METHOD 515.5

ACOUSTIC NOISE

NOTE: Tailoring is essential. Select methods, procedures, and parameter levels based on the tailoring process described in Part One, paragraph 4.2.2, and Appendix C. Apply the general guidelines for laboratory test methods described in Part One, paragraph 5 of this standard.

1. SCOPE.

1.1 Purpose.

The acoustic noise test is performed to demonstrate the adequacy of materiel to resist the specified acoustic environment without unacceptable degradation of its functional performance and/or structural integrity.

1.2 Application.

This test is applicable to systems, sub-systems, and units, hereafter called materiel, which must function and/or survive in a severe acoustic noise environment. This test is also applicable for materiel located where acoustic noise excitation is used in combination with or in preference to mechanical vibration excitation for the simulation of aerodynamic turbulence.

1.3 Limitations.

Technical limitations restrict production and control of laboratory acoustic environments. Thus laboratory acoustic fields can be significantly different from many of the real fluctuating pressure loadings classed as "acoustic." Consider these limitations when choosing a test type and test facility as well as in interpreting test results. For example, diffuse field acoustic noise (see paragraph 2.3.3.1) better represents acoustics in internal cavities where local reflection and re-radiation from vibrating structures predominate. For external skins exposed to aerodynamic turbulence or jet noise, grazing incidence acoustic noise (see paragraph 2.3.3.2) more closely represents flow/acoustic wave propagation along skin surfaces.

2. TAILORING GUIDANCE.

2.1 Selecting the Acoustic Noise Method.

After examining the requirements documents and applying the tailoring process in Part One of this standard to determine where acoustic noise may be encountered in the life cycle of the materiel, use the following to confirm the need for this method and to place it in sequence with other methods.

2.1.1 Effects of the acoustic noise environment.

The acoustic noise environment is produced by any mechanical or electromechanical device capable of causing large airborne pressure fluctuations. In general, these pressure fluctuations are of an entirely random nature over a large amplitude range (5000 Pa to 87000 Pa), and over a broad frequency band extending from 10 Hz to 10000 Hz. On occasion there may exist very high amplitude discrete frequency pressure fluctuations referred to as ‘tones.’ When pressure fluctuations impact materiel, generally, a transfer of energy takes place between the energy (in the form of fluctuating pressure) in the surrounding air to the strain energy in materiel. This transfer of energy will result in vibration of the materiel, in which case the vibrating materiel may re-radiate pressure energy, absorb energy in materiel damping, or transfer energy to components or cavities interior to the materiel. Because of the large amplitude and broad frequency range of the fluctuating pressure, measurement of materiel response is important. The following list is not intended to be all-inclusive, but it provides examples of problems that could occur when materiel is exposed to an acoustic noise environment.

a. Wire chafing

b. Component acoustic and vibratory fatigue

c. Component connecting wire fracture

d. Cracking of printed circuit boards

e. Failure of wave guide components

f. Intermittent operation of electrical contacts

g. Cracking of small panel areas and structural elements

h. Optical misalignment

i. Loosening of small particles that may become lodged in circuits and mechanisms

j. Excessive electrical noise

2.1.2 Sequence among other methods.

a. General. See Part One, paragraph 5.5.

b. Unique to this method. Like vibration, the effects of acoustically induced stresses may affect materiel performance under other environmental conditions, such as temperature, humidity, pressure, electromagnetic, etc. When it is required to evaluate the effects of acoustic noise together with other environments and when a combined test is impractical, expose a single test item to all relevant environmental conditions in turn. Consider an order of application of the tests that is compatible with the Life Cycle Environmental Profile.

2.2 Selecting Procedures.

This method includes three acoustic noise test procedures. Determine which of the following procedure(s) to be used.

a. Procedure I (Diffuse Field Acoustic Noise)

b. Procedure II (Grazing Incidence Acoustic Noise)

c. Procedure III (Cavity Resonance Acoustic Noise).

2.2.1 Procedure selection considerations.

The choice of test procedure is governed by the in-service acoustic environments and test purpose. Identify these environments from consideration of the Life Cycle Environmental Profile as described in Part One, Appendix A, Task 402. When selecting procedures, consider:

a. The operational purpose of the materiel. From the requirements documents, determine the functions to be performed by the materiel in an acoustic noise environment, the total lifetime exposure to acoustic noise, and any limiting conditions.

b. The natural exposure circumstances.

c. The test data required to determine if the operational purpose (function and life) of the materiel has been met.

d. The procedure sequence within the acoustic noise method. If more than one of the enclosed procedures is to be applied to the same test item, it is generally more appropriate to conduct the less damaging procedure first.

