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|---|---|---|---|
| PETROBRAS | **TECHNICAL SPECIFICATION** | **No.:** I-ET-3000.00-1300-98A-P4X-002 | |
| | **CLIENT:** | | **SHEET:** 1 of 16 |
| | **JOB:** | | |
| | **AREA:** | | |
| SRGE | **TITLE:** **SHIP COLLISION STUDY** | | NP-1 |
| | | | ESUP |

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## INDEX OF REVISIONS

| REV. | DESCRIPTION AND/OR REVISED SHEETS |
|---|---|
| 0 | ORIGINAL ISSUE |
| A | REVISED WHERE INDICATED |

| | REV. 0 | REV. A | REV. B | REV. C | REV. D | REV. E | REV. F | REV. G | REV. H |
|---|---|---|---|---|---|---|---|---|---|
| DATE | DEC/20/19 | JUL/06/20 | | | | | | | |
| DESIGN | ESUP | EPS | | | | | | | |
| EXECUTION | DANIELA | B79G | | | | | | | |
| CHECK | GBMATTER | NTX1 | | | | | | | |
| APPROVAL | IGORG | UP6E | | | | | | | |

# SUMMARY

## 1 INTRODUCTION

The Ship Collision Study is a consequence analysis used to evaluate the effects of possible collision scenarios of various types of ships on a Floating Production Unit (FPU) or Fixed Unit, and on certain Main Safety Functions (MSF) of this Unit. In addition to the MSF, other items considered critical to the safety of the Unit shall be evaluated, such as those described in the scope of the study and included in item 3 of this Technical Specification.

The accidental loads due to collision are estimated in this study, in order to evaluate the need for protective measures for the MSF and other critical items, as well as to evaluate their annual frequency of impairment as a result of ship collision effects.

The MSF and the items considered critical for the safety of the Facility are defined in Petrobras' Safety Engineering Guidelines (DR-ENGP-M-I-1.3). The set of MSF and critical items will henceforth be referred to as "Critical Safety Items" (CSI).

Upon the execution of the study, the requirements for analysis and management of operational risks of the National Petroleum, Natural Gas and Biofuels Agency (ANP), Ministry of Labor and Social Security, Petrobras standard N-2782 - Applicable Techniques to Industrial Risk Analysis and Petrobras' Safety Engineering Guidelines shall be followed.

This Technical Specification (TS) establishes requirements for the development of the Ship Collision Study and elaboration of its respective report, in accordance with Petrobras' Safety Engineering Guidelines, current in force on the date of signing of the contract.

## 2 OBJECTIVES

This document has following goals:

- Define scope, methodology and criteria for the execution of the Ship Collision Study for the basic design phase, Front End Engineering Design (FEED), executive project and assisted operation of the Floating Production Unit (FPU) or Fixed Unit, hereinafter referred to as the Unit. This TS may be optionally used as a guide in the operation phase of the Unit at the time of a review of the study;
- Provide guidelines for the planning, development and follow-up on the study, and its final approval by the parties involved;
- Define the standardization, content and minimum requirements for presentation of the study report.

## 3 SCOPE OF THE STUDY

The study shall assess ship collision scenarios, their frequencies of occurrence, and possible consequences for the Unit from the use of databases and mathematical equations to estimate their effects on each Unit region. From the technical analyzes performed, the following results shall be presented:

- The assessment of impacts on critical safety items (CSI), resulting from the collision effects of passing vessels, supply vessels and multipurpose vessels;
- The impairment frequency of the following CSI;
    - Embarkation stations;
    - Primary structures of riser balcony;
    - Riser lines;
    - Mooring lines;
    - Hull
- Recommendations for risk and frequency of CSI impairment reduction.

In addition to the CSI listed above, based on the project characteristics the inclusion of other critical safety items may be required, which shall be discussed and validated by Petrobras.

All evaluated CSI shall be presented in the report, with their location indicated on plans and arrangement design views, in a specific item of the report, as illustrated below:

