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Systèmes spatiaux — Essais acoustiques

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Foreword

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This document was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

Space systems — Acoustic testing

1 Scope

This document provides guidance for test providers and interested parties to implement acoustic tests of aerospace systems, subsystems, modules and units for applicable spacecraft programs. This document specifies a framework to meet test and process requirements and acts as a supplement to ISO 15864.

The acoustic test system, the technical requirements and the procedures for acoustic tests in reverberant chambers are described. Furthermore, the criteria for the manual test interruption and evaluation are also described.

The technical requirements in this document can be tailored to fulfil the objectives of tests.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 15864:2004, *Space systems — General test methods for space craft, subsystems and units*

ISO 14620, *Space systems — Safety requirements*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
acoustic reverberation chamber
acoustic chamber built in hard and highly reflective surface walls such that the sound field therein becomes diffused

3.2
diffuse sound field
sound field that has uniform energy density in a given region so that all directions of energy flux at all parts of the region are equally probable

3.3
sound pressure
p
root mean square value of instantaneous sound pressure over a given time interval, unless specified otherwise

Note 1 to entry: Normally given in Pa.

3.4
sound pressure level
SPL
L_p
expressed by

$$L_p = 20\lg\left(p / p_0\right)$$

where

p	is root mean square value of instantaneous *sound pressure* (3.3) over a given time interval (Pa);
p_0	is reference pressure at threshold (Pa), p_0 = 20 µPa.

3.5
overall sound pressure level
OASPL
value computed from *one-third-octave* (3.13) or octave band sound pressure levels, L_i

$$L_g = 10\lg\sum_{i=1}^{m} 10^{L_i/10}$$

where

L_g	is the overall sound pressure level in dB;
L_i	is the *sound pressure level* (3.5) in one-third-octave or octave band;
m	is the number of one-third-octave or octave bands.

3.6
bandwidth
difference between the nominal upper and lower cut-off frequencies

3.7
centre frequency
geometric mean of the nominal cut-off frequencies of a pass-band

Note 1 to entry: The definition of *octave* (3.12) and third-octave bands preferred centre frequency values refers to ISO 266.

3.8
cut-off frequency of acoustic horn
frequency below which an acoustic horn becomes increasingly ineffective

3.9
measurement point
specific points spatially distributed in the sound field at which *sound pressure levels* (3.4) are measured during test

3.10
control point
measurement points (3.9), spatially distributed inside the reverberant chamber, whose signals are used for the sound pressure level test control

3.11
multipoint control
control achieved by using the average of the signals at the *control points* (3.10)

3.12
octave
1/1 Oct
interval between two *centre frequencies* (3.7) which have a ratio equal to 2

3.13
one-third-octave
1/3 Oct
interval between *centre frequencies* (3.7) which have a ratio equal to $2^{1/3}$

3.14
test level tolerances
allowance of superior limit and inferior limit of a test level

3.15
closed-loop control
feedback control
system where the output acts upon the process in such a way as to reduce the difference between the measured value and the desired set-point value to zero

[SOURCE: ISO 16484-2:2004, 3.41]

3.16
open-loop control
control action not using any automatic means of deviations from the target value

3.17
statistical DOF
number of independent variables in an estimate of some quantity

3.18
root mean square
RMS
<of a time varying quantity> obtained by squaring the amplitude at each instant, obtaining the average of the squared values over the interval of interest and then taking the square root of this average

3.19
power spectral density
PSD
measure of the distribution of the energy (squared amplitude) of the signal as a function of frequency

3.20
broadband reverberant field
includes signals over a relative large frequency range of 22,5 Hz ~ 10 000 Hz (1/3 oct)

4 Abbreviated terms

All abbreviated terms in Table 1 are applied to this document.

Table 1 — Abbreviated terms

Oct	Octave
DOF	Degree of freedom
PSD	Power spectral density
RMS	Root mean square
SPL	Sound pressure level
OASPL	Overall sound pressure level

5 Test purpose

The purpose of acoustic test is to demonstrate the ability of the test specimen to endure acoustic levels imposed by the launch vehicle and to validate unit random vibration test levels. Depending on the product development stage, it can include qualification of the design with margin, detection of workmanship defects, flaw of material and manufacturing failures.

There are two types of acoustic tests. The first test addresses the specimen functional compatibility with acoustic environment.

The second test addresses mechanical resistance of the structures. In this case, the use of accelerometers shall be required to measure responses to low levels before and after high load testing.

6 General

a) If there is no condition for a reverberant field acoustic test (RFAT), a direct field acoustic test (DFAT) may be applied.

b) For compact specimen, random vibration may replace the acoustic test if analysis and/or heritage data show that the payload responses are clearly dominated by random vibration compared to the acoustic field. It is important to make a decision knowing that vibration tests do not reach high frequency contents; whether the structure is sensitive to acoustic loads and the region that the equipment is embedded shall also be considered. The decision shall be made by customers.

c) Generally, all structures and components requiring acoustic testing should be subjected to a broadband reverberant field. The corresponding acoustic random noise source shall have an approximate normal amplitude distribution.

