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1 OBJECTIVE

This specification establishes the minimum requirements for noise and vibration control concerning human exposure on the UNIT and describes the basic procedures for the measurement and reporting of airborne sound levels of equipment.

2 DEFINITIONS AND ABBREVIATIONS

2.1 Definitions

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

2.2 Abbreviations

AVM:	Anti-Vibration Mounting
FAT:	Factory Acceptance Test
HPU:	Hydraulic Power Unit
HVAC:	Heating, Ventilation and Air Conditioning
LQ:	Living Quarters
PAGA:	Public Address & General Alarm
SPL:	Sound Pressure Level (Lp)
SWL:	Sound Power Level (Lw)


3 NORMATIVE REFERENCES

SUPPLIER 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, standards, specification, etc. shall be presented in writing for OWNER's resolution.

3.1 Applicable Codes, Standards and Regulations

The latest issue of the following codes and standards shall be fully complied with:

Classification Society	Rules for Offshore Facilities
HSE OTO 2001/068	Offshore Technology Report – Noise and Vibration
IEC 60534-all parts	Industrial-process Control Valves
IEC 61260-all parts	Electroacoustics – Octave-band and Fractional-octave-band Filters
IEC 61672-all parts	Electroacoustics – Sound Level Meters
IOGP S-717	Supplementary Specification to ISO 15664 Noise Emitting Equipment
IOGP S-717L	Information Requirements for Noise Emitting Equipment
IOGP S-717Q	Quality Requirements for Noise Emitting Equipment
IOGP S-717D	Data Sheet for Noise Emitting Equipment
ISO 354	Acoustics - Measurement of Absorption Coefficient in a Reverberation Room
ISO 717-1/2	Acoustics - Rating of Sound Insulation in Buildings and of Building Elements
ISO 2631-1	Evaluation of Human Exposure to Whole Body Vibration / Part 1 – General Requirements
ISO 15664	Acoustics - Noise Control Design Procedures for Open Plant
NORSOK S-002	Working Environment
NR-9	Brazilian Government Regulation – Norma Regulamentadora N° 9, Avaliação e Controle das Exposições Ocupacionais a Agentes Físicos, Químicos e Biológicos
NR-15	Brazilian Government Regulation – Norma Regulamentadora N° 15, Atividades e Operações Insalubres
NR-26	Brazilian Government Regulation – Norma Regulamentadora N° 26, Sinalização de Segurança
NR-37	Brazilian Government Regulation – Norma Regulamentadora N° 37, Segurança e Saúde em Plataformas de Petróleo

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

3.2 Applicable Documents

3.2.1 Typical Project Documents

The following project documents shall be fully complied with:

I-ET-3000.00-1200-98A-P4X-001 Noise and Vibration Study

3.2.2 Specific Project Documents

The following project documents, supplied by OWNER, shall be fully complied with. Since these documents are specific to each project, their identification numbers are not unique, and their titles may vary slightly from one project to another. Project's DOCUMENT LIST shall be consulted to verify the correct document number and title.

- DOCUMENT LIST;
- EQUIPMENT LIST (LEQ);
- ARRANGEMENT DRAWINGS;
- 3D MODEL OF THE UNIT;
- ARCHITECTURE MATERIALS AND EQUIPMENT SPECIFICATION;
- ARCHITECTURE 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.

4 BASIC REQUIREMENTS

4.1 General

- 4.1.1 Human exposure to noise and vibration is dangerous for health and safety. Exposure limits are established by Brazilian federal regulation. Noise and vibration criteria described in this specification shall be strictly followed.
- 4.1.2 SUPPLIER shall perform noise and vibration control during Detailed Engineering Design, construction, and commissioning phases. Selection of low-noise and low-vibration machinery and piping systems shall be the primary noise and vibration control measure.
- 4.1.3 During the design phase, SUPPLIER shall perform a study for prediction of noise and vibration levels according to I-ET-3000.00-1200-98A-P4X-001 – Noise and Vibration Study. This study shall indicate any modifications needed on equipment and arrangement.
- 4.1.4 During construction and commissioning phases, SUPPLIER shall verify the conformity with the noise and vibration requirements.