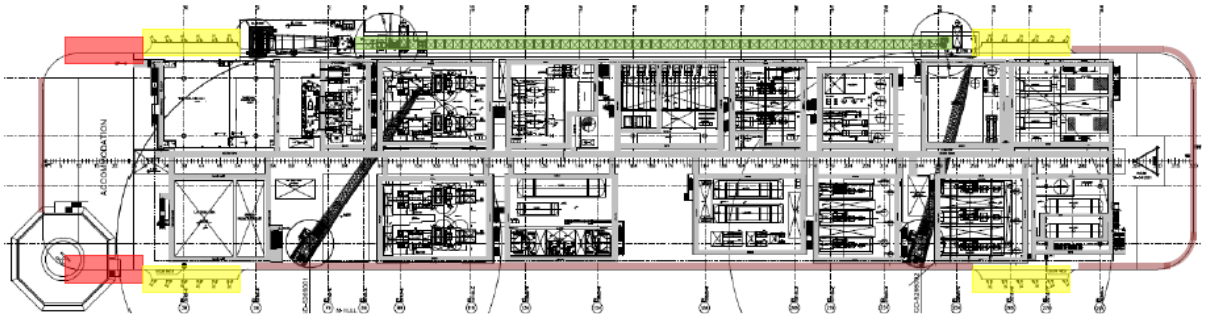

Figure 1: Example of CSI location presentation

## 4 ABBREVIATIONS AND DEFINITIONS

For the purpose of this specification, the following abbreviations and definitions shall be considered:

**Abbreviations**

CSI - Critical Safety Items

FEED - Front End Engineering Design

FEM - Finite Element Method

FPU – Floating Production Unit

MSF - Main Safety Functions

PHA – Preliminary Hazard Analysis

SIGEM - Integrated System for Project Management;

TS - Technical Specification

WOAD - World Offshore Accident Database

**Definitions**

Collision scenario - corresponds to any combination considering the type of a vessel that may collide with the Unit, collision condition and vessel displacement (mass);

Critical Safety Items (CSI) - items of the Unit that shall be maintained intact and functional at all times in order to perform their safety function for a certain period of time during an emergency situation. It includes the Main Safety Functions (MSF) and other critical items defined in the Safety Engineering Guidelines;

Designer - Company responsible for the execution of the engineering project such as conceptual project, basic project, FEED or executive project, being Petrobras itself or outsourced company hired to carry out the project;

Flotel - Platform with dynamic positioning that connects through a gangway to an operating FPU or Fixed Unit allowing people residing in the flotel to perform services on the Unit, on a daily basis, returning to flotel for their rest time;

In-field Vessels - Vessels that periodically attend the Unit, with purpose to meet operational needs of the Unit, such as: shuttle tankers, supply vessels, tugboats, flotels, rigs, among others;

Main Safety Function (MSF) - Function that a safety system, device or safety barrier shall fulfill to enable and/or guarantee the effectiveness of the emergency response strategy, escape and abandonment of the Unit during an accidental event. These functions are defined in Petrobras' Safety Engineering Guidelines and shall remain available for a period of one (1) hour after the beginning of the event;

Passing Vessels - Commercial, fishing, recreational, naval and offshore vessels not related to operations of the Unit;

Study Consulting - Responsible for the execution of Ship Collision Study. Study Consulting may be an outsourced company hired by either the Designer or Petrobras, or it can be the Designer itself or an internal Petrobras workforce;

Parties Involved – Includes the parties involved in the execution or follow-up on the Ship Collision Study: the Designer, the Study Consulting and Petrobras.

## 5 REFERENCE DOCUMENTATION

As an input to the execution of the study, the following documents shall be considered, in their most up-to-date version and with RELEASED or RELEASED WITH COMMENTS status by Petrobras in SIGEM or another electronic document management system defined in contract.

a) Preliminary Hazard Analysis (PHA):
b) General arrangement of the Unit;
c) Updated 3D model of the Unit (optional);
d) Metocean data;
e) Safety Plan indicating the MSF;
f) Reports of Risk Studies already performed for the Unit, in special the PHA;
g) Equipment list and equipment data sheets;
h) Mooring Plan;
i) Subsea arrangement;
j) Midship Section;
k) Arrangement drawings of the riser balcony, indicating the positioning of the oil and gas risers.

The review of each document used in the development of the study shall be clearly indicated in the study report.

## 6 RELEVANT ASPECTS OF THE STUDY

The Ship Collision Study shall consider at least the following aspects that influence collision frequency and consequence calculations:

- Data from the Unit under analysis, according to project documentation;
- Ship traffic data in the region where the Unit is located;

- Data of approach and operation of in-field vessels with the Unit (eg: operating side, operating distance, approach speed);
- Data of approach and operation of in-field vessels with other Units located in the same region of the Unit under analysis;
- Relevant technical characteristics of in-field vessels and passing vessels (e.g. provision of a dynamic positioning system);
- Impact energies to be considered to prevent CSI impairment.

## 7 SOFTWARE REQUIREMENTS

If there is a need for the use of collision modeling tools using finite element method (FEM), ANSYS or ABAQUS software may be applied. Any other software specific for the execution of the study shall be submitted to Petrobras for prior validation.