2.2.2 Difference among procedures.

While all procedures involve acoustic noise, they differ on the basis of how the acoustic noise fluctuating pressure is generated and transferred to the materiel.

a. Procedure I – Diffuse Field Acoustic Noise. Procedure I has a uniform intensity shaped spectrum of acoustic noise that impacts all the exposed materiel surfaces.

b. Procedure II – Grazing Incidence Acoustic Noise. Procedure II includes a high intensity, rapidly fluctuating acoustic noise with a shaped spectrum that impacts the materiel surfaces in a particular direction – generally along the long dimension of the materiel.

c. Procedure III – Cavity Resonance Acoustic Noise. In Procedure III, the intensity and, to a great extent, the frequency content of the acoustic noise spectrum is governed by the relationship between the geometrical configuration of the cavity and the materiel within the cavity.

2.3 Determine Test Levels and Conditions.

2.3.1 General.

Having selected this method and relevant procedures (based on the materiel's requirements and the tailoring process), it is necessary to complete the tailoring process by selecting specific parameter levels and special test conditions/techniques for these procedures based on the requirements documents, Life Cycle Environmental Profile, Operational Environment Documentation (see Part One, figure 1-1), and information provided with this procedure. From these sources of information, determine test excitation parameters and the functions to be performed by the materiel in acoustic noise environments or following exposure to these environments.

2.3.2 Use of measured and related data.

Wherever possible, use specifically measured data to develop the test excitation parameters and obtain a better simulation of the actual environment. Obtain data at the materiel location, preferably on the specific platform or, alternatively, on the same platform type. In general, the data will be a function of the intended form of simulation. In some cases, only microphone sound pressure levels will be useful, and in other cases materiel acceleration response measurements will be useful.

2.3.3 Types of Acoustic Excitation.

2.3.3.1 Diffuse field acoustic noise.

A diffuse field is generated in a reverberation chamber. Normally wide band random excitation is provided and the spectrum is shaped. This test is applicable to materiel or structures that have to function or survive in an acoustic noise field such as that produced by aerospace vehicles, power plants and other sources of high intensity acoustic noise. Since this test provides an efficient means of inducing vibration above 100 Hz, the test may also be used to complement a mechanical vibration test, using acoustic energy to induce mechanical responses in internally mounted materiel. In this role the test is applicable to items such as installed materiel in airborne stores carried externally on high performance aircraft. However, since the excitation mechanism induced by a diffuse field is different from that induced by aerodynamic turbulence, when used in this role, this test is not necessarily suitable for testing the structural integrity of thin shell structures interfacing directly with the acoustic noise. A practical guideline is that acoustic tests are not required if materiel is exposed to broadband random noise at a sound pressure level less than 130 dB (ref 20 µPascal) overall, and if its exposure in every one Hertz band is less than 100 dB (ref 20 µPascal). A diffuse field acoustic test is usually defined by the following parameters.

a. The spectrum levels.

b. The frequency range.

c. The overall sound pressure level.

d. The duration of the test.

2.3.3.2 Grazing incidence acoustic noise.

Grazing incidence acoustic noise is generated in a duct, popularly known as a progressive wave tube. Normally, wide band random noise with a shaped spectrum is directed along the duct. This test is applicable to assembled systems that have to operate or survive in a service environment of pressure fluctuations over the surface, such as exist in aerodynamic turbulence. These conditions are particularly relevant to aircraft panels, where aerodynamic turbulence will exist on one side only, and to externally carried stores subjected to aerodynamic turbulence excitation over their total external exposed surface. In the case of a panel, the test item will be mounted in the wall of the duct so that grazing incidence excitation is applied to one side only. An aircraft carried store such as a missile will be mounted co-axially within the duct such that the excitation is applied over the whole of the external surface. A grazing incidence acoustic noise test is usually defined by the following parameters:

a. The spectrum levels.

b. The frequency range.

c. The overall sound pressure level.

d. The duration of the test.

2.3.3.3 Cavity resonance.

A resonance condition is generated when a cavity, such as that represented by an open weapons bay on an aircraft, is excited by the airflow over it. This causes oscillation of the air within the cavity at frequencies dependent upon the cavity dimensions and the aerodynamic flow conditions. In turn, this can induce vibration of the structure and of components in and near the cavity. The resonance condition can be simulated by the application of a sinusoidal acoustic source, tuned to the correct frequency of the open cavity. The resonance condition will occur when the control microphone response reaches a maximum in a sound field held at a constant sound pressure level over the frequency range. A cavity resonance test is defined by the following parameters:

a. The noise frequency.

b. The overall sound pressure level within the cavity.

c. The duration of the test.

