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INDEX OF REVISIONS

REV	DESCRIPTION AND/OR PAGES REVISED
0	ORIGINAL
A	ITEM 5.4 REVISED, INCLUDING SPECIFIC TRAINING REQUIRED ON ITEMS 10 AND 11. ITEM 8 REVISED, ADDING A PRESCRIPTIVE SAFETY CRITICAL PROCEDURE.

	REV. 0	REV. A	REV. B	REV. C	REV. D	REV. E	REV. F	REV. G	REV. H
DATE	30/03/2023	13/04/2023							
PROJECT	ESUP	ESUP							
EXECUTION	DXVM	DXVM							
VERIFICATION	BBBA	BBBA							
APPROVAL	EK9U	EK9U							

SUMMARY

1. INTRODUCTION

The Human Factors Engineering (HFE) consists of the incorporation of human factors within the engineering design process with the main purpose of reducing any risks associated with human factors/ergonomics, as well as the potential for human error to a level that is as low as reasonably practicable (ALARP).

The principles and technical requirements, hereinafter defined, aim to define how to include due consideration of HFE within the design process for engineering projects, to outline the overall approach to be followed, and therefore to encourage early and appropriate application of HFE at design phase.

Following this Technical Standard should allow project to demonstrate that sufficient consideration has been given for designing systems and equipment in a way that minimizes potential for design-induced risks to health, personal or process safety or environmental performance.

2. OBJECTIVES

This Technical Specification (TS) is intended to define minimum technical requirements and risk management principles focused on Human Factors Engineering (HFE) to be considered during the design execution process in addition to the requirements contained in the Safety Guideline DR-ENGP-M-I-1.3-R7 in force on the date of signing the contract. This TS has as main objectives, the following:

2.1 Define scope and criteria for performing the HFE activities for the Detail DE Project phase of the Maritime Production Units, hereinafter designated as Production Unit,

2.2 Define responsibilities between the involved parts for HFE of the Production Unit,

2.3 Define the standardization, content, and minimum requirements for the final technical documentation of the analysis, hereinafter designated as HFIP.

3. GENERAL ASPECTS OF HFE ACTIVITIES

3.1 The areas, systems or equipment that are selected for the HFE activities shall be based on the I-MD-3010.2D-1200-940-P4X-008 DESCRIPTIVE MEMORANDUM – ERGONOMICS, I-ET-3010.2E-1350-196-P4X-002 - ERGONOMICS REQUIREMENTS FOR HULL and I-ET-3010.2D-1400-196-P4X-001 - ERGONOMICS REQUIREMENTS FOR TOPSIDE from Basic Engineering phase by BUYER and item 8 of this document.

3.2 The final documentation of the analysis shall be issued in both English and Portuguese for submission to regulatory agencies in Brazil.

3.3 The analysis shall be based on Detail Design technical documentation of the Production Unit itself.

3.4 It is the responsibility of the SELLER to research and obtain all the information necessary to perform the analysis, including engineering documentation, updated technical data relevant to the analysis, applicable standards etc.

3.5 The final documentation of the analysis shall contain the complete list of reference documents, with the indication of the revision of each document used in the analysis, and it is the responsibility of the performer of the analysis to verify the completeness of the list of documents.

3.6 It is SELLER'S responsibility to carry out the management of changes (MOC) of the project and the reference documents, including the reviewing and adjusting of the safety critical procedures and tasks, if they are impacted for the HFE recommendations.

3.7 The final documentation of the analysis shall be submitted for formal approval by BUYER.

4. DEFINITIONS

For General Technical terms, refer to I-ET-3010.00-1200-940-P4X-002 – GENERAL TECHNICAL TERMS. Following, it is presented the definition of specific technical terms mentioned in this TS.

4.1 As Low as Reasonably Practicable (ALARP) - the concept that efforts to reduce risk should be continued until the incremental sacrifice (in terms of cost, time, effort, or other expenditure of resources) is grossly disproportionate to the incremental risk reduction achieved.

4.2 Consequence - manifestation of how physical effects impact human, environmental and/or material resources caused by fires, explosions, or leaks of toxic or hazardous products, expressed in the form of damage to health, economic loss and impacts on the environment.

4.3 CREAM - Cognitive Reliability and Error Analysis Method, qualitative and quantitative method of human reliability analysis approved by BUYER to be used by SELLER to estimate the likelihood of human errors and identify the performance influencing factors during the performance of safety critical tasks and procedures.

4.4 Deviations - divergences from project intentions or normal operating conditions. The list of applicable deviations is obtained from the combination of process parameters (variables) with guide words.

