PETROBRAS	**TECHNICAL SPECIFICATION**	No. I-ET-3000.00-1200-98A-P4X-001	
	CLIENT: -		SHEET: 1 of 12
	JOB: -		-
	AREA: -		
SRGE	TITLE: **NOISE AND VIBRATION STUDY**		INTERNAL
			ESUP

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INDEX OF REVISIONS

REV	DESCRIPTION AND/OR REVISED SHEETS
0	ORIGINAL
A	REVISED WHERE INDICATED
B	REMOVAL OF REFERENCES TO STANDARDS N-0381 AND N-1710. REVISION MARKS IN YELLOW REFER TO CHANGES IN REVISION “B” AND REVISION MARKS IN GRAY REFER TO CHANGES IN REVISION “A”.
C	REVISED WHERE INDICATED
D	REVISED ITEM 10
E	REMOVED ITEM 10

	REV. 0	REV. A	REV. B	REV. C	REV. D	REV. E	REV. F	REV. G	REV. H
DATE	DEC/17/19	OCT/29/20	OCT/30/20	NOV/10/20	NOV/13/20	NOV/18/20			
DESIGN	ESUP	ESUP	ESUP	ESUP	ESUP	ESUP			
EXECUTION	ERNANI	CXLB	CXLB	CXLB	CXLB	UPF8			
CHECK	IGORG	UPF8	UPF8	UPF8	UPF8	UQX8			
APPROVAL	PAOLO	CXM6	CXM6	CXM6	CXM6	CXM6			

SUMMARY

1 OBJECTIVE

1.1 The Noise and Vibration Study is a predictive analysis of noise and vibration levels for both operational areas and acoustic classified areas/rooms of the UNIT. The main purpose of this analysis is to identify the areas/rooms where noise and vibration levels exceed certain limits, and to recommend changes that can reduce these levels to acceptable values.

1.2 The following actions can be taken on the design due to the Study results:

- Determine the areas/rooms where noise levels exceed the limits and provide adequate signaling to those areas;
- Determine the acoustic performance levels (transmission losses/attenuation) required for bulkheads, floors and lining in general;
- Identify the equipment and valves that contribute most to non-compliance with the required levels;
- Rearrange the position of equipment in order to reduce the noise and vibration levels when required;
- Identify the required measures in order to reduce noise and/or vibration levels in equipment and valves.

1.3 This specification has the following goals:

- Define scope, methodology and criteria for the execution of Noise and Vibration Study for the Basic Design, Front End Engineering Design (FEED) and Detailed Engineering Design of the UNIT;
- 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.

2 DEFINITIONS AND ABBREVIATIONS

2.1 Definitions

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

2.2 Additional Definitions

- **DESIGNER**

Company responsible for the execution of the Engineering Design such as Conceptual Design, Basic Design, FEED, or Detailed Engineering Design, being the OWNER itself or an outsourced company hired to carry out the design;

- **PARTIES INVOLVED**

Parties involved in the execution or follow-up on the Noise and Vibration Study: DESIGNER, STUDY SUPPLIER, and OWNER;

- **STUDY SUPPLIER**

Company responsible for the execution of the Noise and Vibration Study. STUDY SUPPLIER may be an outsourced company hired by either DESIGNER or OWNER, or it can be the DESIGNER itself or an in-house OWNER department.

2.3 Abbreviations

AVM	Anti-Vibration Mounting
BDV	Blowdown Valve
FEED	Front End Engineering Design
FORM I/II	Forms with acoustic data of the equipment to be filled out by MANUFACTURER
HVAC	Heating, Ventilation and Air Conditioning

LEQ Equipment List
NR Brazilian Government Regulation
SPL Sound Pressure Level, in dB
SPW Sound Power Level, in dB
TL Transmission Loss

3 SCOPE OF THE STUDY

3.1 The Study shall assess the noise and vibration levels in the operational areas and acoustic classified areas/rooms according to NOISE CONTROL REQUIREMENTS [document supplied by OWNER].

3.2 For the determination of noise, both airborne noise (airborne propagation) and the structure-borne noise shall be considered.

3.3 All components that contribute to the noise level shall be included in the analysis, such as but not limited to machinery, piping, valves, and HVAC (equipment and ducts).

