	TECHNICAL SPECIFICATION		Nº	I-ET-3010.1M-1200-300-P4X-002	
	CLIENT:		SRGE		SHEET: 1 of 20
	JOB:		REFERENCE BASIC DESIGN		1001056398 0010
	AREA:		BÚZIOS		
DP&T-SRGE	TITLE:		NOISE CONTROL REQUIREMENTS FOR ACCOMMODATION/SHIPSIDE		NP-1
					ESUP

MICROSOFT WORD / V. 2016 / I-ET-3010.1M-1200-300-P4X-002_0.DOCX

INDEX OF REVISIONS

REV.	DESCRIPTION AND/OR REVISED SHEETS
------	-----------------------------------

0	ORIGINAL ISSUE
---	----------------

	REV. 0	REV. A	REV. B	REV. C	REV. D	REV. E	REV. F	REV. G	REV. H
DATE	MAY/21/19								
DESIGN	ESUP								
EXECUTION	ERNANI								
CHECK	MATTANA								
APPROVAL	TMCAMPOS								

INFORMATION IN THIS DOCUMENT IS PROPERTY OF PETROBRAS, BEING PROHIBITED OUTSIDE OF THEIR PURPOSE.

FORM OWNED TO PETROBRAS N-0381 REV. L.



SUMMARY

1	INTRODUCTION	3
2	REGULATION CODES AND STANDARDS	3
3	GENERAL REQUIREMENTS	4
4	SPECIFIC RECOMMENDATIONS	10
5	NOISE CONTROL IN DETAILED DESIGN	12
6	PRESENTATION OF EQUIPMENT NOISE DATA.....	13
7	WORKING ENVIRONMENT AREA DATA SHEET AND FORM I/II.....	17

PRELIMINARY

1 INTRODUCTION

This specification establishes the minimum requirements for noise control and vibration human exposure on topside facilities during Detailed Design of Reference Basic Design, and describes the basic procedures for the measurement and reporting of airborne sound levels of equipment.

2 REGULATION CODES AND STANDARDS

2.1 International Codes

- IEC 60534-all parts – Industrial-process Control Valves
- ISO 717-1/2 – Acoustics - Rating of Sound Insulation in Buildings and of Building Elements - 2013
- ISO 354 – Acoustics - Measurement of Absorption Coefficient in a Reverberation Room - 2003
- ISO 15664 – Acoustics - Noise Control Design Procedures for Open Plant - 2001
- ISO 2631-1 – Evaluation of Human Exposure to Whole Body Vibration / Part 1 – General Requirements (1997) – AND Amendment I of 2010
- NORSOK S-002 – Working Environment - 2018
- Offshore Technology Report 2001/068 – Noise and Vibration – HSE (Health & Safety Executive)

2.2 Brazilian Government Regulation

- NR-15 – Atividades e Operações Insalubres
- NR-37 – Segurança e Saúde em Plataformas de Petróleo

2.3 Petrobras Specifications

- I-DE-3010.1M-1200-942-P4X-002 - General Arrangement
- I-DE-3010.1M-1350-190-P4X-001 - Main Deck Accommodation Layout
- I-DE-3010.1M-1350-190-P4X-002 - A Deck Accommodation Layout
- I-DE-3010.1M-1350-190-P4X-003 - B Deck Accommodation Layout
- I-DE-3010.1M-1350-190-P4X-004 - C Deck Accommodation Layout
- I-DE-3010.1M-1350-190-P4X-005 - D Deck Accommodation Layout
- I-DE-3010.1M-1350-190-P4X-006 - E Deck Accommodation Layout
- I-DE-3010.1M-1350-190-P4X-007 - F Deck Accommodation Layout
- I-DE-3010.1M-1350-190-P4X-008 - Top Roof And Helideck Plan
- I-DE-3010.1M-1350-190-P4X-009 - Accommodation Insulation, Doors And Windows Arrangement
- I-DE-3010.1M-1350-190-P4X-010 - Gymnasium Layout
- I-DE-3010.1M-1350-190-P4X-011 - Galley And Messroom Layout
- I-DE-3010.1M-1350-190-P4X-012 - Hospital Layout
- I-DE-3010.1M-1350-190-P4X-013 - Laundry Layout
- I-DE-3010.1M-1350-190-P4X-014 - Accommodation Sections
- I-DE-3010.1M-1350-190-P4X-015 - Accommodation Elevations
- I-DE-3010.1M-1350-190-P4X-016 - Workshops Layout