2.3.3.4 Additional technical guidance.

Additional guidance is given in Annex B.

2.4 Test Item Configuration.

(See Part One, paragraph 5.8.) Where relevant, function the test item and measure and record performance data during each test phase and/or each acoustic level applied.

3. INFORMATION REQUIRED.

The following information is necessary to properly conduct the acoustic test.

3.1 Pretest.

a. General. See the information listed in Part One, paragraphs 5.7, 5.8, 5.9, 5.11 and 5.12, and Part One, Appendix A, Tasks 405 and 406 of this standard.

b. Specific to this method.

(1) Establish test levels and durations using projected Life Cycle Environmental Profiles, available data or data acquired directly from an environmental data-gathering program. When these data are not available, use the guidance on developing initial test severities in Annex A. Consider these overall sound pressure levels (OASPL) as initial values until measured data are obtained. The test selected

may not necessarily be an adequate simulation of the complete environment and consequently a supporting assessment may be necessary to complement the test results.

(2) If the test item is required to operate during the test; the operating checks required are pretest, during the test, and post test. For the pre- and post test checks, specify whether they are performed with the test item installed in the test facility. Define the details required to perform the test, including the method of attachment or suspension of the test item, the effect of gravity and any consequent precautions. Identify the control and monitor points, or a procedure to select these points. Define test interruption, test completion and failure criteria.

3.2 During Test.

a. General. See the information listed in Part One, paragraph 5.10, and in Part One, Appendix A, Tasks 405 and 406.

b. Specific to this method.

(1) Collect outputs of microphones, test control averages, test item operating parameters, and any other relevant transducers at appropriate test times.

(2) Collect log/records of materiel operating parameters.

(3) Give particular attention to interactions of the input excitation (diffuse and uniform, directional or tonal).

(4) Record transient behavior in the input representing a test anomaly.

3.3 Post Test.

a. General. See the information listed in Part One, paragraph. 5.13, and in Part One, Appendix A, Tasks 405 and 406 of this standard.

b. Specific to this method. Identify any indication of failure under specified failure criteria. Account for tolerance excesses when testing large materiel, the number of simultaneous test items in Procedure I, and any other environmental conditions at which testing was carried out, if other than standard laboratory conditions.

4. TEST PROCESS.

4.1 Test Facility.

Ensure the apparatus used to perform the acoustic test has sufficient capacity to adequately reproduce the input requirements. Diffuse acoustic field apparatus that produce uniform acoustic fields above 165 dB are rare. For high level acoustic input (above 165 dB), consider testing using grazing incidence acoustic noise. For measured data that indicates tonal input, consider a facility that can be configured to produce a cavity resonance condition.

4.2 Control.

The control strategy depends upon the type of test and the size of the materiel.

4.2.1 Control options.

4.2.1.1 Single point noise control.

Define the single point, providing an optimum control position in the chamber or progressive wave tube.

4.2.1.2 Multiple point noise control.

Select the control points to define a controlled volume within the reverberation chamber. Base control upon the average of the sound spectrum levels at each microphone. Where the range of measurements at the monitoring positions does not exceed 5 dB (OASPL) a simple arithmetic average of the sound spectrum levels (in dB) may be used. For a range of 5 dB or greater, use an average of the non-logarithmic sound spectrum levels (i.e., μPa or microbar), then convert to dB.

4.2.1.3 Vibration response control.

Where it is necessary to achieve a given vibration acceleration response on the test item, adjust the acoustic test spectrum to achieve the required response which may be monitored at either a single point or as the average from multiple monitoring points. Refer to method 514.5 for further guidance.

4.2.2 Control methods.

Control can be by either open or closed loop. Open loop control is adequate for progressive wave tubes and for small chambers having a single noise source. Closed loop control is more effective for large chambers having multiple noise sources that cover different bands in the test frequency range.

4.2.3 Overall accuracy of control.

Ensure the uncertainty of measurement of the total measurement system, including statistical errors, does not exceed one-third of the specified tolerance for the overall sound pressure level.

4.2.4 Calibration and tolerance.

Test tolerances are given in table 515.5-I. Ensure the calibration and test tolerance procedures for test control are generally consistent with the guidance provided in Part One, paragraphs 5.3.2 and 5.2, respectively.