4 NORMATIVE REFERENCES

The Study shall comply with the requirements of this technical specification, documents as stated below and with those referred to herein. Any conflict between the requirements of this specification and related codes and standards, regulations, specifications, etc. shall be presented in writing for OWNER's resolution.

4.1 Government Regulations

Government regulations shall be fully complied with, including its annexes:

NR-15 Brazilian Government Regulation – Norma Regulamentadora Nº 15, Atividades e Operações Insalubres
NR-17 Brazilian Government Regulation – Norma Regulamentadora Nº 17, Ergonomia
NR-37 Brazilian Government Regulation – Norma Regulamentadora Nº 37, Segurança e Saúde em Plataformas de Petróleo

Brazilian Government regulations are mandatory and shall prevail, if more stringent, over the requirements of this specification and other references herein. STUDY SUPPLIER shall comply with any other government regulations stated in the Contract and not listed above.

4.2 Project Documents

The latest revision of the following documents shall be fully complied with. The document identification number may vary according to the project. The document title may also vary slightly from one project to another. Project's DOCUMENT LIST shall be consulted in order to verify the correct document number and title.

- NOISE CONTROL REQUIREMENTS;
- DOCUMENT LIST;
- EQUIPMENT LIST (LEQ);
- ARRANGEMENT DRAWINGS;
- 3D MODEL OF THE UNIT;
- ARCHITECTURAL DRAWINGS (ARRANGEMENT AND ISOLATION PLAN);
- EQUIPMENT DATA SHEETS, WITH FORM I/II ANNEXED;
- MONITORING POINTS FOR THE PURPOSE OF VIBRATION ANALYSIS;
- HVAC ARRANGEMENT DRAWINGS;
- STRUCTURE DRAWINGS;
- ENVIRONMENTAL DATA SPECIFICATION.

The Study report shall clearly identify the revision of each document used in the development of the Study.

5 SOFTWARE REQUIREMENTS

The Study shall be developed using calculation tools that may be commercially available software or developed by an organization recognized by its technical competence. OWNER shall previously approve the calculation tools selected for the Study. STUDY SUPPLIER shall provide a reference list presenting the use of the proposed software in similar applications to serve as an input for OWNER analysis and approval for use.

6 STUDY METHODOLOGY

6.1 The Study shall include:

- Airborne noise;
- Structure-borne noise;
- Combination of airborne and structure-borne noise;
- Vibration.

6.2 For the process plant area, airborne noise and vibration analysis are required. For the acoustic classified areas/rooms, structure-borne noise analysis is also required.

6.3 During the planning meeting, the STUDY SUPPLIER shall present the methodology and software provided for the analysis.

6.4 The analysis shall take into account at least the following aspects:

- Equipment SPW and/or SPL. The values considered shall be those reported by the equipment MANUFACTURER in the Form I / II provided by DESIGNER. For the Basic Design, reference values databases may be used. For subsequent stages, the use of reference values shall be submitted for OWNER's approval.
- Type of equipment installation on the structure of the UNIT, considering the vibration transmission effects;
- Classification of equipment according to the different vibration sources (spectrum type);
- Equipment arrangement;
- Distance from the sound sources to the receivers, considering the acoustic effects of attenuation, shadowing, and reflection;
- Noise contribution from HVAC equipment and propagation through the ducts;
- TL of bulkheads, floors and other lining;
- Noise from piping, control valves and pressure control valves;
- Volume of the rooms;
- Equipment weight;
- Structural Path (between source and receivers);
- Environmental data.

6.5 STUDY SUPPLIER shall update the inputs for the analysis during the project progress, as MANUFACTURER's data becomes available.

7 STUDY FOLLOW-UP MEETINGS

The meetings for the Study follow-up shall be according to the guidelines below.

7.1 General

7.1.1 DESIGNER shall follow-up the Study development, with OWNER's participation in cases mentioned in this specification.

7.1.2 The follow-up meetings shall occur in the STUDY SUPPLIER's premises, with the exception of the planning meeting and the meeting for project documentation analysis, which shall occur at the

DESIGNER's premises. The meeting venue may be amended by common agreement between the PARTIES INVOLVED. OWNER's participants may attend meetings by videoconference.