	TECHNICAL SPECIFICATION	Nº: I-ET-3010.1M-1200-300-P4X-002	REV. 0
	AREA:	BÚZIOS	
	TITLE:	NOISE CONTROL REQUIREMENTS FOR ACCOMMODATION/SHIPSIDE	SHEET: 4 of 20
NP-1			
ESUP			
<ul style="list-style-type: none"> • I-DE-3010.1M-1350-190-P4X-017 - Engine Room Insulation And Doors Arrangement • I-DE-3010.1M-1350-942-P4X-001 - Equipment Layout Plan-Engine Room-Lower Floor • I-DE-3010.1M-1350-942-P4X-002 - Equipment Layout Plan-Engine Room - 1st Deck • I-DE-3010.1M-1350-942-P4X-003 - Equipment Layout Plan-Engine Room-2nd Deck • I-DE-3010.1M-1350-942-P4X-004 - Equipment Layout Plan-Engine Room-3rd Deck • I-DE-3010.1M-1350-942-P4X-005 - Equipment Layout Plan-Engine Room-Tank Top • I-ET-3000.00-1200-98A-P4X-001 - Noise and Vibration Analysis • I-ET-3010.1M-1400-190-P4X-001 - Architecture Materials and Equipment Specification 			
<h3>3 GENERAL REQUIREMENTS</h3>			
<h4>3.1 General</h4>			
<p>Noise and vibration control analysis are mandatory items to be carried-out at the Detailed Design and equipment installation. It shall consider both airborne and structure-borne noise and whole-body vibration.</p>			
<p>During the design phase, the noise study can show the need for modifications to machines and equipment layout.</p>			
<p>The acoustical criteria as well as the main design guidelines are discussed in this document.</p>			
<p>The employee exposure to noise and vibration is dangerous for health and safety and is established by Brazilian federal regulation. The noise and vibration criteria are described here and shall be strictly observed. The criteria cannot be altered unless previously authorized by Petrobras.</p>			
<p>The noise criteria described in this document cannot be exceeded by more than 2 dB(A) in any situation.</p>			
<p>The vibration criteria described in this document cannot be exceeded by more than 3 dB (ref. 1g).</p>			
<p>Any criteria deviation must be submitted for Petrobras approval.</p>			
<h4>3.2 Goal - Noise Criteria</h4>			
<p>The noise criteria were divided in two groups:</p>			
<ul style="list-style-type: none"> • Criteria for exposure in operational areas; • Criteria for acoustic classified rooms, which resumes to Accommodation and Engine Rooms ambients. 			
<p>The noise criteria are presented in Table 1 and Table 2 below.</p>			

Table 1 – Noise Criteria for Operational Areas^{1, 2, 3}

EXPOSURE TIME (HOURS)	MAXIMUM NOISE LEVEL dB(A)
UNLIMITED	< 82
12	82
10	83
9	84
8	85
6	87
4	90
3	92
2	95
1.5	97
1	100
0.5	105
0.25	110

¹ As the typical employee exposition is between 8 and 12 hours, the noise levels in the operational areas shall be between 82 dB(A) to 85 dB(A). Operational areas are defined as those where production plant equipment or utilities machinery are installed and that are not acoustically classified as specified in Table 2 or that don't have a similar functional occupation.

² Values in the range of 86 to 100 dB(A) are acceptable in the operational areas in special cases, in some areas normally not manned, and must be submitted for Petrobras approval.

³ Noise levels exceeding 100 dB(A) will be not acceptable in the operational areas, unless in the acoustic hood interiors. In case where more than one machine is installed inside rooms, these rooms cannot be considered as hood.

Table 2 – Criteria for Acoustic Classified Areas – Noise Limits^{1,2}

ROOM DESCRIPTION	Level of manning ³	Noise total dB(A)	Noise HVAC dB(A) ⁴
GENERAL OUTDOORS AREAS			
Mustering areas	U	75 ⁵	
External walkways and access ways		80 ⁶	
GENERAL INDOORS AREAS			
Break rooms outside living quarters	I	60	50
Corridor in work areas (between areas with low noise levels)	U	60 ⁷	-
Switchboard and transformers rooms	I	85	70
Battery Rooms	U	85	70
Workshops, Paint shop	M	65 ⁸	50
Local Control Room	M	60	50
Electrical, Instrument and Telecom rooms	U	75	60
Stairs, walkways and access ways in enclosed work areas	I	80	
Stores	M	65	60
Toilets/Changing Rooms	I	60	50
HVAC Rooms	U	90	--
Unmanned machinery room (e.g. combustion engine room, firefighting pumps, compressor room)	U	110 ⁹	80

¹ Any space not identified directly in the table above shall be classified to the most similar space, considering its occupation, location and degree of concentration and relaxation necessary. This classification must be submitted for Petrobras approval. For spaces that cannot be correlated to any space from table above, the maximum value of 65 dB(A) shall be used.

All limits refer to broadband noise without any distinct tonal characteristics. In case of tonal characteristics, the noise level limit shall be set 5 dB lower.