7 Test system

7.1 Test facility

In general, an acoustic reverberation test facility is composed of a chamber system, gas supply system, sound source system, control system and measurement system. An example of acoustic reverberant test facility is shown in Figure 1.

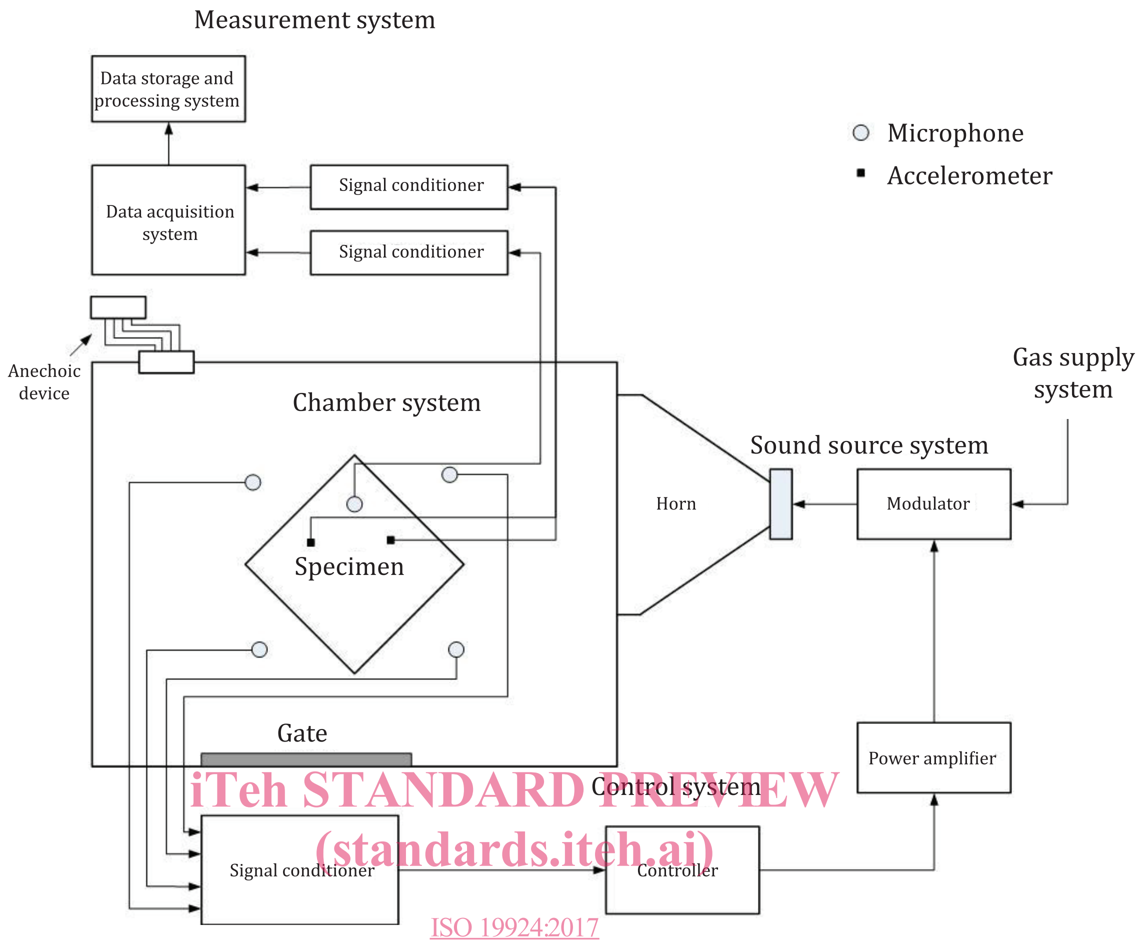


Figure 1 — General composition of the acoustic reverberation test facility

7.2 Equipment requirement

7.2.1 Chamber system

Chamber system general requirements are as follows.

a) Generally, the shape of the chamber is a polyhedron. The surface of the reverberation chamber shall be smooth and rigid enough.

b) The maximum OASPL of the chamber system shall be higher than the requirement of the tests to be performed.

c) The chamber shall have enough channels that are connected to the control and measurement system outside the chamber to meet the requirement of the customers.

d) The volume of the reverberation chamber should be 10 times bigger than the volume of the test specimen if it is possible. In all cases, the volume of the reverberation chamber shall be large enough to achieve the adequate test environment taking into account the volume of the test specimen. The geometrical size of the reverberation chamber also defines the homogeneity of the SPL in the low frequency third-octave bands. Chamber size shall be considered when low-frequency noise loading is an essential test objective.