7.1.3 DESIGNER shall draw up the minutes of meeting and make it available as a project document or include it as an annex to the Final Report.

7.1.4 All validation decisions (of premises, data, geometry, etc.) shall be included in the Final Report as an annex. Representatives of all PARTIES INVOLVED shall sign the validations.

7.2 Planning Meeting

7.2.1 This meeting is for a brief presentation of the project, clarification of aspects related to the objectives and scope of the Study, delivery of project documentation, evaluation and necessary adjustments in the work schedule and resources required for the Study. At least the following items shall be covered in this meeting:

- Safety briefing by DESIGNER;
- Presentation of the project for STUDY SUPPLIER by DESIGNER;
- Clarifications on objectives, scope of analysis and requirements for the Study by DESIGNER and OWNER;
- Delivery of the project documentation to STUDY SUPPLIER by DESIGNER, including the 3D model of the UNIT;
- Definition of the teams of DESIGNER and STUDY SUPPLIER 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 the PARTIES INVOLVED and identification of the responsible for each discipline from each party that will participate in the follow-up meetings and the validations required in this specification;
- Presentation of the methodology and software provided for analysis;
- Presentation of planned schedule for the execution of the Study in accordance with the project schedule by STUDY SUPPLIER and DESIGNER;
- Definition of locations, resources needed and duration of follow-up meetings by DESIGNER and STUDY SUPPLIER.

7.2.2 Meeting participants: The focal points of the PARTIES INVOLVED, representatives of STUDY SUPPLIER and discipline leaders of DESIGNER responsible for the Study follow-up.

7.2.3 The schedule shall include 10 working days for comments on the reports (partial and final) by OWNER, as well as the time needed for implementing those comments.

7.3 Project Documentation Analysis Meeting

7.3.1 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 Study, due to possible failures or omissions of information in the documentation required for carrying out of the Study.

7.3.2 STUDY SUPPLIER may request clarification about the contents of the documents provided, considering the DOCUMENT LIST of the project. In case of missing or pending documents, DESIGNER shall inform the deadline for resolving the pending issues and/or sending the documents, in a way that does not affect the final issuance date of the Study.

7.3.3 At the end of the meeting, STUDY SUPPLIER shall sign terms of acceptance containing the list of pending items, if any.

7.3.4 DESIGNER, as responsible for the management of changes in the project, shall inform other PARTIES INVOLVED about any change in the project that affects the Study. DESIGNER shall formally send to STUDY SUPPLIER all modified documents that affect the Study.

7.3.5 STUDY SUPPLIER shall evaluate the changes and inform the impacts of the changes on the analysis and schedule. STUDY SUPPLIER shall formally send this information to DESIGNER and communicate to OWNER.

7.3.6 Meeting participants: Representatives from STUDY SUPPLIER and discipline leaders from DESIGNER responsible for the Study follow-up. OWNER's participation in this meeting is optional.

7.4 Assumptions and Methodology Meeting

7.4.1 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.

7.4.2 STUDY SUPPLIER shall present the proposed assumptions for the development of the Study and its questions about the methodology proposed in this specification. The questions shall be clarified by DESIGNER with participation of OWNER.

7.4.3 Assumptions shall be defined by mutual agreement among the PARTIES INVOLVED and shall be included in the study report.

7.4.4 Meeting participants: Representatives from STUDY SUPPLIER, discipline leaders from DESIGNER and OWNER's representatives who are responsible for the Study follow-up.

7.5 Follow-up and Validation Meetings

7.5.1 The purpose of these meetings is for DESIGNER to follow-up the Study development with the participation of OWNER, checking compliance of the requirements defined in the methodology.

7.5.2 DESIGNER, in agreement with the STUDY SUPPLIER and considering the schedule for the Study, shall present the agenda of meetings to follow-up the Study development. The meetings shall contemplate the Study steps foreseen in the STUDY METHODOLOGY of this specification. Follow-up and validation meetings shall be provided as per Table 1:

Table 1 – Follow-up and validation meetings

Item	Minimum Agenda
R1	**Geometry validation:** Presentation of computational model - assessment of the geometry and material properties, including structures, floors and walls, bulkheads and linings.
R2	**Noise and Vibration Sources validation:** Presentation and validation of noise and vibration sources.
R3	**Validation of results and recommendations:** Presentation, discussion and validation of the simulation results and recommendations to achieve the appropriate levels of noise and vibration.
R4	**Validation of compliance with recommendations:** Presentation, discussion and validation of the simulation results considering the recommendations implemented in the design.