² Limits were defined considering only the internal sources in the environment.

³ M = Permanently manned: work area or work place manned at least 8 hours a day at least 50% of the installation's operation time

I = Intermittently manned: work area or work place where inspection, maintenance or other work is planned to last at least two hours a day at least 50% of the installation's operation time

U = Normally not manned: work area or work place that is not permanently or intermittently manned

⁴ HVAC noise limit refers to maximum noise level acceptable resulting from HVAC system, whichever type of equipment or equipment mounting solution is chosen (including fan-coils mounted directly inside the ambient).

⁵ The limit is defined to achieve reasonable speech intelligibility. Noisy equipment including combustion intakes, HVAC intakes and exhaust outlets shall not be positioned close to these areas. For lifeboat stations/mustering areas the noise limit is 90 dB(A) and 130 dB(C) PEAK in an emergency (emergency flaring, depressurization in the process facility, etc.)

⁶ For in-module walkways/access ways (e.g. between skids), a limit equivalent to the adjacent area applies, provided acceptable PA system audibility is maintained.

⁷ For in-module walkways/access ways (e.g. between skids), a limit equivalent to the adjacent area applies, provided acceptable PA system audibility is maintained.

⁸ The noise limit refers to background noise including ventilation system and external noise sources, but not manually controlled operations. For these operations, the maximum noise exposure for a 12h working day applies.

⁹ The highest permissible noise limit [110 dB(A)] is only allowed during brief inspections or work tasks that are to be carried out in an area where there is no passage through to other areas. Provisions shall be made for noise deflection of noisy equipment when maintenance or other work is carried out in the area.



TECHNICAL SPECIFICATION

Nº: I-ET-3010.1M-1200-300-P4X-002

REV. 0

AREA: BÚZIOS

SHEET: 7 of 20

TITLE: **NOISE CONTROL REQUIREMENTS FOR ACCOMMODATION/SHIPSIDE**

NP-1

ESUP

LIVING QUARTERS			
Cabins	M	40 ¹⁰	35
Central Control Room, emergency preparedness room, radio room, bridge, traffic control room center, offices/meeting rooms	M	45 ¹¹	40
General Recreation Areas (e.g. rest room, TV, music and games rooms)	I	45	40
Corridor, vestibule, saloon in Living Quarter	I	60	50
Dining Room, serving area and gymnasium	M	55	50
Scullery and Laundry Room	M	75 ¹²	60
Galley, hot and cold kitchens, food preparation area	M	60 ¹³	55
Hospital, sickroom, examination room	M	40	35
Laundry-work area	M	65	60
HVAC Rooms	U	90	

¹⁰ The highest permitted noise level for personnel sleeping during the day when a helicopter departs or lands is 55 dB(A).

¹¹ In an emergency, the noise limit for the central control room, emergency preparedness room and radio room is 60 dB(A).

¹² For rooms dedicated to coarse pot and pan washers that are unattended when operating, a limit of 85 dB(A) can be applied.

¹³ The noise limit refers to background noise including ventilation system and external noise sources, but not manually controlled operations. For these operations, the maximum noise exposure for a 12h working day applies.

PRELIMINARY



As established in note 1 of Table 1, the noise levels in the operational areas shall be between 82 dB(A) to 85 dB(A). Detailed Design shall consider the possibility of installation of barriers, ceilings and floors to increase transmission loss between noisy sources and other areas, and thus segregate noisy areas. The installation of such noise reduction measures must be approved by Petrobras, which will evaluate the feasibility of such type of construction. The use of hearing protection must not be considered as a design premises in order to achieve noise limits.

During design emergency conditions, e.g. near safety relief valves or outdoor areas during full emergency flaring, etc., the maximum allowable noise level of 115 dB(A) applies, except lifeboat stations/mustering areas which maximum allowable noise level is 90 dB(A)

3.3 Design goal - Vibration Criteria

Excessive vibration may cause:

- employee discomfort;
- structure members failure;
- noise build-up in acoustically rated spaces.

In this document, vibration control is concerned exclusively with employee discomfort.

Maximum limits for continuous whole-body vibration from machinery and equipment are shown in Table 3. Vibration limits are based on boundaries given in NORSOK S-002. The limits are derived from the acceptability of the exposure of human beings to vibrations and are based on a 12-hour working day.

The vibration limits (whole-body vibration, total $[a_v, \text{rms}, \text{m/s}^2]$ are based on frequency-weighted curves and a method of evaluating health and comfort as described in ISO-2631-1. The limits are specified as the total triaxial rms level for vertical and horizontal movements and cover the frequency range from 1Hz to 80Hz in which the major body resonances occur. The total vibration level is calculated in accordance with ISO-2631-1, where k_x , k_y and k_z are 1. They shall not be extrapolated outside this range.