## 8 METEOROLOGICAL CONDITIONS

The meteorological conditions to be used in the study shall be those of the final location of the Unit. The use of meteorological data in the study shall comply with the requirements from Safety Engineering Guidelines. In the study report a table with the data of wind (direction and speed), wave (direction, height and period) and current (direction and speed) shall be presented.

The most frequent values for wind speed shall be obtained from the weighted average of the most frequent wind speeds in each of the eight or sixteen directions, according to metocean data of the region. The weighting is performed by the number of occurrences of each most frequent speed considered in the calculation. When frequency values or number of occurrences are provided by intensity ranges, the average value of the range shall be used.

## 9 STUDY METHODOLOGY

The methodology to be adopted for the Ship Collision Study shall meet the requirements as specified in this TS, in accordance with the Safety Engineering Guidelines.

Any deviation from the methodology shall be submitted to Petrobras for evaluation and prior validation.

Based on the data listed in items 5 and 6, the following steps shall be performed in the development of the study:

- Selection of scenarios;
- Frequency analysis;
- Consequence analysis;
- Analysis of the frequency of CSI impairment.

### 9.1 Selection of scenarios

The selection of scenarios for Ship Collision Study shall be carried out by analyzing interaction of ships with the facility, having as a source of information the history of ship collisions that occurred in Petrobras, the World Offshore Accident Database (WOAD) or other recognized databases and previously approved by Petrobras.

Scenario selection shall also consider accidental collision scenarios identified in the Preliminary Hazard Analysis (PHA) with respect to their risk ranking. Scenarios whose risk categorizations for the "People" or "Asset" are classified as Moderate with severity categories IV or V, and Non Tolerable scenarios (for any severity category and any aspects evaluated – people, assets, environment,

reputation) shall be considered in the study. Risk ranking follows the Risk Tolerability Matrix as per Petrobras Standard N-2782 - Applicable Techniques to Industrial Risk Analysis.

The study shall consider accidental collision scenarios that can generate damages that compromise the functionality of critical safety items, covering at least the following types of vessels and collision conditions:

- Types of vessels:
  - Supply boats;
  - Shuttle tankers;
  - Tugboats;
  - Flotel;
  - Rigs;
  - Passing vessels;
  - Fishing vessels.
    Note: Other types of vessel may be included, whenever applicable.

- Collision conditions (in traffic, normal operation and approach):
  - In traffic: Collision of vessels passing near the Unit;
  - In normal operation; Collision of vessels during operations;
  - In approach: Collision of vessels during approaching or leaving the Unit.

## 9.2 Additional Scenarios

Accidental scenarios that have not previously been evaluated in the PHA, identified during the course of the study but which are categorized as relevant as described in item 9.1, shall also be considered in the analysis, as well as scenarios resulting from changes in design and operational changes.

## 9.3 Frequency Analysis

The collision frequency is one of the determining factors for the risk of ship collision for production units. This information shall be presented in a clear and objective format in tables containing the frequency values for each collision scenario identified in the previous item.

Collision frequency values can be estimated based on historical data or calculated using equations. In case of use of historical data, its sources and the region considered in the database shall be informed in the report. In case the region considered for the historical data is not the same of the Unit under study, justification shall be provided. When the collision frequencies are calculated by equations, the calculation memory for each of the collision scenarios and the sources of the equations shall be presented in the report.

Fault trees used to determine the collision frequency shall be presented, considering the main possible causes of failure for each type of vessel and collision condition. Figure 2 below shows an example of a simplified fault tree for supply vessels in normal operating condition:

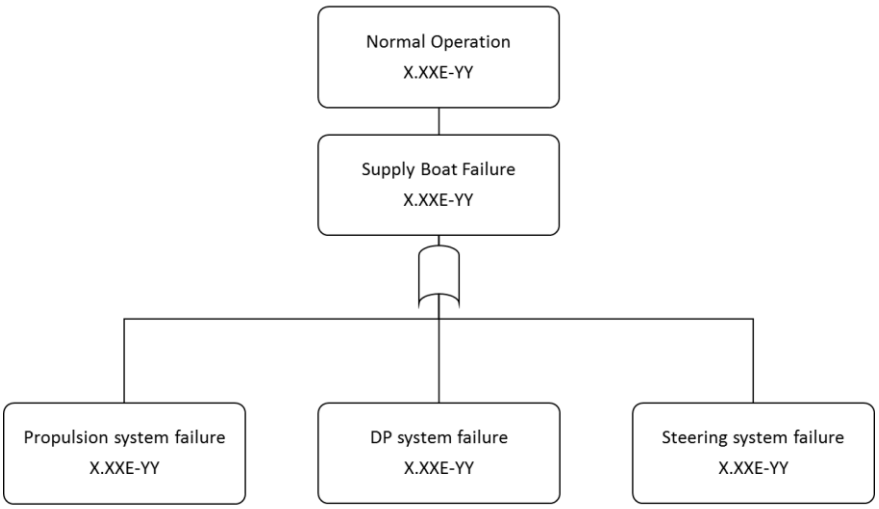


Figura 2: Fault Tree

Collision frequency calculations shall consider vessel traffic within a 10 nautical mile radius.

