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	CLIENT: -		SHEET: 1 de 11
	JOB: -		
	AREA: -		
SRGE	TÍTLE: LAYER OF PROTECTION ANALYSIS - LOPA		ESUP INTERNAL

INDEX OF REVISIONS

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SUMMARY

1. INTRODUCTION

Layer of Protection Analysis (LOPA) is a semi-quantitative risk assessment technique (by orders of magnitude) which its primary purpose is to determine whether the protective measures present against an accidental scenario are sufficient to reduce its risk to a tolerable level. This is basically done by assigning a frequency to the initiating cause and a probability of failure on demand (PFD) to each independent protection layer (IPL) and comparing the value of the risk thus obtained with the tolerable risk criteria.

Consequently, LOPA can provide guidance on the need for additional risk reduction against a scenario, which can be obtained by increasing the integrity of existing safeguards, new safeguards, or modifying the design of the process to make it inherently safer.

2. PURPOSE

This Technical Specification (TS) has the following purpose:

2.1. Define scope and criteria for conducting LOPA for project phase of Basic Design (when applicable), Detailing Design and Pre-Operation of Offshore Production Unit, hereinafter referred to as the Unit. This TS may optionally be used as a guide in the Operation phase of the Unit.

2.2. Guide the dynamics for the planning, development and follow up of the analysis by the parties involved and final approval thereof.

2.3. Define the model, minimum content and minimum requirements for submission of the LOPA report.

3. SCOPE

3.1. The final LOPA report shall be issued in Portuguese (Brazil). If the contractual language of the project is English, the report shall also be issued in English.

3.2. Analyzes shall be based on the data, released by Petrobras, contained in the design documentation of the Unit used as reference, according to this Technical Specification (TS).

3.3. If pending or incomplete information is identified in the project documents, prior to the LOPA or during its development, the LOPA Consulting shall request them from the Designer. These requests shall be informed to Petrobras.

3.4. The Project Designer is responsible for searching and obtain all information necessary to carry out the LOPA in administration, whether public or not, including engineering documentation, updated technical data, technical standards and applicable legislation. If the

project is executed internally at Petrobras, the department responsible for the project will have the same responsibility as the Designer.

3.5. The final report of LOPA shall contain the complete list of reference documents, indicating the revision used in the analysis. It is LOPA Leader's responsibility the verification of completeness of the list of documents.

3.6. The final LOPA report shall be submitted to formal approval by Petrobras.

4. ABBREVIATIONS AND DEFINITIONS

Abbreviations:

F^{TOL} - Tolerable Frequency

HAZOP – Hazard and Operability Analysis

LOPA - Layer of Protection Analysis

P&IDs - Process and Instrumentation Diagrams

PFD - Probability of Failure on Demand

PRD - Pressure Relief Devices

SIGEM – Sistema Integrado de Gerenciamento de Empreendimentos

TS - Technical Specification

Definitions:

4.1. Hazard - Condition or property inherent in a substance, an activity, a system or a process, with potential to cause harm to people, environment, asset or image of the Company.

4.2. Independent Protection Layer (IPL) is a safeguard capable of providing measurable risk reduction in a scenario. Therefore, the IPL shall be effective (sufficient to prevent the scenario), independent of the initiating cause and other IPLs in the same scenario (so that

neither the scenario itself nor the failure or action of another IPL can cause its failure) and auditable as to its integrity (so that it can be verified through records).

4.3. Initiating Cause is a primary equipment failure, a human error, or an external event that initiates the chain of events that can culminate in the undesired consequence.

4.4. Designer - company responsible for the elaboration of the engineering project, which may be conceptual design, basic design or executive design, being Petrobras itself or contracted company.

4.5. LOPA Consulting – Company responsible for the execution of LOPA, which may be a contracted company, either by DESIGNER or Petrobras, or an internal Petrobras department / workforce.

4.6. Recommendations - proposed measures to prevent the occurrence of the accidental event or mitigate its consequences, whenever the existing safeguards are considered insufficient.

4.7. Risk - Combination of the expected frequency of occurrence of an accidental scenario with the severity of its consequence.

4.8. Safeguard - Any device, system or action, already planned in the project or existing in the Unit, capable of interrupting the chain of events that occurs from an initiating event, reducing the probability of occurrence of the undesirable scenario (preventive) or reducing the severity of its consequences (mitigatory).

5. REFERENCE DOCUMENTATION

5.1. As inputs for the elaboration of LOPA, the following documents shall be considered, in its most up-to-date version and with status of COMMENTS ADDED or RELEASED by Petrobras at SIGEM or another electronic document management system defined in a contract. The revision of each document to be used shall be indicated in the analysis report.

a) Process Flow Diagrams.

b) Process and Instrumentation Diagrams (P&IDs).

c) Cause and Effect Matrix.

d) Process Descriptive Memorandum.

e) Process/utilities equipment data sheets.

f) General Arrangement of the Unit. Specific equipment layout of accommodations, process plant; utilities and hull compartments such as engine room, pump room, bow compartments shall also be used, if available.

g) Risk Analysis Reports already performed for the Unit, including records of the status of the recommendation's implementation.