Table 3 – Criteria for Acoustic Classified Areas – Vibration Limits

ROOM DESCRIPTION	Level of manning ¹	Whole body vibration [a_v , rms, m/s^2]
GENERAL OUTDOORS AREAS		
Mustering areas	U	0,07
External walkways and access ways	I	-
GENERAL INDOORS AREAS		
Break rooms outside living quarters	I	0,07
Corridor in work areas (between areas with low noise levels)	U	-
Switchboard and transformers rooms	I	0,21
Battery Rooms	U	0,21
Workshops, Paint shop	M	0,07
Local Control Room	M	0,07
Electrical, Instrument and Telecom rooms	U	0,07
Stairs, walkways and access ways in enclosed work areas	I	-
Stores	M	0,07
Toilets/Changing Rooms	I	0,07
HVAC Rooms	U	0,21
Unmanned machinery room (e.g. combustion engine room, firefighting pumps, compressor room)	U	0,21
LIVING QUARTERS		
Cabins	M	0,04
Central Control Room, emergency preparedness room, radio room, bridge, traffic control room center, offices/meeting rooms	M	0,04
General Recreation Areas (e.g. rest room, TV, music and games rooms)	I	0,04
Corridor, vestibule, saloon in Living Quarter	I	0,04
Dining Room, serving area and gymnasium	M	0,04
Scullery and Laundry Room	M	0,07
Galley, hot and cold kitchens, food preparation area	M	0,04
Hospital, sickroom, examination room	M	0,04
Laundry-work area	M	0,07
HVAC Rooms	U	0,21

¹ M = Permanently manned: work area or work place manned at least 8 hours a day at least 50% of the installation's operation time

I = Intermittently manned: work area or work place where inspection, maintenance or other work is planned to last at least two hours a day at least 50% of the installation's operation time

U = Normally not manned: work area or work place that is not permanently or intermittently manned

4 SPECIFIC RECOMMENDATIONS

4.1 Introduction

In this specific item, basic recommendations are described for both rooms and equipment. The present recommendations shall be understood as reference guidance to be detailed later.

The main sources of airborne and structure-borne noise on Offshore Production Units are:

- Equipment in General;
- Fluid flow in piping and valves in general;
- Ventilation and Air Conditioning (HVAC) System.

Main aspects of noise control for machinery, including HVAC system, are described in:

- Specific noise control documentation;
- The technical specifications of particular equipment;
- In the systems design.

The recommendations described here are reinforcement and a summary of those specifications. ASHRAE, ISO and IEC references (described at item2) must be used by Detailed Design for the noise control final specifications development.

The Basic Design noise recommendations are based on preliminary data. At this phase, the structure-borne noise analysis cannot be detailed by a lack of sufficient information from the manufacturers, as well as from structural design. Definitive data shall be used to validate, alter or complement the basic design.

Structure-borne noise analysis must be carried-out in detail to support accurate vibration isolation specifications, in order to avoid excessive noise levels in acoustically rated rooms installed near high power machinery.

4.2 Rooms – General

The acoustic environment in occupied rooms shall be strictly controlled. Noise levels exceeding more than 2 dB(A) from the established criteria won't be accepted. This deviation will be restricted for some rooms, in special cases only.

The acoustic environment in the occupied rooms is defined by airborne and structure-borne noise. The design recommendations described here are minimum requirements to meet the noise criteria.

All doors and hatches shall be acoustically treated according to the ambient requirements where they are installed.

Special attention shall be taken to noise leakage to acoustically rated rooms from cables and ducts cofferdams and from piping and ducts transition sleeve. Detailed Design shall specify appropriate treatment to keep noise level inside the rooms below the maximum allowable.

The HVAC rooms and other Equipment rooms shall be internally lined with glass wool protected by aluminum sheet, as specified in Architecture Specification.

In rooms or doors with windows and any other glass screen, the windows and glasses cases shall be mechanically uncoupled from the steel structure by means of noise damping material. Double glass shall also be used to isolate noise transmission. For more details, see Architecture Specification.

In rooms that may be classified as "relaxed noise criteria" (central control room, radio room, telecommunication room, mess room, tv/cinema, games room, offices in general and any other leisure room where a high human occupation is expected), the use of an acoustically absorptive ceiling is recommended to attenuate reverberant levels

For workshops, laboratories, control rooms, radio room, meeting rooms, rest/TV rooms, dining room and offices, the average octave band sound absorption coefficient shall not be less than 0.4 in the frequency range 250Hz to 2kHz.

High performance acoustic bulkheads are necessary at the side facing production area.