## 9.4 Classification of collision frequencies

The collision frequency shall be calculated and classified for each collision scenario. In the frequency analysis item of the report, a table with minimum information from Table 1 below shall be presented:

Table 1: Collision Frequency

| TYPE OF VESSEL | CONDITION | | VESSEL DISPLACEMENT (ton) | VISITS OR TRAFFIC (Occ./year) | COLLISION FREQUENCY (Occ./year) |
|---|---|---|---|---|---|
| Supply Vessel | In normal operation | | Note 1 | Note 2 | Note 3 |
| | In approach | | Note 1 | Note 2 | Note 3 |
| | In traffic | | Note 1 | Note 2 | Note 3 |
| Shuttle tanker | In normal operation | Loaded | Note 1 | Note 2 | Note 3 |
| | | Unloaded | Note 1 | Note 2 | Note 3 |
| | In approach | Unloaded | Note 1 | Note 2 | Note 3 |
| | In traffic | Loaded | Note 1 | Note 2 | Note 3 |
| | | Unloaded | Note 1 | Note 2 | Note 3 |
| Tugboat | In normal operation | | Note 1 | Note 2 | Note 3 |
| | In approach | | Note 1 | Note 2 | Note 3 |
| | In traffic | | Note 1 | Note 2 | Note 3 |
| Flotel | In normal operation | | Note 1 | Note 2 | Note 3 |
| | In approach | | Note 1 | Note 2 | Note 3 |
| | In traffic | | Note 1 | Note 2 | Note 3 |
| Rigs | In normal operation | | Note 1 | Note 2 | Note 3 |
| | In approach | | Note 1 | Note 2 | Note 3 |
| | In traffic | | Note 1 | Note 2 | Note 3 |
| Passing vessels | In traffic | | Note 1 | Note 2 | Note 3 |
| Fishing vessels | In traffic | | Note 1 | Note 2 | Note 3 |

Note 1: For ship displacement, depending on each type of vessel and condition, as many values as necessary shall be included in the table.
Note 2: Include the number of vessel visits to the Unit or traffic within 10 nautical miles, as applicable.
Note 3: Include the collision frequency calculated according to item 9.2 of this TS.

## 9.5 Confidence limits

It is preferable to present the confidence limits along with the collision frequency values for each collision scenario. As a reference, see the figure below with confidence limits for collision frequencies, sorted by type of Unit [1].

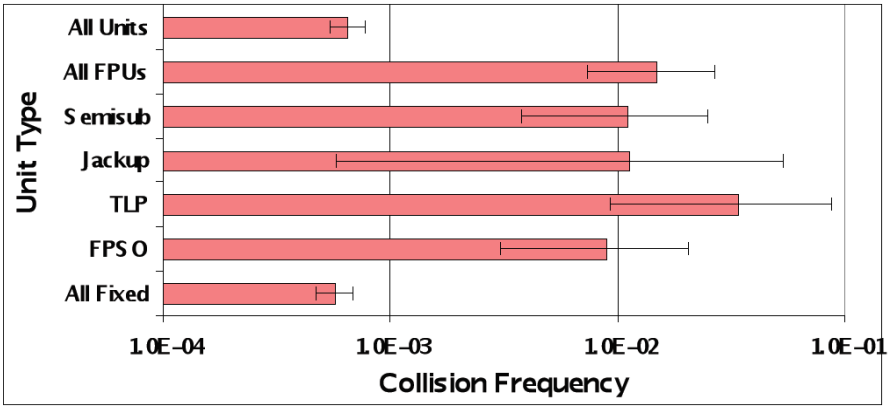


Figure 3: Confidence limits (source: OGP)

## 9.6 Consequence Analysis

Since all vessels that can collide with the Unit have different mass and geometry, just as those collisions may occur at different speeds, a categorization of the kinetic energies generated by type of vessel and collision condition is required.

An impact energy table considering the type of vessel, collision condition, ship displacement, speed and impact energy (bow or stern / lateral) shall be presented. Table 2 below illustrates a model for presenting the data.