Depending on the project phase for which LOPA is being prepared, some of the documents mentioned above may not be available. In this case, Petrobras shall be consulted about its relevance to the preparation of the study.

5.2. Other documents can be used to assist the team during the analysis. They shall be properly recorded, with their revisions, in the report.

6. REQUIREMENTS FOR THE PARTICIPATING TEAM DEFINITION

The following are the main requirements for professionals involved in LOPA:

6.1. The LOPA shall be elaborated by a multidisciplinary team involving professionals from the Designer and Petrobras. The Designer team shall be formed by professionals involved in the project and that are experienced in the area they represent, with representatives of the following disciplines: process, instrumentation/automation and control, safety, mechanics, electrical and naval*. Petrobras team may be composed of professionals from all disciplines cited or in part, however, there shall be full participation of safety, process, instrumentation/automation and control, operation, maintenance and subsea systems professionals*.

* Applicable when the analyzed system interfaces with naval or subsea systems.

6.2. The analysis leader shall have experience and training in applying LOPA methodology and in leadership of risk analysis for offshore production Units. The leader shall also have participated in at least five (5) LOPA meetings, two (2) of which as a leader in units with a similar process.

6.3. The defined LOPA team shall have composition, function and attributions performed as follows:

Table 1 - Basic composition of the LOPA team

FUNCTION	ACTIVITIES
COORDINATOR	Professional of the designer responsible for the event and who shall: · organize the team; · gather up-to-date information, such as P&IDs, general arrangement, etc. · distribute material to the team; · schedule meetings.
LOPA LEADER	Professional of the LOPA Consulting who knows the technique, responsible for: · comply with the schedule of planned meetings; · explain the technique to be employed to the other participants, facilitate meetings and define its progress status; · ask participants for pending from the previous meetings; · prior evaluation of the documentation to be used in the analysis, defining the sections to be evaluated; · preparing the final analysis report.
PARTICIPANTS	Professionals of the designers/suppliers and Petrobras, who have knowledge about the design of the unit or system to be analyzed, or experience acquired in similar systems/units.

	At least one representative from each discipline shall have at least 3 years' experience in the area they represent. Each discipline shall have a professional with this experience, not necessarily the same professional, for full-time participation during LOPA.
SPECIALISTS	Professionals from the designer, suppliers or even Petrobras who have advanced knowledge about specific equipment, technologies or systems that can participate on demand, according to the need.

7. PLANNING

Prior to the LOPA, a planning stage shall occur, when shall be defined the objectives and scope of the analysis, the schedule of the meetings, the identification of the necessary documentation, the location of the meetings and the team involved, in accordance with item 6.

In addition, invitations shall be sent and all the documentation to be used shall be previously available to the participants.

The language for conducting and recording LOPA meetings shall be defined.

During planning, all interfaces between systems shall be identified, which shall be included in LOPA scope, in order to guarantee their integrated analysis.

8. METHODOLOGY

8.1. Regarding the assumptions adopted

8.1.1. The installation and process, including associated equipment and devices considered to be safeguards and detection modes in risk scenarios have been designed and will be installed, commissioned and maintained in compliance with engineering best practices, standards and applicable technical standards.

8.1.2. Process and safety systems, equipment, and devices will be operated within design limits and will have their functionalities and performance properly maintained throughout the full life of the installation, in accordance with a maintenance plan drawn up in line with an integrity program.

8.1.3. The installation, its process equipment and safety systems will have security access that will prevent improper and/or unauthorized personnel and any changes in the characteristics of the installation or process will be properly planned and handled through change management.

8.1.4. Operators will be trained periodically in the operational procedures of the unit, which will be elaborated in accordance with industry best practices, recorded and controlled in the corporate system and kept up to date according to the recommendations of the five-year risk studies, with special emphasis on critical alarm response procedures and emergency response procedures.

8.1.5. Maintenance technicians will be trained periodically in the maintenance procedures of the systems, equipment and process and safety devices. These procedures will be elaborated in accordance with the recommendations of the manufacturers, the design and the integrity

program of the facility and will be recorded and controlled in the corporate system and kept up to date according to the recommendations of the five-year risk studies.

8.2. Selection of Scenarios for Analysis

8.2.1. Among the scenarios identified through appropriate technique (e.g. HAZOP), those that meet the objectives of the analysis shall be selected for LOPA application.

EXAMPLE 1: If the analysis aims to determine the required SIL, scenarios shall be selected where there is an automatic instrumented function (interlocking, permissive logic or control) as a safeguard or as a recommendation of the risk analysis.

EXAMPLE 2: If the analysis aims to confirm that there are no risks in the Not Tolerable region, scenarios with a risk category of Moderate IV and V or Not Tolerable shall be selected, in which there is doubt about the sufficiency of the existing layers of protection.

8.2.2. Each LOPA scenario shall have only one cause and one consequence. Cause-consequence pairs shall be obtained by combinations of the causes and consequences of each HAZOP scenario selected for LOPA application. However, it is usually unnecessary to analyze all pairs when the effectiveness of the safeguards is independent of the initiating cause and the consequence, and it is sufficient, in these cases, to perform the analysis for the highest frequency of initiating cause and the greatest severity of the consequence.