4.5 Effects - consequences arising from the occurrence of a failure mode, which may affect operation, function and could result in consequences for the facilities, people, environment, and image of the Company.

4.6 Hazard - condition or property inherent to a substance, activity, system, or process, with the potential to cause damage to the physical integrity of the company's persons, environment, property, or image.

4.7 Human Error – actions, tasks or activities performed by people, which may contribute or result in accidents by exceeding acceptability limits defined by the system.

4.8 Human Factors Incorporation Plan (HFIP) - final documentation compiling all deliverables of HFE from design lifecycle.

4.9 Human Reliability Analysis (HRA) - methods used to qualitatively and quantitatively analyze the human actions, tasks and services required by a system. For Petrobras, the pre-approved methods to be used are Petro-HRA, CREAM (quantitative), SCTA and FRAM (qualitative).

4.10 Major Accident Hazards (MAHs) - scenarios with initial severity “III”, “IV” or “V”, or with initial risk classified as “non-tolerable”, based on the risks tolerability matrix indicated on Safety Guideline DR-ENGP-M-I-1.3-R7 including scenarios which can lead to multiple fatalities, severe injuries, extensive damage to the asset, or large-scale impact to the environment.

4.11 Petro-HRA - qualitative and quantitative method of human reliability analysis approved by BUYER to be used by SELLER to estimate the likelihood of human errors and identify the performance influencing factors during the performance of safety critical tasks and procedures.

4.12 Recommendations - Proposed measures to reduce the likelihood of accidental scenario occurrence or mitigate its consequences whenever existing safeguards are considered insufficient.

4.13 Risk - Combination of the expected frequency of occurrence of an accidental scenario with the severity of the consequence of this scenario.

4.14 Safeguards - Safeguards are considered only those means existing or already provided for in a project that are adequately sized and in operational conditions that allow the effective prevention or mitigation of the analyzed accidental scenario.

4.15 Safety Barriers - These are all physical and non-physical means designed to prevent, control, or mitigate accidental events. Barriers include design safeguards and safety operational procedures.

4.16 Safety Critical Task - task whose execution failure or omission may cause or contribute for a major accident hazard (MAH) or may not reduce the MAH's consequences.

4.17 Safety Critical Procedures - procedures whose execution failure or omission may cause or contribute for a major accident hazard (MAH) or may not reduce the MAH's consequences.

4.18 Task Requirement Analysis (TRA) - process of undertaking a review of the tasks to be performed to identify any key HFE requirements to be taken forward for the design. The aim is to early identify any design requirements that should be met to optimize task performance and minimize any risk of unsafe operations. It is typically carried out for safety critical tasks and shall be based on Annex D of IOGP Report 454.

4.19 Valve Criticality Analysis (VCA) - process of valves categorization and prioritization according to their criticality and frequency of operation, based on an agreed priority ranking criteria. The aim is to locate valves appropriately to ensure easy access and visibility for operation or maintenance.

4.20 Vendor Package Screening and Review (VPAR) - process of identifying the critical vendor packages, based on criticality and frequency of manual interaction, and the HFE aspects of the design and layout of the unit which require special attention.

4.21 Control Room Analysis and Review (CRAR) - process of reviewing the operation of the control room, the equipment requirements, the staffing level and roles, and tasks of key operators, aiming to define the specific requirements that need to be addressed.

4.22 HMI Analysis and Review (HMIAR) - process of identifying the HF and ergonomics good practice principles and requirements for HMI design, focusing on new HMIs or modifications of existing HMIs if in case, to ensure system "usability" and reduce the potential for human error.

4.23 Alarm System Analysis and Review (AAR) - process of identifying the HF and ergonomics good practice principles and requirements for alarm systems design. The output of this process typically forms part of the wider input into HMI analysis and review.

4.24 Facility/plant Layout Design Review (DR) - design review process which takes into consideration the HF and ergonomics good practice principles and requirements for workplaces design, ensuring safe and efficient operations, accessibility to equipment, as well as enable operators to move around safely, easily, and efficiently.

5. REQUIREMENTS FOR HFE ACTIVITIES ON THE DESIGN PHASES

The focus of this section is on the application and incorporation of HF considerations to the design phases of engineering projects. Ensuring that HFE is properly addressed means that plant, systems, and equipment will be designed to effectively support operator tasks, taking account of human capabilities and limitations. This in turn reduces the likelihood of human errors and leads to improved operational efficiency.