4.2 Noise Criteria

4.2.1 Noise criteria described in this document shall not be exceeded by more than 2 dB(A) in any situation.

4.2.2 For operational areas, criteria in Table 1 shall be followed (NR-15).

4.2.3 For acoustic classified areas, criteria in Table 2 shall be followed (NORSOK S-002).

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

MAXIMUM NOISE LEVEL dB(A)	EXPOSURE TIME (MINUTES)
< 80	UNLIMITED
80	960
81	840
82	720
83	600
84	540
85	480
86	420
87	360
88	300
89	270
90	240
91	210
92	180
93	160
94	135
95	120
96	105
98	75
100	60
102	45
104	35
105	30
106	25
108	20
110	15

Notes:

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) and 85 dB(A). Operational areas are defined as those where production plant equipment or utilities machinery are installed and that are not acoustic classified as specified in Table 2 or do not 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 shall be submitted for OWNER approval.

³ Noise levels exceeding 100 dB(A) are not acceptable in the operational areas, unless in the acoustic hood interiors. If more than one machine is installed inside a room, this room cannot be considered as a hood.



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Table 2 – Noise and Vibration Limits for Acoustic Classified Areas ¹

Area Description	Noise total dB(A)	Noise HVAC dB(A) ²	Whole body vibration [a _v , rms, m/s ²]
General outdoors areas			
Mustering areas, lifeboat stations and laydown areas	75 ^{3, 4}		0.07
External walkways and access ways	80 ⁵		
General indoors areas			
Break rooms outside LQ	60	50	0.07
Corridor in work areas (between areas with low noise levels)	60 ⁵		
Switchboard and transformers rooms, battery rooms	85	70	0.21
Laboratory, workshops, paint shop	65 ⁶	50	0.07
Local control rooms	60	50	0.07
Electrical, instrument and telecom rooms	75	60	
Stairs, elevators, walkways, and access ways in closed work areas	80		
Stores	65	60	0.07
HVAC room, air compressor room	90		0.21
Unmanned machinery room (e.g., combustion engine room, firefighting pumps)	110 ⁷	80	0.21
LQ			
Cabins	40 ⁸	35	
Central control room, emergency preparedness room, radio room, bridge, traffic control room center, offices, and meeting rooms	45 ⁹	40	0.04
General recreation areas (e.g., rest room in LQ, TV, music, and games rooms)	45	40	0.04
Dining room, serving area and gymnasium	55	50	0.04
Toilets/changing rooms	60	50	0.07
Scullery and laundry room	75 ¹⁰	60	0.07
Galley, hot and cold kitchens, food preparation area	60	55	0.04
Hospital/sickroom, examination room	40	35	0.04
Laundry-work area	65	60	0.04

Notes:

¹ Any area in the UNIT not directly identified in this table shall be classified as the most similar one, considering its occupation, location and degree of concentration or relaxation necessary. This classification shall be submitted for OWNER approval. For areas that cannot be correlated to any other in this table, 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 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).

³ The limit is defined to achieve reasonable speech intelligibility. Noisy equipment including combustion / HVAC intakes, and exhaust / HVAC 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.)

⁴ For secondary laydown areas / in-module laydown areas and outdoors storage areas, a limit equivalent to the adjacent area applies, provided acceptable PAGA system audibility is maintained and that communication to crane driver remains possible.

⁵ For in-module walkways/access ways (e.g., between skids), a limit equivalent to the adjacent area applies, provided acceptable PAGA system audibility is maintained.


⁶ 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.

⁷ The highest permissible noise limit [110 dB(A)] shall only be allowed in connection with brief inspections or work tasks that are to be carried out in an area where there is no passage to other areas. Provisions shall be made for noise deflection of noisy equipment when maintenance or other work is carried out in the area.

⁸ The highest permitted noise level for personnel sleeping during the day when a helicopter departs or lands is 55 dB(A).

⁹ In an emergency, the noise limit is 60 dB(A)

¹⁰ For rooms dedicated to coarse pot and pan washers that are unattended when operating, a limit of 85 dB(A) can be applied.

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4.3 Vibration Criteria

4.3.1 For operational areas, NR-15 shall be followed. Both limits for whole-body vibration shall be complied with:

- Normalized Acceleration Resulting from Exposure (aren): 1.1 m/s²;
- Resulting Vibration Dose Value (VDVR): 21.0 m/s^{1.75}.

4.3.2 For acoustic classified rooms, criteria in Table 2 shall be followed (NORSOK S-002).

4.3.3 Vibration limits in Table 2 (whole-body vibration, total [a_v , rms, m/s²] 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 1 Hz to 80 Hz 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. The limit values apply to 12-hour exposure.

5 SPECIFIC RECOMMENDATIONS

5.1 General

5.1.1 This item describes recommendations for rooms, equipment, piping systems and arrangement, and shall be understood as a reference guide. NORMATIVE REFERENCES shall be used by Detailed Engineering for the noise and vibration control final specifications development.