8.3. Categorization of Severity

8.3.1. Each scenario shall have its consequence analyzed regarding the potential damages to the dimensions of people, environment and asset, disregarding the existence of preventive safeguards and other means of reducing frequency, such as time of exposure to risk, probability of ignition and presence of people.

NOTE: The limitation of damages by mitigating safeguards shall also be disregarded when the LOPA aims to evaluate the effectiveness of these layers of protection.

8.3.2. The consequence of each scenario in each of the dimensions people, environment and asset shall be classified according to the PETROBRAS Risk Tolerability Matrix, annex of DR-ENGP-M-I-1.3.

8.3.3. If the severity categories of a LOPA scenario are not the same as those estimated for the corresponding scenario when it was analyzed through the application of a qualitative technique

(HAZOP), it is recommended to record the fact and the justifications as an observation in the study spreadsheet.

8.4. Tolerable Frequency (F^{TOL})

8.4.1. The tolerable frequencies for each dimension shall be determined according to the severity of the consequences of the scenario for people, environment and asset, according to the PETROBRAS Risk Tolerability Matrix, annex of DR-ENGP-M-I-1.3.

8.5. The complete methodology shall be in accordance with annex B of Petrobras standard N-2595 or other similar Petrobras standard that may replace the N-2595 in the future.

8.6. Regarding recommendations, additional comments and notes

Recommendations are proposed measures to prevent the occurrence of the accidental scenario or mitigate its consequences whenever the existing safeguards are considered insufficient.

Recommendations shall be clear understandable, concise, well-defined and preceded by action verb. Terms such as planning, designing, elaborating, identifying, specifying, installing, etc. shall be complemented by conclusive actions.

For each recommendation originating from the LOPA, the company or organization responsible for its implementation shall be identified.

The designer shall manage the implementation of these recommendations generated in the analysis, including the impact on the revision of reference documents used in the LOPA. If any recommendation is not implemented, or an alternative solution is indicated, it shall be justified and submitted to Petrobras' approval.

Observations are complementary information that can be recorded to elucidate the scenario analyzed, without, however, requiring any action.

Further comments are general or specific information that may contribute to elucidation of aspects considered in the analysis, but which do not fit as recommendations or observations.

The LOPA recommendations will be identified as LRxxx, the observations will be identified as Oxxx, where xxx corresponds to the sequential numbering.

9. REQUIREMENTS FOR LOPA MEETINGS

Meetings shall follow as described below:

9.1. Planning Meeting

The scope of this meeting is to summarize the project to be assessed, define the objectives and scope of the contracted analysis, as well as evaluate and make the necessary adjustments in the work schedule proposed by the LOPA Consulting, where the minimum agenda shall be:

- Define Petrobras, designer and leader of LOPA (preparation of list of participants to issue invitations).

- Define objectives and scope of the analysis.
- Prior analysis of all necessary documentation for the execution of the LOPA and elaboration of hold list, if any, to be completed by the Designer.
- Presentation of proposal meetings schedule by the LOPA Consulting and evaluation regarding the project schedule.
- Definition of locations, resources needed and duration of meetings.
- Participants: Representatives of Petrobras, designer and LOPA Consulting (mandatory participation of the LOPA leader).

9.2. Initial LOPA meeting and others study development meetings

At the initial LOPA meeting, the Leader shall address the following topics:

- Participants presentation.
- Presentation of analysis objective and scope.
- Presentation of the meetings schedule.
- Brief presentation of the methodology and premises.
- Short description of the Unit.
- Description of process systems.

Participants: Professionals from Petrobras, designer and LOPA Consulting (including the LOPA Leader), as defined in item 6 of this TS.

10. REPORT CONTENT

The LOPA Report shall include at least the following items:

10.1. Purpose and scope of the analysis

Description of the objectives, the scope covered by the analysis, and the structure of the report.

10.2. List of participants

The list of participants shall contain the general data of each participant (full name, company, department, position, contact email, project discipline representing and time of experience in it).

10.3. Executive summary

10.4. Introduction

The introduction shall contain the description of the Unit, description of the process plant, considering modes of operation, and any relevant aspects related to the analysis.

10.5. Justification and description of the LOPA technique

10.6. List of documents

All the documents that were used for the analysis with their respective revisions shall be listed.

10.7. Analysis Development

10.8. Assumptions defined for the analysis

10.9. List of recommendations

It shall be presented in a table to allow management of the implementation of the recommendations. It shall be listed in this table, the responsible for each recommendation (sector), phase of implementation, as well as the corresponding scenario number.

10.10. List of observations

It shall be displayed in a table, with the corresponding scenario number.

10.11. Conclusions

10.12. References used in the analysis

10.13. ANNEXES

a. Filled out LOPA worksheet
b. Documents analyzed
c. Signed presence list

The daily presence lists shall be attached, which shall be signed by the participants in each of the meetings.