Considering BUYER's Production Units involve complexity (in terms of technology, tasks, equipment, systems, and layout), high risks for safety, environment, asset, and Company's reputation, and the historical of known problems involving HF, based on IOGP Report 454, Annex A, this TS pre-sets that HFE strategy to be considered for BUYER's Production Units is a "High Estimated level of HF specialist input". Therefore, the HFE strategy requires:

1. designated HFE professionals of SELLER with suitable level of competence (as per the criteria of IOGP 454 described on **item 6**) to carry out and manage the HFE activities on the project.

2. integration of HF on the engineering projects, hereinafter designated as HFE.

For BUYER's Productions Units, the HFE consists on:

1. determine the scope of HFE for a given project,

2. carry out HFE analyses to support the project design process,

3. considerate HF during risk studies, including applying a quantitative HRA,

4. issue HFE recommendations to be incorporated on the design process or, if applicable, for operations phase,

5. develop HFE plan for construction,

6. manage and monitor the closeout of the HFE recommendations,

7. document the HFE activities and their results, compiling on a final documentation, the HFIP.

The following content provides information about the HFE activities required at each stage of the project design life cycle.

5.1 Phase I – Opportunity Identification

Not applicable.

5.2 Phase II – Concept Engineering

In this phase, the BUYER's HFE representative did:

1. identify the relevant HFE issues which are: task complexity, unit criticality, novelty, design scope over HFE aspects, and HFE known problems,

2. indicate the activities / areas of the project which will be applied an Ergonomic Evaluation for, based on the input of the identification of the relevant HFE issues,

3. issue a Descriptive Memorial documenting the relevant HFE issues identified and the application of the Ergonomic Evaluation.

5.3 **Phase III – Basic Engineering**

In this phase, the BUYER's HFE representative did:

4. review the standards that are proposed for the project which may include regulatory, international, national and industry standards, as well as company-specific standards and specifications,

5. develop design Technical Specifications for hull and topside with HFE standards and requirements for the development of Detailing Engineering Phases,

6. include HFE requirements on design Technical Specifications from other disciplines, such as Architecture, Cargo Handling, HVAC, Electric, Instrumentation and Mechanic, as applicable,

7. issue a Descriptive Memorial documenting the essential information for the design next phase development, including HFE standards, HFE issues to be analyzed, type of analysis and expected deliverables.

5.4 **Phase IV – Execution**

This phase is fully performed by SELLER. BUYER's HFE representative has the responsibility to review and validate the HFE activities performed by SELLER.

In this phase, the SELLER shall:

1. dedicate a qualified HFE specialist according to IOGP 454 for the HFE at Detailing Engineering and Construction phases,

2. carry out the HFE analyses (as per described on **item 7**), based on the Descriptive Memorial from Basic Engineering phase,

3. ensure HFE specialist participation on the risk studies development at the Detailing Engineering phase (HAZOP and APR) to ensure the potential for, and consequences of, human errors are considered, as well as the safety critical procedures and tasks are identified for the Production Unit (as per described on **item 8**),

4. validate the results of the risks studies with BUYER, including the safety critical procedures and tasks identified, and document the final List of Safety Critical Procedures and Tasks,

5. apply a quantitative HRA techniques (preferably Petro-HRA or alternatively CREAM, but limited to the before-mentioned techniques) to identify, for each safety critical procedure and task, the human errors, and the performance influencing factors more likely to contribute to a MAH,

6. propose safety measures to reduce contribution of human errors to a MAH for the human errors and performance influencing factors identified on the quantitative HRA as more likely to contribute to a MAH,

7. for regular operations, degraded operations and emergency situations, identify the minimum effective staff to safely perform each safety critical procedures and tasks identified for the Production Units,

8. validate with BUYER's HFE representative, potential end-users and project engineers the HFE recommendations generated from the HFE analyses, risk studies and quantitative HRA, documenting the HFE recommendations on the Ergonomic Analysis Reports,

9. review and adjust the safety critical procedures and tasks, as applicable,

10. apply specific training, involving manufactures and project team, for operators involved on the safety critical procedures and tasks, demonstrating how the human errors and performance influencing factors may contribute to a MAH,

11. apply specific training, involving manufactures and project team, for operators involved on the actuation of safety system, which is actuated manually, or which is automatic but when in failure demands human intervention for recuperation,

12. raise a management of change (MOC) for the HFE recommendations, as applicable, and manage it according to the requirements of I-ET-3000.00-5400-947-P4X-001 (Management of Change of Safety Studies),

13. implement the HFE recommendations, applicable to the Detailing Engineering and Construction phases, and the HFE requirements from design Technical Specifications issued at Basic Engineering phase,

14. document the HFE recommendations on the Ergonomic Evaluation Reports and on the Closeout Report and manage them according to the requirements of I-ET-3000.00-5400-947-P4X-002 (management of recommendations from safety studies).