5.1.2 The main sources of airborne and structure-borne noise on the UNIT are:

- Machinery;
- Fluid flow in piping and valves;
- HVAC systems.

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

- Specific noise control documentation;
- Specific equipment technical specification;
- Systems design.

5.1.4 Basic Design noise recommendations are based on preliminary data. At this phase, the structure-borne noise analysis cannot be predicted due to the lack of information from MANUFACTURERS and from structural design. Definitive data shall be used to validate, modify, or complement the Basic Design.

5.1.5 Structure-borne noise analysis shall be carried out in detail to support accurate vibration isolation and absorption specifications, to avoid excessive noise levels in acoustic classified areas installed near high power machinery.

5.2 Rooms

5.2.1 The acoustic environment in occupied rooms shall be strictly controlled. Noise levels that exceed more than 2 dB(A) from the established criteria are not acceptable. This deviation shall be restricted for some rooms, in special cases only.

5.2.2 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.

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



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- 5.2.4 Special attention shall be taken to noise leakage to acoustic classified areas from cables and ducts cofferdams and from piping and ducts transition sleeve. Detailed Engineering shall specify appropriate treatment to keep noise level inside the rooms below the maximum allowable.
- 5.2.5 HVAC rooms and other machinery rooms shall be internally lined with glass wool protected by aluminum sheet, as specified in Architecture Specification.
- 5.2.6 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.
- 5.2.7 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.
- 5.2.8 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 250 Hz to 2 kHz.
- 5.2.9 High performance acoustic bulkheads are necessary at the side facing production area.
- 5.2.10 SUPPLIER 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
- 5.2.11 The partitions between rooms shall be designed to achieve an adequate sound insulation. Minimum permissible airborne sound insulation indices for horizontal, vertical, and diagonal sound transmission between adjacent rooms are shown below:


Minimum permissible airborne sound insulation indices (Rw) between rooms in LQ (ISO 717-1/2). The maximum unfavorable deviation from the reference curve should not exceed 8 dB				
	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

- 5.2.12 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).
- 5.2.13 When selecting the design of enclosed spaces, i.e., when decisions on acoustic treatment shall be taken, the requirements to PAGA system and speech intelligibility shall be considered. Low reverberation times shall be adhered to.

Notes:

¹ Does not apply to partition between kitchen and dining room.
² Common partition with clinic/ward shall be avoided.

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<p>5.3 Equipment, Piping and Ducts</p> <p>5.3.1 Reciprocating machinery, equipment with total power exceeding 200 kW, HVAC equipment and transformers shall have vibration isolation (AVM), unless vibration analysis and/or evaluation of structure-borne sound transmission show that vibration isolation is not feasible or necessary.</p> <p>5.3.2 Equipment with AVM shall have sufficient flexibility in all pipe, cable, and duct connections.</p> <p>5.3.3 If necessary, equipment shall be supplied with an acoustic enclosure to comply with noise requirements of affected areas.</p> <p>5.3.4 Equipment furnished with an acoustic / thermal hood shall have:</p> <ul style="list-style-type: none"> - Its own ventilation and safety systems; - External panel gauges to allow easy visualization of operational parameters. <p>5.3.5 PACKAGER / MANUFACTURER shall analyze the use of resilient mounts for turbine gas exhaust ducts.</p> <p>5.3.6 Diesel Engine PACKAGES (driver and driven equipment) shall be installed with resilient mounts, with a minimum vibration isolation efficiency of 95%. Exhaust ducts 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.</p> <p>5.3.7 For equipment, the maximum allowable SPL at 1 meter in any direction around it shall not exceed 85 dB(A). This is applicable to all operating conditions of the equipment.</p> <p>5.3.8 For control valves, the maximum allowable SPL at 1 meter in any direction around it shall not exceed 82 dB(A). This is applicable to all operating conditions of the control valve.</p> <p>5.3.9 Quiet valves shall be used. If valve noise is higher than 85 dB(A), diffusers, silencers, piping acoustic insulation, or another valve shall be considered by Detailed Engineering.</p> <p>5.3.10 Piping abrupt changes of flow direction, particularly at high speeds, are potential noise sources and shall be avoided.</p> <p>5.4 Arrangement</p> <p>5.4.1 Noisy equipment, equipment with high structure-borne sound emission levels and areas with noisy activities (e.g., laydown areas, workshops) shall not be in the immediate vicinity of areas with an allowable noise level limit of 50 dB(A) or bellow.</p> <p>5.4.2 Exhaust ducts of Diesel generators and firefighting pumps shall be oriented as far as possible from living quarters or from boarding station.</p> <p>5.4.3 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.</p> <p>5.4.4 Access to laboratories and other quiet rooms from noisy areas shall be through corridors or buffer zones in which the noise level does not exceed the room noise level by more than 5 dB(A). Access from walkways to permanently manned areas shall be provided without passing through a zone with noise level above 82 dB(A).</p> <p>6 REQUIRED DOCUMENTATION</p> <p>6.1.1 PACKAGER / MANUFACTURER shall document noise emission data for all noisy equipment according to Forms I and II (annexes).</p>			