Table 2: Impact Energy Results

| TYPE OF VESSEL | CONDITION | | VESSEL DISPLACEMENT (ton) | SHIP SPEED (Knots) | IMPACT ENERGY (MJ) | |
|---|---|---|---|---|---|---|
| | | | | | Bow or stern | Lateral |
| Supply Vessel | In normal operation | | Note 1 | Note 2 | Note 3 | NA |
| | In approach | | Note 1 | Note 2 | Note 3 | NA |
| | In traffic | | Note 1 | Note 2 | Note 3 | NA |
| | Drifting | | Note 1 | Note 2 | Note 3 | Note 4 |
| Shuttle tanker | In normal operation | Loaded | Note 1 | Note 2 | Note 3 | NA |
| | | Unloaded | Note 1 | Note 2 | Note 3 | NA |
| | In approach | Unloaded | Note 1 | Note 2 | Note 3 | NA |
| | In traffic | Loaded | Note 1 | Note 2 | Note 3 | NA |
| | | Unloaded | Note 1 | Note 2 | Note 3 | NA |
| Tugboat | In normal operation | | Note 1 | Note 2 | Note 3 | NA |
| | In approach | | Note 1 | Note 2 | Note 3 | NA |
| | In traffic | | Note 1 | Note 2 | Note 3 | NA |
| | Drifting | | Note 1 | Note 2 | Note 3 | Note 4 |
| Flotel | In normal operation | | Note 1 | Note 2 | Note 3 | NA |
| | In approach | | Note 1 | Note 2 | Note 3 | NA |
| | In traffic | | Note 1 | Note 2 | Note 3 | NA |
| | Drifting | | Note 1 | Note 2 | Note 3 | Note 4 |
| Rigs | In normal operation | | Note 1 | Note 2 | Note 3 | NA |
| | In approach | | Note 1 | Note 2 | Note 3 | NA |
| | In traffic | | Note 1 | Note 2 | Note 3 | NA |
| Passing vessels | In traffic | | Note 1 | Note 2 | Note 3 | NA |
| Fishing vessels | In traffic | | Note 1 | Note 2 | Note 3 | NA |

Note 1: For ship displacement, depending on each type of vessel and condition, as many values as necessary shall be included in the table.
Note 2: Include ship speed.
Note 3: Include the impact energy from the bow or stern of the vessel reaching the Unit.
Note 4: Include the impact energy from the side of the drifting vessel reaching the Unit.
NA: Not Applicable

The impact energy by collision of vessels, indicated in Table 2 above, can be expressed as:

$$E = \frac{1}{2}\, a.m.V^2 \quad (kJ)$$

Where:

a = hydrodynamic added mass [1.1 for bow or stern collision and 1.4 for sideways impact with drifting vessels]

m = vessel displacement (ton)

V = impact speed, (m/s)

## 9.7 Analysis of the CSI impairment frequency

Based on the collision frequency for the various types of vessel with the Unit and on the consequences analysis, it is necessary to calculate the impairment frequency for the CSI described in item 3 of this TS.

The impairment frequency of a CSI is the sum of the collision frequencies (corrected by the geometric factor) whose impact energies are higher than the impact energy to which the CSI resists. The definition of the energy each CSI resists shall be validated with Petrobras in the meeting for discussion of premises and methodology (see item 10.4).

Note: Geometric factor represents the fraction of the length of the region occupied by the CSI on the perimeter of the Unit exposed to collision.

In order to evaluate the impairment of the hull structure, in the absence of specific information of the project under study, the impact energy corresponding to the hull strength shall be assumed to be:

- For stern or bow impact: 11 MJ [ref. 2]
- For side impact: 14 MJ [ref. 2]

In the case of Jackets, in the absence of specific information from the project under study, the limiting energy of impact resistance of 4 MJ can be considered, according to HSE recommendations [ref. 3].

For the mooring lines, in the absence of specific information from the project under study, the 8 MJ impact resistance limit energy corresponding to the loss of two mooring lines can be considered.

When it is not possible to define a resistance limiting energy for the CSI, it shall be considered that, in the event of a collision, there will be loss of functionality for the CSI. In this case, the impairment frequency of the CSI shall be considered equal to the collision frequency (corrected by the geometric factor).

A table according to the example indicated in Annex A shall be presented.

The impairment frequency for each CSI shall be compared with the tolerability criterion established for the accidental load – ship collision, according to the Safety Engineering Guidelines. If the impairment frequency exceeds the criterion, adequate risk reduction measures shall be evaluated and recommended.

# 10 REQUIREMENTS FOR FOLLLOW-UP MEETINGS

The meetings for the follow-up on the study shall follow the guidelines below.