Contractor shall test the noise reduction performance for bulkheads, according to ISO R-717-1/2, at least when used for:

- Living Quarters x Production Areas
- Control Room x Production Areas
- Central Control Rooms
- Radio and Communication Rooms
- Between Bedrooms


The partitions between rooms shall be designed in order to achieve an adequate sound insulation. Minimum permissible air borne sound insulation indices for horizontal, vertical and diagonal sound transmission between adjacent rooms are shown below:

Minimum permissible air borne sound insulation indices (Rw) between rooms in the living quarters (ISO 717-1/2). The maximum unfavorable deviation from the reference curve should not exceed 8dB				
	Noisy Rooms	Work rooms	Silent rooms	Corridor/staircases
Noisy rooms	40 dB ¹⁾	40 dB	45 dB ²⁾	35 dB
Work rooms		40 dB	40 dB	35 dB
Silent rooms			40 dB	40 dB
Notes				
1. Does not apply to partition between kitchen and dining room.				
2. Common partition with clinic/ward shall be avoided.				

Examples of "noisy rooms" are gymnasium, TV-rooms/cinema, kitchen, dining and change rooms. "Work rooms" are offices, meeting rooms, radio room and control rooms. "Silent rooms" require a high degree of privacy and include cabins, clinic/ward and rest rooms (e.g. reading room).

Partitions dividing dormitories should be Class I rated (Ia 40 dB), at minimum

When selecting the design of enclosed spaces, i.e., when decisions on acoustic treatment shall be taken, the requirements to PA system and speech intelligibility shall be taken into account. Low reverberation times shall be adhered to.

	TECHNICAL SPECIFICATION	Nº: I-ET-3010.1M-1200-300-P4X-002	REV. 0
	AREA:	BÚZIOS	
	TITLE:	NOISE CONTROL REQUIREMENTS FOR ACCOMMODATION/SHIPSIDE	SHEET: 12 of 20
			NP-1
			ESUP

4.3 Equipment

All dynamic equipment shall be installed with anti-vibration mountings, preferably made by helical springs. For equipment where Anti-Vibration mountings are not acceptable, structure-borne noise damping measures shall be used in the area surrounding the foundations. The use of anti-vibration mountings may be disregarded in case a structure-borne noise study proves that the equipment vibration does not contribute to noise generation in controlled areas.

It is important for all equipment with anti-vibration mountings to have sufficient flexibility in all pipe, cable and duct connections.

If necessary, equipment must be supplied with its proper enclosure to comply with noise requirements of affected areas.

Manufacturers/packagers shall analyze the use of resilient mounts for turbine gas exhaust ducts.

The Diesel Engine package (driver and driven equipment) shall be installed with resilient mounts, helical springs with the minimum vibration isolation efficiency of 95%. Exhaust duct shall be installed with flexible joints as well as flexible hangers and stabilizers. Engine shall be installed with high-performance, reactive, all metallic, double walled silencer for exhaust duct and protected with an acoustic hood

The maximum allowable sound level at any location 1 meter from all equipment shall not exceed 85 dB(A). This is applicable to all operating conditions of the equipment. For Control Valves, The maximum allowable sound level at any location 1 meter from all equipment shall not exceed 82 dB(A).

In case noise limits are higher than allowable, the equipment must be furnished with an acoustic and thermal hood, its ventilation system and safety requirements.

5 NOISE CONTROL IN DETAILED DESIGN

Quiet valves shall be used. If valve noise is higher than 85 dB(A), pipeline wrapping, silencer, defacer or other valve shall be considered by the Detailed Design.

Piping abrupt changes of flow direction, particularly at high speeds, are potential noise sources and shall be avoided.

Exhaust ducts of diesel generators and firefighting pumps shall be oriented as far as possible from living quarters or from boarding station.

Noisy equipment, equipment with high structure-borne sound emission levels and areas with noisy activities (e.g. laydown areas, workshops) shall not be located in the immediate vicinity of areas with an allowable noise level limit of 50 dB(A) or bellow.

No noise sources which may significantly reduce the speech intelligibility shall be installed in the immediate vicinity of lifeboat stations and muster points. This also applies to the location of safety relief valves.

Access to laboratories, etc. from noisy areas shall be through corridors or buffer zones in which the noise level does not exceed the quiet room noise level by more than 5 dB. Access from walkways to permanently manned areas shall be provided without passing through a zone with noise level above 82 dB(A).

5.1 Documents to be submitted to Petrobras

- Form I/II Submission Noise Data for all noisy equipment (see chapter 7 of this specification)
- Working environment area Data Sheet (see chapter 7 of this specification)

- Noise Report, including at least:
 - a) Noise prediction mapping for all ship areas;
 - b) Complete noise study;
 - c) Noise control for equipment;
 - d) Plan of insulation installation;
 - e) Outfits specified for structural-borne noise control;
 - f) For more details, see I-ET-3000.00-1200-98A-P4X-001 - Noise and Vibration Analysis.