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<p>6.2 SUPPLIER shall document noise and vibration in acoustic classified areas according to the Working Environment Area Charts (annex), even if the area is not directly mentioned in this specification. Working area may be divided in two or more areas if necessary.</p> <p>6.3 SUPPLIER shall perform adequate calculations to ensure the implementation of area requirements in design and data sheets for PACKAGES. These calculations shall be documented on the Working Environment Area Charts where relevant.</p> <p>6.3.1 The implementation of the requirements shall be verified by appropriate measurement methods and documented in the Working Environment Area Charts.</p> <p>6.3.2 SUPPLIER shall issue the Noise and Vibration Study report, according to I-ET-3000.00-1200-98A-P4X-001 – Noise and Vibration Study, including at least:</p> <ul style="list-style-type: none"> - Noise prediction map for all UNIT areas; - Complete noise and vibration study; - Noise control for equipment; - Plan of insulation installation; - Outfits specified for structure-borne noise control; - Natural frequencies of structures supporting major equipment; - Forced frequencies from equipment; - Structural resonance evaluation. <p>Note: Vibration analysis shall consider only vibration from permanently installed equipment and piping. Waves, wind, and other vibration sources are beyond the scope of this work.</p> <p>7 EQUIPMENT NOISE DATA</p> <p>7.1 General</p> <p>7.1.1 PACKAGER / MANUFACTURER shall present noise data regarding the items included in its scope of supply, according to the procedures described in this specification.</p> <p>7.1.2 Noise data are required by OWNER with the Proposal and after the FAT, even if limits of airborne noise emission are not specified by OWNER.</p> <p>7.1.3 OWNER 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.</p> <p>7.1.4 When calculated values are presented, PACKAGER / MANUFACTURER shall submit the assumptions, procedures and calculation sheets that support and guarantee the reported values for OWNER review, including in the Forms I and II the remark Calculated Values.</p> <p>7.1.5 All noise data shall be always presented as a continuous equivalent level, Leq, for 60 seconds sampling time, and include:</p> <ul style="list-style-type: none"> - Value in dB(A); - Linear values, not weighted, in the octave bands between 63 Hz and 8 kHz. <p>7.1.6 PACKAGER / MANUFACTURER 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 FAT. A maximum deviation of 2 dB is allowable, both for the A-scale weighted value and for the octave bands between 63 Hz and 8 kHz.</p> <p>7.1.7 For all equipment installed inside acoustic hoods, the following data are required with the Proposal:</p>			



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- SWL of the equipment without the acoustic hood;
- SPL in each of the four main directions and in one point of the top, for the equipment with hood;
- Acoustic data of the hood and silencers (when applicable).

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

- SWL of the equipment;
- SPL in each of the four main directions and in one point of the top.

7.1.9 During the FAT, PACKAGER / MANUFACTURER 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.

7.1.10 If the values measured and reported during the FAT are outside the limits submitted by the PACKAGER / MANUFACTURER with the Proposal and approved by OWNER, the PACKAGER / MANUFACTURER shall provide the means for sound attenuation to the agreed limit. OWNER reserves the right to witness the tests.

7.1.11 OWNER will carry out acceptance tests in the UNIT, for all equipment.

7.1.12 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.

7.1.13 Ideally, there will be no surface other than the floor, or other equipment, within 10.0 m of the tested equipment.

7.1.14 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.

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

7.1.16 The instruments shall have preferably Leq 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.

7.1.17 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.

7.1.18 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 3 – Corrections for background measurements

Difference between Lp 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 Lp for the machine only
3	3
4 - 5	2
6 - 9	1
10	0

7.1.19 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.