## 10.1 General

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

The follow-up meetings shall be held in the premises of Study Consulting, with an exception of the planning meeting, which shall be carried out at Designer's premises. The meeting venue may be amended by common agreement among the parties involved. Petrobras' participants may attend meetings by videoconference.

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

All validation decisions (of premises, of data, of geometry among others) shall be included in the final study report as an annex. The validations shall be signed by the representatives of each party involved.

## 10.2 Planning Meeting

The meeting for a brief presentation of the project shall have at least the following scope:

- Safety briefing - (by Designer);
- Presentation of the project for Study Consulting - (by Designer);
- Clarifications on objectives, scope of analysis and requirements for the study (by Designer and Petrobras);
- Delivery of the project documentation and data relevant to the analysis, as provided in items 5 and 6 of this TS (by Designer), including the 3D model of the Unit, when applicable;
- Sizing the teams of Designer and Study Consulting that will participate in the execution and follow-up on the study, with definition of the matrix of responsibilities;

- Presentation of the focal points of each involved party and identification of the responsible for each discipline from each involved party that will participate in the follow-up meetings and the validations required in this TS. The following disciplines shall be considered as a minimum: Safety, Naval and Structures;
- Presentation of planned schedule for the execution of the study in accordance with project schedule (by Study Consulting and Designer);
- Definition of locations, resources needed and duration of follow-up meetings (by Designer and Study Consulting).

Meeting participants: The focal points of the parties involved, representatives of Study Consulting and discipline leaders from Designer responsible for the follow-up on the study.

Note: The schedule shall include twenty working days for comments on the reports (partial and final) by Petrobras, as well as the time needed for implementing those comments.

### 10.3 Project Documentation Analysis

The purpose of this meeting is to analyze and validate the project documentation required for the development of the Study. In this meeting a list of pending items shall also be prepared, with the objective of avoiding errors and reworking in the studies, due to possible failures or omissions of information in the documentation which is input data for carrying out of the study.

From the analysis of the documents provided, and considering the document list for the project, Study Consulting may request clarification and clarify questions about the information from the documents. In case of identification of pending documents or the need to provide other documents, Designer shall inform the deadline for resolving the pending issues and/or sending the documents, in a way that does not affect the schedule of the study.

In the following meeting, Study Consulting shall sign terms of acceptance containing the list of pending items, if any.

Note: Designer, as responsible for the management of changes for the project, shall inform the parties involved about any change in the project that impacts the study. Documents modified as a result of the changes affecting the study shall be sent to Study Consulting.

Study Consulting shall evaluate the changes and inform the impacts of the changes on the analysis and schedule. This information shall be formally sent to Designer and communicated to Petrobras.

Meeting participants: Representatives from Study Consulting and discipline leaders from Designer responsible for the follow-up on the study. Petrobras' participation in this meeting is optional.

### 10.4 Assumptions and Methodology Meeting

The purpose of this meeting is to present and define assumptions to be used in the study, clarification of the methodology and confirmation of basic data of the Unit.

Study Consulting shall present the proposed assumptions for the development of the study and its questions about the methodology proposed in this TS. The questions shall be clarified by Designer with participation of Petrobras.

This meeting aims, among other goals, to validate the collision scenarios to be considered and the impact energies that cause impairment of CSI, and also to consolidate the assumptions defined in this TS, and any additional premise not covered by this TS and Safety Engineering Guidelines.

Assumptions shall be defined by mutual agreement among the parties involved and shall be included in the study report.

In addition to the assumptions and methodology, the Designer shall confirm the basic information for the beginning of the study, such as meteorological conditions, confirmation of the heading and positioning coordinates of the Unit, risers arrangement (submarine and surface - arrangement of risers

balcony) and the CSI that shall be evaluated in the study. The information shall be confirmed or amended by Petrobras.

Meeting participants: Representatives from Study Consulting, discipline leaders from Designer and Petrobras' representatives who are responsible for the follow-up on the study.

### 10.5 Follow-up and Validation Meetings

The purpose of these meetings is to follow-up on the study by Designer with the participation of Petrobras, when the requirements stated in the methodology shall be addressed.