4.2.5 Test interruption.

a. General. See Part One, paragraph 5.11 of this standard.

b. Specific to this method. Interruption of an acoustic noise test is unlikely to generate any adverse effects. Normally, continue the test from the point of interruption.

4.3 Instrumentation.

Ensure that all test environment monitoring instrumentation and test item function monitoring instrumentation is consistent with the calibration and test tolerance procedures, and are generally consistent with the guidance provided in Part One, paragraphs 5.3.2 and 5.2, respectively.

4.4 Data Analysis.

Detailed data analysis for verification of the input to the test item, i.e., the acoustic field and the response monitoring of the test item, are to be in accordance with the test plan.

TABLE 515.5-I. Test tolerances.

PARAMETER	TOLERANCE
Overall sound pressure level averaged over all control microphones, ref specified overall sound pressure level	+3dB -1dB
Overall sound pressure level at each control microphone, ref specified overall sound pressure level	+4dB -2dB
Averaged test spectrum from all control microphones at levels above -15dB in 1/3 octave bands, ref specified 1/3 octave band sound pressure levels.	±4dB
Averaged test spectrum from all control microphones at levels below -15dB and above -25dB in 1/3 octave bands, ref specified 1/3 octave band sound pressure levels.	±6dB
Averaged test spectrum from all control microphones at levels -25dB and below in 1/3 octave bands, ref specified 1/3 octave band sound pressure levels.	±10dB
Duration	±5% or ±1 min whichever is less

4.5 Test Conditions.

4.5.1 Installation of the test item.

4.5.1.1 Diffuse field acoustic noise.

Suspend the test item (or as otherwise mounted) in a reverberation chamber on an elastic system in such a manner that all appropriate external surfaces are exposed to the acoustic field and no surface is parallel to a chamber surface. Ensure the resonance frequency of the mounting system with the specimen is less than 25 Hz or 1/4 of the minimum test frequency, whichever is less. If cables, pipes etc., are required to be connected to the test item during the test, arrange them to provide similar restraint and mass as in service. Locate a microphone in proximity to each major different face of the test item at a distance of 0.5 meter from the face, or midway between the center of the face and the chamber wall, whichever is smaller. Average the outputs from these microphones to provide a single control signal. Where the chamber is provided with a single noise injection point, place one microphone between the test item and the chamber wall furthest from the noise source. The orientation of the microphones in such a facility is not critical, but do not set the microphone axes normal to any flat surface. Calibrate the microphones for random incidence.

4.5.1.2 Grazing incidence acoustic noise.

Mount test items such as panels in the wall of the duct such that the required test surfaces are exposed to the acoustic excitation. Ensure this surface is flush with the inner surface of the duct to prevent the introduction of cavity resonance or local turbulence effects. Suspend test items (such as aircraft external stores) centrally within the duct, on an elastic support. Orient the test item such that the appropriate surfaces are subjected to progressive acoustic waves. For example, orient an aircraft external store parallel to the duct centerline so that the acoustic waves sweep the length of the store. Ensure the rigid body modes of the test item are lower than 25 Hz or ¼ of the lowest test frequency, whichever is less. Ensure that no spurious acoustic or vibratory inputs are introduced by the test support system or by any ancillary structure. Mount the microphone(s) for control and monitoring of test conditions in the duct wall opposite the test panel. Select other positions within the duct assuming the microphone is positioned so that it responds to only grazing incidence waves and that the necessary corrections are applied to the measured level. Calibrate the microphones for grazing incidence.

4.5.1.3 Cavity resonance acoustic noise.

Suspend the test item (or as otherwise mounted) in a reverberation chamber such that only that part of the cavity to be tested is exposed to the direct application of acoustic energy. Protect all other surfaces so that their level of acoustic excitation is reduced by 20 dB. Do not use protective coverings that provide any additional vibration damping to the structure. Do not locate the microphone for control of the test within the cavity to be tested.

4.5.2 Effects of gravity.

Tests will normally be carried out with the test item mounted in the correct attitude, unless it is shown that the performance of the test item is not affected by gravity.

4.5.3 Preparation for test.

4.5.3.1 Preconditioning.

Unless otherwise specified, allow the test item to stabilize at ambient conditions.

4.5.3.2 Inspection and performance checks.

Inspection and performance checks may be carried out before and after testing. Define the requirements for these checks in the test plan. If these checks are required during the test sequence, specify the time intervals at which they are required.

