D);
- List of equipment.

5.2. Additional documents shall be provided for the identification of other relevant aspects.

6. RELEVANT ASPECTS OF THE ANALYSIS

6.1. The study shall consider at least the following aspects:

- The geometry and physical arrangement of the evaluated region;
- The environmental conditions to be used in the simulations.

7. SOFTWARE REQUIREMENTS

7.1. The Flare Radiation Study shall be developed using industry validated semi-empirical models to conduct simulations and shall comply with the requirements of the Safety Guideline.

8. WEATHER CONDITIONS

8.1. The weather conditions to be used in the study shall be those of the final lease of the Facility. The use of meteorological data in the study shall comply with the provisions of the Safety Guideline and the Flare Technical Specification. In the study report, a table shall be presented with wind directions, speeds of each wind direction, as well as the calm condition and all considerations adopted in relation to the environmental data used in the study.

8.2. The radiation fluxes shall be calculated using weather conditions described in the METOCEAN DATA 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.

9. STUDY METHODOLOGY

9.1. The methodology to be adopted in the study of radiation and dispersion of gases shall meet the requirements of the Safety Guideline, complemented by the requirements of this TS.

9.2. The methodology for the study shall follow the steps described in this technical specification. Any deviation from the methodology shall be presented for prior analysis and validation by Petrobras. The following steps shall be performed in the development of the study:

9.3. Monitoring Points

Select the most relevant monitoring points in the Installation where human presence is possible during operation.

9.4. Burning Cases

All burning cases for the study shall be considered from the Flare Process data sheet, considering the limits described on the API STD 521, in the selected monitoring points and flare structure (flare tower).

9.5. Additional Cases

Cases that have not been previously defined in the Flare Process Data Sheet, but identified during the development of the study, and that are categorized as relevant shall also be considered in the study of radiation of gases, as well as scenarios caused by design changes, operational changes, and unit start-up.

9.6. Process Data

9.6.1. For the determination of the properties of flammable gases and other data relating to the process variables to be used in the study, only up-to-date project data shall be used. All documents used as a reference for obtaining the data shall be indicated in the reference document item of the report with their revisions.

9.6.2. All simulated cases shall have their information on the properties of the fluids (flammable gases) presented in the report, at least: current composition, pressure, temperature, density, stream code, reference document code (e.g. PFDs, PI&Ds, data sheets, mass and energy balance), mode of operation and other properties to trace the origin and relevance of the information used shall be indicated. These data shall be provided by the Designer and presented for analysis and validation by Petrobras before being used in the simulations.

9.6.3. It is the responsibility of the Designer to provide the reliable input data to be used in the simulations, so any detected inaccuracies that impact the results and require new simulations will be the responsibility of the same. In case of changes in the project formally requested by Petrobras, such as change in composition of the fluids produced or increase / reduction of plant capacity that impact the study, it will be in charge of Petrobras.

10. REQUIREMENTS FOR FOLLOW-UP MEETINGS

10.1. The follow-up meetings of the study shall follow the guidelines below.

10.2. General Considerations

10.2.1. The development of the study follow-up shall be carried out by the team of the Designer with Petrobras participation in the cases mentioned in this specification.

10.2.2. The follow-up meetings shall be held at the Study Consultant's premises, except for the project documentation planning and analysis meeting, which shall be held at the Designer's premises. The place of meetings may be amended in agreement between the parties concerned. Petrobras, at its discretion, may participate in the meetings by videoconference.

10.2.3. The meeting minutes shall be prepared by the Designer and made available as a project document or included as an annex to the report in its final review.

10.2.4. All validation decisions (assumptions, data, geometry, among others) shall be included in the final report of the study in the form of an annex. Validations shall be signed by the persons responsible for each party involved.

10.3. Planning Meeting

10.3.1. Meeting aimed at the summary presentation of the project, the clarification of aspects related to the objectives and scope of the study, delivery of the project documentation, evaluation and necessary adjustments in the work schedule and the resources necessary to carry out the study, where the minimum agenda shall be:

10.3.2. Safety Briefing - (Designer);

10.3.3. Presentation of the Project to the study Consultant - (Designer);

10.3.4. Clarifications on objectives, scope of analysis and requirements of the study (Designer and Petrobras);

10.3.5. Delivery of the project documentation as provided for this TS (Designer), including the 3D model of the Installation;

10.3.6. Dimensioning of the teams of the Designer and Performer of the study that will participate in the preparation and follow-up of the study, with the definition of the matrix of responsibilities;

10.3.7. Presentation of the focal points of each party involved and identification of the responsible of each discipline of each party involved who will participate in the follow-up meetings and validations required in this TS;

10.3.8. Presentation of the schedule foreseen for the execution of the study in accordance with the project schedule (Study Consultant and Designer);

10.3.9. Definition of the locations, resources needed and duration of the follow-up meetings (Project designer and Study Consultant).

10.3.10.Participants of the planning meeting: The focal points of the parties involved, the professionals of the Study Consultant involved and the leaders of the Designer's disciplines responsible for monitoring the study shall participate.

Note: The schedule shall include the deadline of twenty working days for comments of the reports (partial and final) by Petrobras, as well as the deadline for implementation of the comments made.

10.4. Documentation Analysis Meeting

10.4.1. Meeting for the analysis and validation of the project documentation necessary for the development of the Study and preparation of backlog, if any. The objective is to avoid errors and rework in the studies due to possible failures or omissions of information in the documentation, which will serve as an input database for the study.

10.4.2. From the analysis of the list of project documents and the documents provided, the study consultant may request clarifications and answer doubts about the information contained in the documents. In the case of identification of pending documents or need to provide other documents, the Designer shall inform the time required to remedy the pending and/or to send the documents, so that it does not affect the schedule provided for the study.