Designer, in agreement with Study Consulting and considering the schedule for the study, shall present the agenda of meetings to monitor development of the study. The meetings shall contemplate the study steps foreseen in item 9 of this TS (Methodology). Follow-up and validation meetings, at minimum, shall be provided as per Table 1 below:

Table 3: Follow-up and validation meeting

| Item | Minimum Agenda | Ref. |
|---|---|---|
| R1 | **Presentation of Partial Report:** Presentation and discussion of the scenarios considered, the calculations of frequency analysis and consequence analysis. | Item 9 |
| R2 | **Presentation of Final Report** (preliminary version), including conclusions and recommendations in addition to the items already presented in meeting R1. | Item 9 |

The number of meetings may be altered by mutual agreement among the parties involved, provided that all items that compose the methodology and those which require validation are addressed, study outputs are analyzed and recommendations from the study are evaluated for their applicability to the project.

Meeting participants: Representatives from Study Consulting, discipline leaders from Designer and Petrobras representatives who are responsible for the follow-up on the study.

### 10.6 Final Report Presentation Meeting - Preliminary Version

This meeting is to present the final report (preliminary version) before its release to Petrobras. The final report is under the responsibility of the Designer and shall be issued by him. The final report shall include the report issued by Study Consulting and the treatment of the study recommendations to be implemented in the project by Designer. The codification of the report and its stamp shall identify the Designer as author of the document. The report coding shall be in accordance with Petrobras standard N-1710 - Coding of Technical Engineering Documents, and the format in accordance with N-381 - Execution of Drawing and Other General Technical Documents.

The presentation shall focus on the main accidental scenarios, main findings, conclusions and recommendations from the study. The treatment given to each of the study recommendations shall be addressed in this meeting.

Meeting participants: Representatives from Study Consulting, discipline leaders from Designer and Petrobras representatives who are responsible for the follow-up on the study. The participation of operations representative is recommended for this meeting.

## 11 STUDY REPORTS

The final report shall be issued in Portuguese and English. The report shall meet the content required in the Safety Engineering Guidelines and the one specified in this document.

All simplification assumptions and assumptions adopted for the study execution shall be presented and explained in the report. In addition, the minutes of the meetings shall be annexed to the report, especially those for validation of methodology steps. The charts and figures of the reports shall be presented with the respective scales, legends and the winds rose with indication of predominant wind direction. For elaboration of the tables, graphs and figures, the units of the International System of Units shall be applied.

All charts and figures that support the conclusions and recommendations of the study shall be presented in the final report.

### 11.1 Partial Report

At least one partial report shall be submitted by Study Consulting to Petrobras for acceptance prior to the release of the final report.

The Partial Report shall contain the following, at least:

- Goals;
- Premises;
- 3D model, geometry and mesh, when applicable;
- Analyzed scenarios (item 9.1);
- Frequency Analysis (item 9.2);
- ConsequencesAnalysis (item 9.3);
- Analysis of the CSI impairment frequency (item 9.4);
- Conclusions and recommendations.

### 11.2 Final Report

The Final Report corresponds to the release of the report under review 0. It shall include all the requirements from item 11.1, take into account the comments made to the Partial Report, and additionally contain:

- Minutes of meeting presented as an Annex of the report (item 10.1);
- Checklist presented as an Annex of the report (item 14);

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

## 12 DEADLINES

The deadlines required for the study and the release of the partial and final reports shall be defined by Designer, in agreement with Study Consulting, taking into account the complexity of the project, the scope of the study and the deadlines established in the contract. These deadlines shall be included in the schedule mentioned in item 10.2 of this TS.

## 13 TRAINING FOR CARRYING OUT OF THE STUDY

The study shall be performed by a qualified company pertaining to Petrobras' pre-approved list of suppliers and outsourced companies.

## 14 APPLICATION OF THE CHECKLIST

Designer shall provide a checklist of the follow-up on Study Consulting’s activities, which shall be included as an annex to the report. The checklist shall contain the requirements of this TS. The verification of each requirement shall have the identification and signature of the person in charge of the verification.

## 15 INFORMATION PROTECTION

Designer and Study Consulting shall have a data protection system to guarantee the integrity, reliability, traceability, confidentiality and inviolability of the data contained in the analysis and the data provided by Petrobras. All information shall be protected against accidental or information security events for at least five years.

## 16 REFERENCES

[1] OGP Risk Assessment Data Directory - Ship/installation collisions – report 434-16, March 2010.

[2] DNV-OS-A101, Safety Principles and Arrangements, April 2011

[3] Offshore Installations: Guidance on Design, Construction and Certification, Fourth Edition, UK Health & Safety Executive, London, 1990 – withdrawn June 1998 (ref. HSE Operations Notice, ON27). Technical guidance republished in Offshore Technology Report Series. OTO 2001 013, 'Loads', available from www.hse.gov.uk/research/otopdf/2001/oto01013.pdf, includes vessel collision information.