7.5.3 Table 1 is based on OWNER's experience, and 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, the Study outputs are analyzed and recommendations from the Study are evaluated for their applicability to the project.

7.5.4 Meeting participants: Representatives from STUDY SUPPLIER, discipline leaders from DESIGNER and OWNER's representatives who are responsible for the Study follow-up.

7.6 Final Report Presentation Meeting - Preliminary Version

7.6.1 This meeting is to present the final report (preliminary version) before its release to OWNER.

7.6.2 The presentation shall focus on the identification of areas/rooms and their noise and vibration levels, and the mitigating measures to adjust the levels exceeded.

7.6.3 Meeting participants: Representatives from STUDY SUPPLIER, discipline leaders from DESIGNER and OWNER's representatives who are responsible for the Study follow-up.

8 STUDY REPORT

8.1 General

8.1.1 All premises and simplifications adopted for the Study execution shall be presented and explained in the report.

8.1.2 The minutes of meetings shall be annexed to the report, especially those for validation of methodology steps.

8.1.3 All tables, charts and figures that support the conclusions and recommendations of the Study shall be presented in the report. The International System of Units shall be adopted. The charts and figures shall be presented with the respective scales, legends and indication of predominant wind direction.

8.2 Partial Report

8.2.1 STUDY SUPPLIER shall submit at least one partial report to OWNER for approval prior to the release of the Final Report.

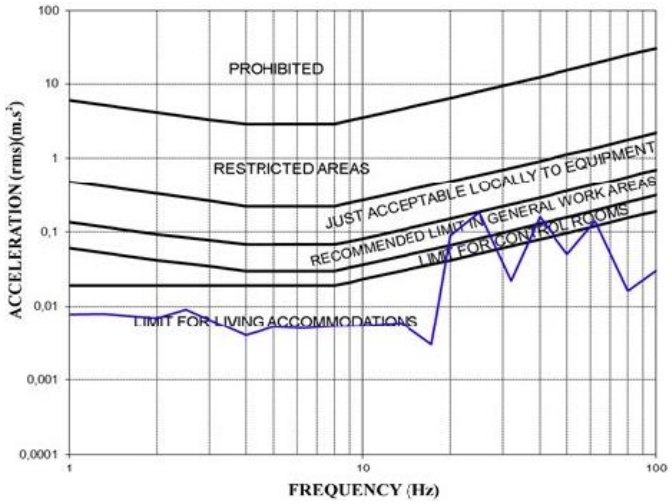
8.2.2 The Partial Report shall contain at least the following items:

8.2.2.1 Threshold limit values for noise control considered in the Study, according to NOISE CONTROL REQUIREMENTS [document supplied by OWNER];

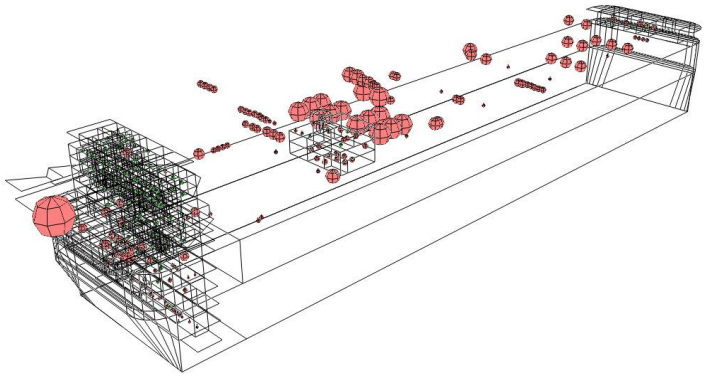
8.2.2.2 A table with the different areas/rooms analyzed, with the following information: Area/room name, type of occupation, sound pressure level in dB (A) total and sound pressure level due to HVAC system. Refer to the example below:

Site Description	Occupation (1)	Total Noise [dB(A)]	HVAC Noise [dB(A)]
Fitness Rooms	I	60	45