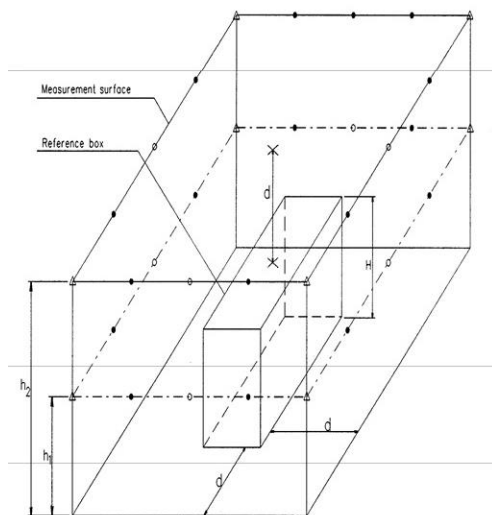
7.1.20 SPL shall be measured for the actual operating condition and in the loading condition that produces the highest SPL.

7.1.21 If the normal operating condition of the machine cannot be reached in the test stand, the PACKAGER / MANUFACTURER shall perform the measurements in the possible conditions, agreeing with OWNER the operational conditions of the test. In this case, SUPPLIER shall estimate, through calculations, the SPL to be expected in the actual operating conditions, submitting the calculation sheets to review and approval by OWNER.

7.2 SPL Measurement

7.2.1 PACKAGER / MANUFACTURER shall 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.

7.2.2 PACKAGER / MANUFACTURER shall determine the measuring surface, which is the imaginary surface that is distant 1.0 m (or other required according to special conditions established by OWNER) 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 > 5.0 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

7.2.3 Initially, SPL 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 OWNER, and heights shall be determined according to Table 4.

Table 4 – Reference Box Heights calculation


Height of the reference box	Measurement height
$H \leq 2.5$ m	$h1 = (H + d^1) / 2$
$H > 2.5$ m	$h1 = (H + d) / 2$ $h2 = H + d$

7.2.4 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);

Notes:

¹ $d = 1.0$ m

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- 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).

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

7.2.6 After the preliminary measurements, the final measurements shall proceed as follows:

- 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 dimensions greater than 5.0 m, 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.

7.2.7 When it is required to report SPL at a given distance, PACKAGER / MANUFACTURER shall include the following information for OWNER 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 shall be described in Form I/II.
- A condensed report, informing the measuring surfaces and the mean pressure calculated by Equation (1):

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

Where \bar{L}_p is the mean sound pressure level, $L_{p,i}$ is the sound pressure level for the i^{th} measurement point, N is the total number of microphone positions. \bar{L}_p and $L_{p,i}$ are applicable to values in dB(A) and octave bands.



8 ANNEXES

WORKING ENVIRONMENT AREA CHART MODEL

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

Notes:

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

² According to Table 2

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-3010.00-1200-300-P4X-001

REV.

A

SHEET: 15 of 16

TITLE:

NOISE AND VIBRATION CONTROL REQUIREMENTS

INTERNAL

ESUP

FORM I

GENERAL

Equipment: _____

Code: _____

Supplier: _____

Proposal n°: _____

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 Vel.: _____

Flexible Blanket: _____

Manufac.: _____

Model: _____

ACOUSTIC MEASUREMENT DATA

Sound Level Meter: _____

Manufac.: _____

Microphone: _____

Manufac.: _____

Serial: _____

Filter Set: _____

Manufac.: _____

Fast: _____

Slow: _____

Impulse: _____

Leq: _____

Max: _____



TITLE: NOISE AND VIBRATION CONTROL REQUIREMENTS

INTERNAL

ESUP

FORM II

VENDOR DATA		dB(A)	Octave band center frequency (Hz)							
Guaranteed noise levels ¹			63	125	250	500	1000	2000	4000	8000
Lw										
Lp (1)										
Lp (2)										
Lp (3)										
Lp (4)										
Lp (5)										
ENCLOSURE IL ²										
ENCLOSURE absorption coeff.										
MUFFLER DIL ³										
Expected vibration level ⁴										
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		dB(A)	Octave band center frequency (Hz)							
Measured noise levels			63	125	250	500	1000	2000	4000	8000
Lw										
Lp (1)										
Lp (2)										
Lp (3)										
Lp (4)										
Lp (5)										
ENCLOSURE IL										
ENCLOSURE absorption coeff.										
MUFFLER DIL										
Special information:		_____								

Notes:

- ¹ Lp Sound pressure level in dB (ref. 20 µPa) at 1.0 m distance free field conditions
- Lw Sound power level in dB (ref. 1 pW)
- ² IL Insertion Loss
- ³ DIL Dynamic Insertion Loss
- ⁴ VL Vibration Level (triaxial acceleration, rms) on skid adjacent to support points