# ANNEX A - TABLE FOR CSI IMPAIRMENT FREQUENCY

| TYPE OF VESSEL | CONDITION | | VESSEL DISPLACEMENT | COLLISION FREQUENCY | IMPACT ENERGY | MAIN STRUCTURE – RISER BALCONY | | RISER LINES | | MOORING LINES | | HULL | | EMBARKATION STATIONS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (ton) | (occ./year) | (MJ) | Geometric Factor | Impairment Frequency | Geometric Factor | Impairment Frequency | Geometric Factor | Impairment Frequency | Geometric Factor | Impairment Frequency | Geometric Factor | Impairment Frequency |
| Supply Vessel | In normal operation | | Note 1 | Note 2 | Note 3 | | Note 5 | | Note 5 | | Note 5 | | Note 5 | | Note 5 |
| | In approach | | Note 1 | Note 2 | Note 3 | | Note 5 | | Note 5 | | Note 5 | | Note 5 | | Note 5 |
| | In traffic | | Note 1 | Note 2 | Note 3 | | Note 5 | | Note 5 | | Note 5 | | Note 5 | | Note 5 |
| Shuttle tanker | In normal operation | Loaded | Note 1 | Note 2 | Note 3 | | Note 5 | | Note 5 | | Note 5 | | Note 5 | | Note 5 |
| | | Unloaded | Note 1 | Note 2 | Note 3 | | Note 5 | | Note 5 | | Note 5 | | Note 5 | | Note 5 |
| | In approach | Unloaded | Note 1 | Note 2 | Note 3 | | Note 5 | | Note 5 | | Note 5 | | Note 5 | | Note 5 |
| | In traffic | Loaded | Note 1 | Note 2 | Note 3 | | Note 5 | | Note 5 | | Note 5 | | Note 5 | | Note 5 |
| | | Unloaded | Note 1 | Note 2 | Note 3 | | Note 5 | | Note 5 | | Note 5 | | Note 5 | | Note 5 |
| Tugboat | In normal operation | | Note 1 | Note 2 | Note 3 | | Note 5 | | Note 5 | | Note 5 | | Note 5 | | Note 5 |
| | In approach | | Note 1 | Note 2 | Note 3 | Note 4 | Note 5 | Note 4 | Note 5 | Note 4 | Note 5 | Note 4 | Note 5 | Note 4 | Note 5 |
| | In traffic | | Note 1 | Note 2 | Note 3 | | Note 5 | | Note 5 | | Note 5 | | Note 5 | | Note 5 |
| Flotel | In normal operation | | Note 1 | Note 2 | Note 3 | | Note 5 | | Note 5 | | Note 5 | | Note 5 | | Note 5 |
| | In approach | | Note 1 | Note 2 | Note 3 | | Note 5 | | Note 5 | | Note 5 | | Note 5 | | Note 5 |
| | In traffic | | Note 1 | Note 2 | Note 3 | | Note 5 | | Note 5 | | Note 5 | | Note 5 | | Note 5 |
| Rigs | In normal operation | | Note 1 | Note 2 | Note 3 | | Note 5 | | Note 5 | | Note 5 | | Note 5 | | Note 5 |
| | In approach | | Note 1 | Note 2 | Note 3 | | Note 5 | | Note 5 | | Note 5 | | Note 5 | | Note 5 |
| | In traffic | | Note 1 | Note 2 | Note 3 | | Note 5 | | Note 5 | | Note 5 | | Note 5 | | Note 5 |
| Passing vessels | In traffic | | Note 1 | Note 2 | Note 3 | | Note 5 | | Note 5 | | Note 5 | | Note 5 | | Note 5 |
| Fishing vessels | In traffic | | Note 1 | Note 2 | Note 3 | | Note 5 | | Note 5 | | Note 5 | | Note 5 | | Note 5 |
| | | | TOTAL IMPAIRMENT FREQUENCY FOR THE CSI: | | | **Note 6** | | **Note 6** | | **Note 6** | | **Note 6** | | **Note 6** | |

Note 1: For ship displacement, depending on each type of vessel and condition, as many values as necessary shall be included in the table.
Note 2: Include the collision frequency calculated according to item 9.2 of this TS.
Note 3: Include the impact energies calculated according to item 9.3 of this TS.
Note 4: Include the geometric factor considered for each CSI. Geometric factor represents the fraction of the length of the region occupied by the CSI on the perimeter of the facility exposed to the collision.
Note 5: Include the impairment frequency for the CSI considering each collision scenario. This value is the result of the collision frequency multiplied by the geometric factor.
Note 6: Include the total sum of the calculated impairment frequencies for the CSI. This value represents the total impairment frequency of the CSI considering the accidental load – ship collision.