- Vibration Analysis Report, including at least:
 - a) Natural frequencies of beams supporting major equipment items under load;
 - b) The rotational frequencies of supported equipment items;
 - c) Whether the frequencies in a) and b) are similar, leading to structural resonance;
 - d) Whether the vibration limits established in item 3.3 are likely to be exceeded.

Note: the study shall consider only vibration from permanently installed equipment: wave, wind and other vibration sources are beyond the scope of this work.

6 PRESENTATION OF EQUIPMENT NOISE DATA

The Manufacturer/packager shall present noise data regarding the items included in its scope of supply, according to the procedures described in this Specification.

Noise data are required by Petrobras with the Proposal and after the Factory Tests, even if limits of airborne noise emission is not specified by Petrobras.

MANUFACTURER/PACKAGER shall inform Petrobras about noise emission characteristics for every noisy equipment installed in the unit.

Equipment manufacturer shall report the data about the noise emission of the equipment of his supply, using the Forms I and II models. See chapter 7.

Petrobras recommended levels are applicable to the whole package supplied, and not just to the main machine. Thus, for compressors, turbo generators, fans, pumps, etc., the noise control treatment shall be applicable to casings, suction and discharges - piped or not - lubrication consoles, speed multipliers and reduces, and all other parts or components of the equipment, operating continuously or intermittently.

When calculated values are presented, the supplier shall submit the assumptions, procedures and calculation sheets that support and guarantee the reported values for Petrobras review, including in the Forms I and II the remark Calculated Values.

All noise data shall be always presented as a continuous equivalent level, L_{eq} , for 60 seconds sampling time, and include:

- Value in dB(A);
- Linear values, not weighted, in the octave bands between 63 Hz and 8,000 Hz.

The Supplier shall be the sole responsible for the guaranteed airborne sound emission data of the equipment within its scope of supply. These data shall be verified during the Factory Test Phase and a maximum deviation of 2 dB will be allowed, both for the A scale weighted value and for the octave bands between 63 Hz and 8,000 Hz.

For all equipment installed inside acoustic hoods, the following data will be required during Proposal Phase:

- Sound power level of the equipment without the acoustic hood;
- Sound pressure level, in each of the four main directions and in one point of the top, for the equipment plus hood;

- Acoustical data of the hood and silencers (when applicable).

For all equipment installed without acoustic hood, the following data will be required:

- Sound power level of the equipment;
- Sound pressure level, in each of the four main directions and in one point of the top.

Before the shipping of the equipment and together with other factory tests, the supplier shall test the sound emission of the items of its scope of supply. In this phase, the data for equipment installed inside acoustic hoods shall be for the enclosed equipment.

If the values measured and reported during the Factory Tests Phase are outside the limits submitted by the Supplier with the proposal and approved by Petrobras, the supplier shall provide the means for sound attenuation to the agreed limit. Petrobras reserves the right to witness the tests.

Petrobras will carry out acceptance tests in the Unit, for all equipment.

The procedures for sound measurement assume a condition of free field over reflecting floor. This implies that the tests will be preferably performed in an outside area, with a smooth floor made of concrete, asphalt, etc. If this condition is not satisfied, then the correction for measurements in rooms shall be applied.

Ideally, there will be no surface other than the floor, or other equipment, within 10 m of the tested equipment.

The sound pressure meter shall be type I, according to IEC 61672 1/2. The characteristics of the octave filter shall be in accordance with IEC 61260.

The sound pressure reading shall be made as equivalent continuous level, L_{eq} , for 60 s sampling time. The recorded values shall be corrected to the nearest entire value within 1 dB.

The instruments shall have preferably L_{eq} measurement. If not, slow response shall be used, except when an impulsive sound characteristic is detected in the equipment sound emission. In this case the fast response shall be used.

To validate the measurements, the background noise level shall be evaluated in all involved octave bands, in four points at 1.0 m from the equipment being tested, while it is turned off.

If the difference between the background noise level and the sound level of the equipment plus the background is less than 10 dB, the measurements shall be corrected according to Table 4:

Table 4 – Correction Table for background measurements

Difference between L_p measured with the source operating and the background noise	Correction to be subtracted from the measures performed with the machine operating, to obtain the value of L_p for the machine only
3	3
4 - 5	2
6 - 9	1
10	0

Thus, it is preferred that the background noise level is at least 10 dB less than of the tested equipment, for all involved octave band. Measurements cannot be carried-out if the difference between source and background noise is less than 3 dB.