The Ergonomic Analysis Report shall be issued individually per area defined on the Descriptive Memorial from Basic Engineering Phase. For the Ergonomic Evaluation Report, it can be individually per area, or one for Hull and one for Topside.

Regarding the Closeout Report, additionally to the requirements of I-ET-3000.00-5400-947-P4X-002, it shall be indicated their status and referred to the evidence of implementation. If any recommendation is addressed to Operations phase, it shall be clearly informed.

6. HFE PROFESSIONAL COMPETENCY

For BUYER's Production Units, based on IOGP Report 454, Annex B, the SELLER's HFE specialist shall have the following minimum technical qualification requirements:

- **Training requirements** – appropriate degree level qualification in HF, ergonomics, applied psychology or other relevant degree, or equivalent occupational qualification, and certified HF/Ergonomics professional,

- **Experience requirements** – five or more years' experience in application of HFE within high-hazards industries, including at least two years' experience in the energy sector.

7. HFE DESIGN ANALYSES

The HFE analyses to be carried out on a particular project may vary, based on the scope of the project and the findings from HFE issues identification. The HFE analyses required to be carried out for Production Units are:

1. task requirements analysis (TRA) according to item 8 of this document, I-ET-3010.2D-1400-196-P4X-001 – ERGONOMICS REQUIREMENTS FOR TOPSIDE, I-ET-3010.2E-1350-196-P4X-002 - ERGONOMICS REQUIREMENTS FOR HULL and I-MD-3010.2D-1200-940-P4X-008 - DESCRIPTIVE MEMORANDUM – ERGONOMICS,

2. valve criticality analysis (VCA), as described in item 6 of I-ET-3010.2D-1400-196-P4X-001 – ERGONOMICS REQUIREMENTS FOR TOPSIDE, CAE 2D and 3D Model.

3. vendor package screening and review (VPAR) as described in item 16 of I-ET-3010.2D-1400-196-P4X-001 – ERGONOMICS REQUIREMENTS FOR TOPSIDE,

4. control room analysis and review (CRAR) according to item 7 of I-ET-3010.2E-1350-196-P4X-002 - ERGONOMICS REQUIREMENTS FOR HULL, item 3.1.1 of I-MD-3010.2D-1200-940-P4X-008 - DESCRIPTIVE MEMORANDUM – ERGONOMICS, I-ET-3010.00-5520-800-P4X-001 – SUPERVISION AND OPERATION SYSTEM (SOS) SCREENS, ISO 11064

5. HMI analysis and review (HMIAR) according to I-ET-3010.00-5520-800-P4X-001 – SUPERVISION AND OPERATION SYSTEM (SOS) SCREENS,

6. alarm system analysis and review (AAR) according to I-MD-3010.2D-1200-800-P4X-002 – AUTOMATION AND CONTROL SYSTEM - SCOPE DEFINITION,

7. facility/plant layout design review (DR) according to Anex III item 8.3 of the contract and I-ET-3000.00-0000-940-P4X-003 – DESIGN REVIEW REQUIREMENTS.

These HFE analyses shall comply with the BUYER's requirements described on the I-MD-3010.2D-1200-940-P4X-008 – DESCRIPTIVE MEMORANDUM – ERGONOMICS, and with the international standards indicated for each HFE analysis on the IOGP Report 454 (Annexes D.1 to D.7).

Also, the HFE analyses shall be performed taking into consideration the risk-based management in addition to Ergonomics Work Analysis (EWA) required in I-MD-3010.2D-1200-940-P4X-008. For this reason, SELLER shall ensure these HFE analyses are performed by a multidisciplinary team, including Operation, Process Safety, Process, Electrical, Automation and Instrumentation, Piping, Naval Systems, Handling Architecture and Arrangement specialists.

SELLER shall register a technical justification if any BUYER's requirement or international standard is not applied in the project.

8. REQUIREMENTS FOR SAFETY CRITICAL PROCEDURES AND TASKS

The safety critical procedures and tasks shall be identified from the Safety Risk Studies (HAZOP and APR), based on the following criteria:

- procedures or tasks which rely on the human intervention and are considered as preventive or mitigation safeguards of major accident hazards (MAHs).

- procedures or tasks which rely on the human intervention and are considered as degradation factors of preventive or mitigation safety barriers of major accident hazards (MAHs).