10.4.3. At the end of the meeting, the study performer shall sign a term of acceptance of the documentation which shall contain the pending items, if any.

Note: The Designer, as responsible for managing project changes, must inform the other parties involved of any changes in the project that impact the study. The documents altered as a result of the changes, which affect the study, shall be sent to the Study Consultant.

10.4.4. The study consultant shall evaluate the changes and report their impacts on the development of the analysis and the expected schedule. This information shall be formally sent to the Designer and communicated to Petrobras.

10.4.5. Participants of the documentation analysis: The professionals of the study executed involved and the discipline leaders of the Designer responsible for monitoring the study shall participate. This meeting is optional for Petrobras.

10.5. Meeting of Premises and Methodology

10.5.1. Meeting aimed at the presentation and definition of premises to be used in the study, clarification of the methodology and confirmation of basic data of the Installation.

10.5.2. The study consultant shall present the proposed premises for the development of the study and its questions regarding the methodology proposed in this TS. The questions shall be clarified by the Designer with the participation of Petrobras.

10.5.3. This meeting aims to validate the cases to be simulated, consolidate the premises defined in this TS and other additional ones not covered by this TS, and shall include at least the following:

10.5.4. Eliminated scenarios: agree and document deleted scenarios;

10.5.5. The premises shall be defined in agreement between the parties concerned and shall be included in the study report.

10.5.6. Participants of the meeting of premises and methodology: The professionals of the study executed involved and the discipline leaders of the Designer and Petrobras responsible for monitoring the study shall participate.

10.6. Follow-up and Validation Meetings

10.6.1. Meetings aimed at monitoring the study by the Designer with Petrobras participation where the items provided for in the methodology shall be addressed.

10.6.2. The Designer in agreement with the Study Consultant, and considering the schedule foreseen for the study, shall present the agenda of meetings to monitor the development of the study. The meetings shall include the stages of study provided for in item 9 (Methodology) of this TS.

10.6.3. Participants of the follow-up and validation meetings: Professionals of the study consultant involved and the discipline leaders of the Designer and Petrobras responsible for monitoring the study shall participate in the meetings.

10.7. Final Report Presentation Meeting - Preliminary Version

10.7.1. Meeting for the presentation of the final report (preliminary version) before its issuance to Petrobras. The final report is the responsibility of the Designer and shall be issued by the designer. The final report shall include the report of the Study Consultant plus the treatment of the study recommendations to be implemented in the project by the Designer. The codification of the report and its stamp shall identify the Designer as originating from the document. The coding shall be in accordance with Petrobras n-1710 and the format according to N-381.

10.7.2. The presentation shall focus on the main events, the main results, the conclusions and recommendations of the study. The treatment given to each of the study's recommendations shall be addressed.

10.7.3. Participants of the study report presentation meeting:

The focal points of the parties involved, the professionals of the study executed involved and the discipline leaders of the Designer and Petrobras responsible for monitoring the study shall participate. In this meeting it is recommended the participation of professionals operating and maintaining the Installation.

11. STUDY REPORTS

11.1. The final report shall be issued in English. The report shall meet the content specified in this document.

11.2. All the hypotheses of simplification and assumptions adopted shall be presented and explained in the corresponding part of the report. In addition, the minutes of the meetings shall be presented in the annex,

especially those that have validation of stages of the methodology. The graphs and figures of the reports shall be presented with the respective scales, legends and with the rose of the winds and predominant wind direction. For the elaboration of tables, graphs and figures, the units of the International System (IS) shall be applied.

11.3. All graphs and figures supporting the study's findings and recommendations shall be presented in the final report.

11.4. Partial Report

11.5. At least one partial report shall be submitted by the Study Consultant to Petrobras, for acceptance of the study, before the final report is issued.

11.6. The Partial Report shall contain at least the requirements:

- Assumptions
- Software used
- 3D model and geometry
- Mesh and simulation domain (if applicable)
- Process data
- Cases to be examined
- Results of simulations
- Indication of incident radiation at monitoring points

11.7. Final Report

11.8. The Final Report corresponds to the issue of the report under review 0. It shall contain all the requirements of item 11.1, the comments made to the Partial Report, and additionally contain:

11.9. Attached minutes of meeting (item 10);

11.10. LV attached (item 14);

11.11. Additional revisions shall be provided for cases where there are changes in the project that affect the study or if errors in the final issue are identified.

11.12. The minimum content of the report must be in accordance with the requirements of the Petrobras Safety Engineering Guideline.

12. DEADLINES

12.1. According to the complexity of the project, the scope of the study and the deadlines established in the contract, the project designer shall define in agreement with the study consultant the deadlines required for the study and issuance of partial and final reports. These deadlines shall be included in the schedule cited in item 10.2 of this TS.

13. CHECKLIST APPLICATION (LV)

13.1. The Designer shall present as evidence of monitoring the activities of the Study Consultant a checklist (LV), which shall be included as an annex to the report. LV shall contain the requirements contained in the Safety Guideline and those contained in this TS. The verification of each requirement shall have the identification and signature of the person responsible for the verification.

13.2. The verification of the part relating to the adequacy of flare height as to the aspects of interference with persons, structures and equipment shall be included in the project documentation or as an annex to the report. In case this documentation shall not be included in the study report in a specific item, with a clear indication of how and where the study recommendations were met.

14. INFORMATION SECURITY

In addition to the provisions of the Safety Guideline, the Designer and the Study Consultant shall have a data security system that guarantees the integrity, reliability, traceability, confidentiality, and inviolability of the data contained in the study and the data provided by Petrobras. All information shall be preserved against accidental events or information security.