The sound pressure levels shall be measured for the actual operating condition and

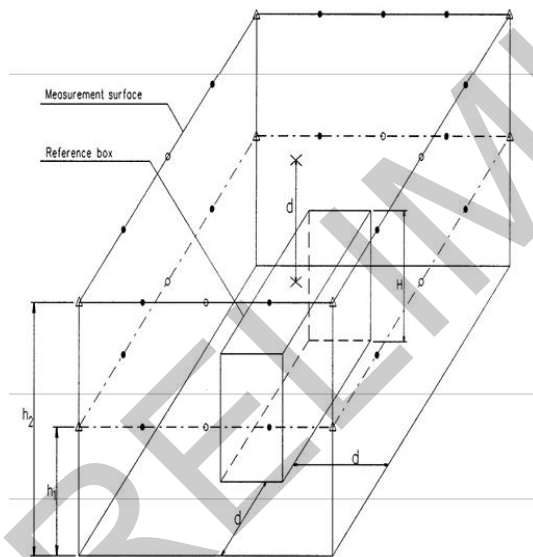
also in the loading condition that produces the higher sound pressure level.

If the normal operating condition of the machine cannot be reached in the test stand, the supplier shall perform the measurements in the possible conditions, agreeing with Petrobras the operational conditions of the test. In this case, the supplier shall estimate, through calculations, the sound pressure levels to be expected in the actual operating conditions, submitting the calculation sheets to review and approval by Petrobras.

6.1 Sound Pressure Level Measurement

Determine the reference box which is the smallest possible imaginary cuboid enclosing the equipment (source) and terminating on the ground on which the source is mounted. Elements protruding from the source which are not major radiators of sound may be neglected. See Figure 1.

Determine the measuring surface which is the imaginary surface that is distant 1.0 m (or other required according to special conditions established by Petrobras) from the reference box. The measuring positions shall be fixed at the measuring surface according to Figure 1.



Keys (microphone positions):
 (o)-Small source = Largest horizontal dimension $\leq d$
 (Δ)-Large source = Largest horizontal dimension $> d$
 (•)-Extra positions, beside (o) and (Δ) to be used with sources with dimensions > 5 m or, when the differences between two positions > 6 dB(A).
 The distance between two microphone positions shall be always less than $2d$

Figure 1 – Reference measurements surfaces

Initially, sound pressure measurements, in dB(A), shall be carried out around the equipment to determine the sound radiation properties. The distance between the equipment and the measuring surface shall be 1.0 m, except when otherwise required by Petrobras, and heights shall be determined according to Table 5.

Table 5 – Reference Box Heights calculation

Height of the reference box	Measurement height
$H \leq 2.5$ m	$h_1 = (H + d^1) / 2$
$H > 2.5$ m	$h_1 = (H + d) / 2$ $h_2 = H + d$

¹ d shall be 1.0 m

The analysis of the obtained sound radiation properties will allow identification of one of following three situations:

- The equipment radiates sound evenly by all surfaces and the difference between the maximum and minimum sound pressure levels is less than 6 dB(A);
- The equipment does not radiate sound evenly, and some surfaces and parts have a variation of more than 6 dB(A) with respect to the rest;
- There are some discrete parts of the equipment or unit that cause the greater part of the total sound power emitted by the equipment (for instance, opening in acoustic hoods).

In the two latter cases of the previous item, additional measurements may be required, at Petrobras discretion.

After the preliminary measurements, the final measurements shall proceed as follows (see Fig. 1):

- When the sound source is small, (no horizontal dimension greater than 1.0 m and the sound is evenly distributed) four measurement points shall be defined, one in the center of each side;
- When the sound source is large (one horizontal dimension greater than 1.0 m and the sound is evenly distributed) eight measurement points shall be defined, four as per the proceeding and four in the corners of the rectangular measuring surface;
- If the sound source is large and the sound is not evenly distributed, then intermediate measuring positions shall be defined, so that the difference between any two adjacent points is no more than 6 dB(A);
- For sources with more than 5.0 m length, the distance between adjacent microphone points shall not be more than 2.0 m, even if differences of more than 6 dB(A) are not observed between them.

When it is required to report the sound pressure level at a given distance, the Supplier shall include following information for Petrobras analysis:

- In Form II: the data for the 5 positions shall inform the maximum level measured in each direction. The value for the top of the equipment may be omitted for some large equipment, and this will be described in Form I/II.
- A condensed report, informing the measuring surfaces and the mean pressure calculated by the equation (1):

$$\bar{L}_p = 10 \log \frac{1}{N} \sum_{i=1}^N 10^{\frac{L_{p,i}}{10}} \quad (1)$$

Where L_p is the mean sound pressure level, $L_{p,i}$ is the sound pressure level for the i^{th} position, N is the total number of microphone positions. In this case L_p and $L_{p,i}$ are applicable to values in dB(A), and octave bands each measurements point.



7 WORKING ENVIRONMENT AREA DATA SHEET AND FORM I/II

The area limits shall be documented on Working Environment Area charts as shown below.