- procedures which encompass operational maneuvers of critical equipment/systems whose failure or omission may have consequences with severity "IV" for people or environment or "V" for asset or reputation, based on the risks tolerability matrix indicated in Safety Guideline DR-ENGP-M-I-1.3.

- procedures which encompass operational procedures for functional tests or integrity assurance activities of critical equipment or systems.

- procedures which encompass tasks or activities which are considered as critical based on historical events, hereinafter designated as prescriptive safety critical procedures.

For BUYER's Production Units, it shall be considered the following prescriptive safety critical procedures:

- Lifeboat tests and maintenance,
- PIG launching and receiving on pipes,
- Services/intervention on high and medium voltage electric panels,
- Hydrostatic/pressurizing tests on surface equipment and piping,
- Confined space services,
- Pump room services of FPSO, FSO and FPU,
- INERGEN, NOVEC 1230 and CO_2 systems tests and maintenance,
- Cargo handling,
- Handling of plugs, caps, lubricators, etc. on pressurizing systems,
- Vapor pressurizing systems maintenance/intervention,
- Alignment maneuvers, start and shutdown of gas compression systems,
- Alignment maneuvers and intervention of pressurized drainage systems,
- Work involving toxic or asphyxiating gas/substances,
- Operation/maneuvers of HC Blanketing System.
- Actuation/intervention on safety systems.

9. REQUIREMENTS FOR HFIP

The HFIP for BUYER's Production Units consists of the compilation of the following documentation:

1. HFE Design Technical Specifications (Hull, Topside and other project disciplines),
2. Descriptive Memorial from Basic Engineering Phase,
3. Safety Risk Studies (HAZOP, APR) and Human Reliability Analysis (HRA),

4. List of Safety Critical Procedures and Tasks,
5. HFE Analyses (TRA, VCA, VPAR, CRAR, HMIAR, AAR and DR),
6. Ergonomic Technical Activities Report,
7. Ergonomic Analysis Reports,
8. Ergonomic Evaluation Reports,
9. Closeout Report.

It is required the HFIP content includes an executive summary and conclusions, as well as BUYER's approval.

10. RULES, REGULATIONS, STANDARDS AND CONVENTIONS

Human Factors/Ergonomics studies and reports shall comply, but not being limited to, with the following applicable rules and regulations:

- IOGP - International Association of Oil & Gas Producers - Report 454 - Human factors engineering in projects - Section 2 (2020),
- ISO 17776 - Petroleum and natural gas industries – Offshore production installations - Major accident hazard management during the design of new installations,
- SGSO - Resolution of the National Agency of Petroleum, Natural Gas and Biofuels - ANP No. 43/2007 - Operational Safety Management System,
- Regulatory norms of the Brazilian ministries whenever applicable, including: NR-11 (Transport, Movement, Storage and Material Handling), NR-12 (Safety in machinery and equipment), NR-17 (Ergonomics), NR-26 (Safety signs) NR-35 (Work at Height) and NR-37 (Safety and Health in Oil Platforms),
- ABS Guidance Notes for the Application of Ergonomics to Marine Systems,
- ASTM F1166-07 – Standard Practice for Human Engineering Design for Marine Systems, Equipment, and Facilities,
- EEMUA PUB NO 201 Control Rooms: A guide to their specification, design, commissioning, and operation,
- ISO 11064, Ergonomic design of control centres (all parts)
- ISA-TR101.01-2022, HMI Philosophy
- ISA-TR101.02-2019, HMI Usability and Performance

11. REFERENCE DOCUMENTS

- I-ET-3000.00-5400-947-P4X-001 – MANAGEMENT OF CHANGE OF SAFETY STUDIES,
- I-ET-3000.00-5400-947-P4X-002 – MANAGEMENT OF SAFETY STUDIES RECOMMENDATIONS,
- I-ET-3010.00-5520-800-P4X-001 – SUPERVISION AND OPERATION SYSTEM (SOS) SCREENS,
- I-ET-3010.2D-1400-196-P4X-001 – ERGONOMICS REQUIREMENTS FOR TOPSIDE,
- I-MD-3010.2D-1200-940-P4X-008 – DESCRIPTIVE MEMORANDUM – ERGONOMICS,
- I-MD-3010.2D-1200-800-P4X-002 – AUTOMATION AND CONTROL SYSTEM - SCOPE DEFINITION,
- I-ET-3010.2E-1350-196-P4X-002 – ERGONOMICS REQUIREMENTS FOR HULL.