8.2.2.3 Vibration spectrum estimated for the compartments, plotted on a chart containing the boundary curves of acceleration. Comparison between the calculated spectra and the acceptable limits. Refer to the example below:



8.2.2.4 Plotting of geometric models considered for the analysis, identifying the noise sources considered. Refer to the example below:



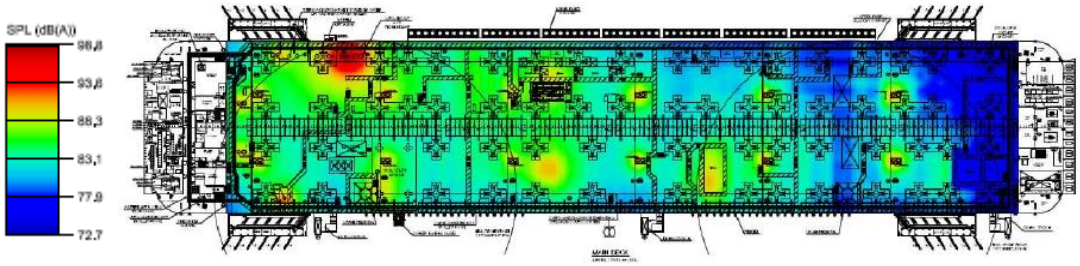
8.2.2.5 List of equipment considered as vibration sources, with equipment identification (TAG and description), location and vibration values/RMS acceleration m/s^2, per octave, in Hz. Refer to the example below:

Localization	Machine	Vibration, Acceleration, RMS m/s^2, 1/1 octave Hz							
		63	125	250	500	1k	2k	4k	8k
6TH DECK - ER	B-5133501 AB	0.435	0.471	0.393	0.628	0.126	0.628	1.257	1.005

8.2.2.6 List of equipment considered as noise sources, identification (TAG and description) of equipment, location and sound power (SPW) and / or sound pressure level (SPL). The table shall indicate whether the values of SPL and SPW considered are from the MANUFACTURER or STUDY SUPPLIER database. Refer to the example below:

TAG	Description	Module / Location	Overall SPL dB(A)	Source
B-5124002 A/B(1)	Cooling Water Circulation Pump	M12	82.8	DATABANK

8.2.3 Results of the SPL on the various levels of the operational area, through distribution maps with color identification of the results. The results shall consider a height of 1.5 m from the floor as the average distance to the ear of personnel. Refer to the example below:



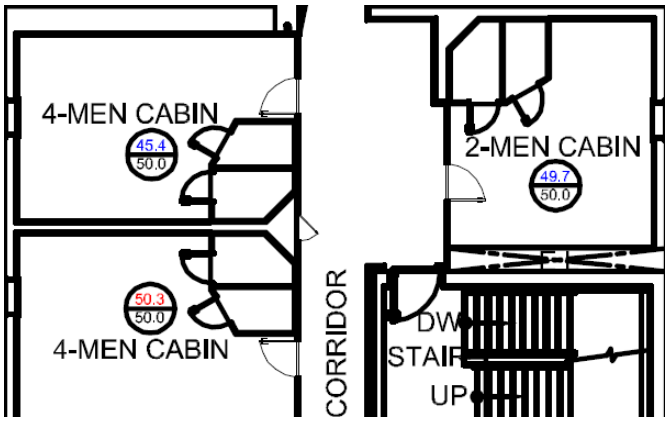
8.2.3.1 List of acoustic classified areas/rooms, with the identification, location, maximum acceptable noise level for the area/room, calculated airborne noise level, calculated level of structure-borne noise and the total noise level in dB (A). When the level exceeds the limit, it shall be indicated by the red color. Refer to the example below:

Room Description	Location	Limit dB (A)	Calculated Airborne(2) (dB (A))	Calculated Structural-borne(2) (dB (A))	Total Noise Level(2) (dB (A))
General Store	2nd Deck ER	65	62.9	60.2	64.8
HVAC (superior)	2nd Deck ER	90	94.1	63.5	94.1(4)

8.2.3.2 List of acoustic classified areas/rooms whose originally calculated noise levels exceeded the limit value, with the identification, location, maximum noise level acceptable for the area, calculated airborne noise level and noise level calculated after the implementation of the recommendations. Refer to the example below:

Room Nr.	Room description	Location	Limit SPL dB(A)	Calculated SPL dB(A)	Calculated with acoustic treatment
-	Paint Shop	Main Deck	65.0	67.7	65.0

8.2.3.3 Arrangement drawings / Architecture drawings of different areas/rooms, with internal marking of the calculated noise level and acceptable limit. When the noise level exceeds the limit, it shall be indicated by the red color. Refer to the example below:

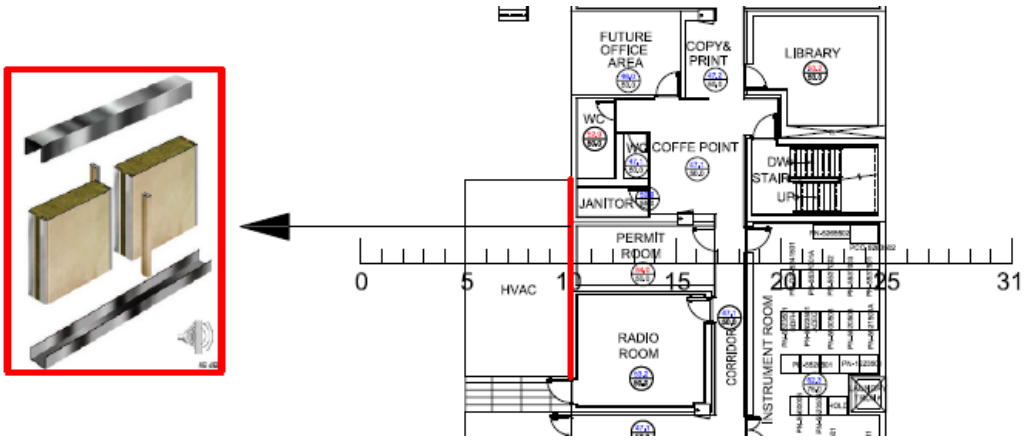


8.2.3.4 Recommendations needed for compliance with maximum acceptable levels of noise and vibration. Recommendations shall include an analysis of the need and the attenuation gain, for example, with:

- Use of low speed in HVAC duct systems;
- Use of silencers in HVAC ducts and electric motors;
- Specification of valves with low noise level;
- Use of Hoods for noisy equipment;

- Use of bulkheads, floors and ceilings with greater TL;
- Changes in the equipment layout;
- Treatment of stiffness of the floors where the dynamic devices are installed;
- Use of anti-vibration mounting (AVM).

8.2.3.5 Recommendations indicated in the design drawings. Refer to the example below:



8.2.3.6 List of material considered as soundproofing for the bulkheads, floors and ceilings, with their characteristics and MANUFACTURER's Catalogue.

8.3 Final Report

8.3.1 DESIGNER shall issue the Final Report in both Portuguese and English. The codification of the report and its stamp shall identify the DESIGNER as the author of the document.

8.3.2 The Final Report shall comply with all the requirements of the Partial Report, and to the comments made to the Partial Report. The Final Report shall also contain the following annexes:

- Minutes of meetings, according to item STUDY FOLLOW-UP MEETINGS of this specification;
- Checklist, according to item CHECKLIST APPLICATION of this specification;
- Final punch list with all pendent issues cleared.

8.3.3 The Final Report shall include the report issued by STUDY SUPPLIER and the treatment of the Study recommendations for the DESIGNER to implement in the project.

8.3.4 The Final Report corresponds to the release of the revision "0" of the Noise and Vibration Study Report on the electronic document management system defined in the Contract.

8.3.5 Additional revisions of the Final Report shall be issued in cases where design changes may affect the Study results or if any failure is identified in the Study.

9 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 SUPPLIER, 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 planned schedule presented during the Planning Meeting.

10 CHECKLIST APPLICATION

DESIGNER shall provide a checklist of the follow-up on STUDY SUPPLIER's activities, which shall be included as an annex to the report. The checklist shall contain the requirements of this specification. The

verification of each requirement shall have the identification and signature of the person in charge of the verification.

11 INFORMATION PROTECTION

DESIGNER and STUDY SUPPLIER 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 OWNER. All information shall be protected against accidental or information security events for at least five years.