7.2.2 Sound source system

Generally, the sound source system is composed of modulators, power amplifiers and horns.

a) The achievable sound spectrum shall meet the test requirements.

b) Taking into account the reverberation time of the chamber and the additional damping of acoustic modes introduced by test articles and test installations, the sound power of the sound source system (i.e. number and type of the sound modulators and horns) shall meet the test requirements.

c) The operational frequency range of the modulators and power amplifiers shall meet the test requirements.

d) In order to well represent the broadband frequency test requirements, different cut-off frequency horns can be used.

7.2.3 Control system

Generally, the control system is composed of the controller, the control microphones and signal conditioners or signal pre-amplifiers.

a) The control system shall have the function of multi-inputs average control.

b) The control system shall be able to store controlled time history of SPL.

c) The control system should allow calibration.

d) The measurement range of the microphones shall meet the test requirements.

e) 1/1 octave or 1/3 octave closed-loop control or open-loop control method may be used.

f) It should be possible to control power spectral density on an equal scale according to the test requirements.

g) The control system should have the function to interrupt the test in adequate sequence when needed.

7.2.4 Measurement system

Generally, the measurement system is composed of sensors, signal conditioners, data acquisition system, data storage and processing system.

a) The measurement system shall be able to acquire accelerometers, microphones and other required sensors, e.g. strain gauges and force sensors. The frequency range of the accelerometers, strain gauges and force sensors should be at least 10 Hz ~ 2 000 Hz. For microphones, the range should be at least 10 Hz ~ 12 000 Hz.

b) The data acquisition system shall have enough measurement channels to meet the requirement of the customers.

c) Measurement uncertainties shall meet the requirements of the customers.

All equipment shall be calibrated and used in the valid period.

8 Test technical requirements

8.1 Laboratory environment

The laboratory environment shall follow the requirements of the related technical documents.

8.2 Test condition and tolerance

8.2.1 Test condition

Test condition is specified in the respective launch vehicle user manual and design standard, generally including

a) octave band or 1/3 octave band centre frequency,

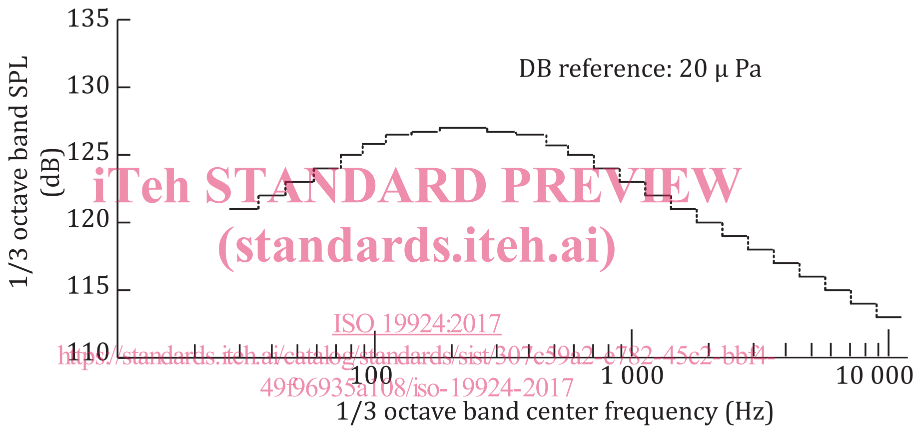
b) spectral SPL,

c) OASPL,

d) test level tolerance, reference to 8.2.3, and

e) test duration, etc.

As an example, the acoustic test level could be 138 dB OASPL with the 1/3 octave band sound pressure level as plotted in Figure 2.



Curve values					
1/3 octave band center frequency (Hz)	Minimum SPL (dB)	1/3 octave band center frequency (Hz)	Minimum SPL (dB)	1/3 octave band center frequency (Hz)	Minimum SPL (dB)
31	121	250	127	2 000	120
40	122	315	126,7	2 500	119
50	123	400	126,5	3 150	118
63	124	500	125,7	4 000	117
80	125	630	125	5 000	116
100	125,7	800	124	6 300	115
125	165,5	1 000	123	8 000	114
160	126,7	1 250	122	10 000	113
200	127	1 600	121	Overall	138

Figure 2 — Exemplary acoustic level

8.2.2 Fill effect

The acoustic sound pressure level in the area between the payload and the payload fairing increases as the gap decreases. This increase in acoustic pressure levels due to payload fill effects has been measured in tests. Thus for large payloads, a fill factor is often used to adjust the acoustic test level for this effect. The fill factor shall be taken out of the customer specification. For information, the calculation of the fill factor is referred to in Annex A.