BIDDER shall fulfill the Working Environment Area charts bellow for every working area and non-working area, even if this area is not related in this document. Working Area may be divided in two or more areas if necessary.

Adequate calculations shall be performed in order to ensure implementation of the area requirements in design and data sheets for vendor packages. These calculations shall be documented on the Working environment area charts where relevant.

The implementation of the requirements shall be verified by appropriate measurement methods and documented in the Working environment area charts.

PRELIMINARY



WORKING ENVIRONMENT AREA CHART MODEL

WORKING ENVIRONMENT AREA CHART					
Doc. n°:	Rev.:	Date:	Page:		
Installation:	Room/area name:	Module/level:	Manning: ¹		
WORKING ENVIRONMENT AREA LIMITS					
Factor	Limit/Level ²	Preliminary prediction ³	Predicted at issue for construction ⁴	As Built ⁵	Status ⁶ /Notes ⁷
Noise: Total HVAC					
Vibration					
Notes:					
PREPARED BY:		CHECKED BY:		APPROVED BY:	

¹ Level of manning: Permanently manned (M), Intermittently manned (I), Normally unmanned (U)

² According to Table 1

³ Preliminary prediction and prediction at issue for construction shall be made for noise. For vibration, only prediction at issue for construction shall be made.

⁴ Preliminary prediction and prediction at issue for construction shall be made for noise. For vibration, only prediction at issue for construction shall be made.

⁵ Measured values during commissioning

⁶ Status: OK; Action required (AR); Nonconformity, action pending (NCP); Nonconformity, approved (NCA); Not identified (NI); Not applicable (NA)

⁷ State references to underlying documentation, e.g. nonconformity reports

**TECHNICAL SPECIFICATION**

Nº: I-ET-3010.1M-1200-300-P4X-002

REV. 0

AREA: BÚZIOS

SHEET: 19 of 20

TITLE: NOISE CONTROL REQUIREMENTS FOR ACCOMMODATION/SHIPSIDE

NP-1

ESUP

FORM I

GENERAL

Equipment:	_____		
Code:	_____		
Supplier:	_____		
Proposal nº:	_____	Date:	_____
Submit According To Standard:	_____		
(If Calculated Values Enclose Worksheets)			

OPERATING CONDITIONS (TEST)

Flow m3/h:	_____	Pressure (bar abs):	_____
Rotation (rpm):	_____	Load Condition:	_____
Temperature (°C):	_____	Control Valve Position (% Open):	_____

NOISE CONTROL DATA

Enclosure	_____	Manufac.:	_____	Model:	_____
Muffler:	_____	Manufac.:	_____	Model:	_____
Type:	_____	Press.Drop	_____	Face Velo	_____
Flexible Blanket	_____	Manuf.:	_____	Model:	_____

ACOUSTICAL MEASUREMENT DATA

Sound Level Meter:	_____	Manufac.	_____						
Microphone	_____	Manufac.	_____	Serial:	_____				
Filter Set:	_____	Manufac.	_____						
Fast	_____	Slow	_____	Impulse:	_____	Leq:	_____	Max	_____



TECHNICAL SPECIFICATION

Nº: I-ET-3010.1M-1200-300-P4X-002

REV. 0

AREA: BÚZIOS

SHEET: 20 of 20

TITLE: **NOISE CONTROL REQUIREMENTS FOR ACCOMMODATION/SHIPSIDE**

NP-1
ESUP

FORM II

SUPPLIER DATA		Octave band centre frequency								
Guaranteed noise levels (Note 1)	dBA	31.5	63	125	250	500	1000	2000	4000	8000
Lw										
Lp (1)										
Lp (2)										
Lp(3)										
Lp(4)										
ENCLOSURE, I.L.										
ENCLOSURE (enclosure absorption coeff)										
MUFFLER, D.I.L.										
Expected vibration levels (Note 2)										
Narrow band component, Yes / No		Frequency / octave band Hz :								
Method / standard for noise level test		:								
Description of implemented noise control measures / other information		:								
AS BUILT NOISE DATA		Octave band centre frequency								
Measured noise levels (Note 1)	dBA	31.5	63	125	250	500	1000	2000	4000	8000
Lw										
Lp (1)										
Lp (2)										
Lp(3)										
Lp(4)										
ENCLOSURE, I.L.										
ENCLOSURE (enclosure absorption coeff)										
MUFFLER, D.I.L.										
Special information		:								
Note 1	SPL	Sound pressure level in dB (re. 20 µ Pa) at 1 m distance free field conditions.								
	SWL	Sound power level in dB (re. 1 pW).								
Note 2	VVL	Vibration velocity level in dB (re. 5x10 ⁻⁴ m/s) RMS on skid adjacent to support points.								