4.5.4 Procedures.

In the test plan stipulate whether the test item is or is not to be operating during the test.

4.5.4.1 Procedure 1 - Diffuse field acoustic noise testing.

Step 1. Install the test item in the reverberation chamber in accordance with paragraph 4.5.1.1.

Step 2. Select microphone positions for control, monitoring, and control strategy in accordance with paragraph 4.5.1.1.

Step 3. When using open loop control, remove the test item and confirm the specified overall sound pressure level and spectrum can be achieved in an empty chamber, then replace the test item in the chamber.

Step 4. Precondition the test item in accordance with paragraph 4.5.3.1.

Step 5. Conduct initial checks in accordance with paragraph 4.5.3.2.

Step 6. Apply the test spectrum for the specified time. If required, carry out inspections and performance checks in accordance with paragraph 4.5.3.2.

Step 7. Record the test acoustic field at each microphone, any average used in test control, and other pertinent transducer outputs. Make the recordings at the beginning, midpoint, and end of each test run. Where test runs are longer than one hour, record every one-half hour.

Step 8. Carry out the final inspection.

Step 9. Remove the test item from the chamber.

Step 10. In all cases, record the information required.

4.5.4.2 Procedure 2 - Grazing incidence acoustic noise testing.

Step 1. Install the test item in accordance with paragraph 4.5.1.2.

Step 2. Select microphone positions for control, monitoring, and control strategy in accordance with 4.5.1.2.

Step 3. Precondition the test item in accordance with 4.5.3.1.

Step 4. Conduct initial checks in accordance with 4.5.3.2.

Step 5. Apply the test spectrum for the specified time. If required, carry out inspections and performance checks in accordance with paragraph 4.5.3.2.

Step 6. Record the test acoustic field at each microphone, any average used in test control, and other pertinent transducer outputs. Make recordings at the beginning, end and midpoint of each test run. Where test runs are longer than one hour, record every one-half hour.

Step 7. Carry out the final inspection.

Step 8. Remove the test item from the duct.

Step 9. In all cases, record the information required.

4.5.4.3 Procedure 3 - Cavity resonance acoustic noise testing.

Step 1. Install the test item into the chamber in accordance with paragraph 4.5.1.3.

Step 2. Locate the control microphone in accordance with paragraph 4.5.1.2.

Step 3. Precondition the test item in accordance with paragraph 4.5.3.1.

Step 4. Conduct initial checks in accordance with paragraph 4.5.3.2.

Step 5. Apply the sinusoidal acoustic excitation at the required frequencies (see table 5.5.5A-II). Adjust the test parameters to the specified levels and apply for the specified time. If required, carry out inspections and performance checks in accordance with paragraph 4.5.3.2.

Step 6. Record the test acoustic field at each microphone, any average used in test control, and other pertinent transducer outputs. Make recordings at the beginning, midpoint, and end of each test run. Where test runs are longer than one hour, record every one-half hour.

Step 7. Perform the final inspection.

Step 8. Remove the test item from the chamber.

Step 9. In all cases, record the information required.

5. ANALYSIS OF RESULTS.

Refer to Part One, paragraphs 5.14 and 5.17, and Part One, Annex A, Tasks 405 and 406.

6. REFERENCE/RELATED DOCUMENTS.

a. NATO STANAG 4370, Environmental Testing.

b. NATO Allied Environmental Engineering and Test Publication (AECTP) 400, Mechanical Environmental Testing.

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ANNEX A

GUIDANCE FOR INITIAL TEST SEVERITY

1. BROAD BAND RANDOM AND INCIDENCE NOISE TESTING.

1.1 Overall Sound Pressure Level (OASPL).

From the known area of operation for the materiel, the test overall sound pressure level and duration may be obtained from table 515.5A-I.

1.2 Test Spectrum.

The applied test spectrum associated with these levels is shown on figure 515.5A-1 with breakpoints defined in table 515.5A-III. Achieve the test spectrum while maintaining the test parameters within the tolerances given in table 515.5-I.

1.3 Simulation of Aerodynamic Turbulence.

Where a broadband noise test is required for the simulation of aerodynamic turbulence, derive the test levels and durations in conjunction with those for the complementary mechanical test.

2. CAVITY RESONANCE TESTING.

For cavity resonance testing, the sound pressure level B_o, frequencies f_N and duration T will be as calculated or defined in table 515.5A-II.

3. EXTERNAL STORES TESTING.

3.1 Test Spectrum.

A typical store profile is shown on figure 515.5A-2. The applied test spectrum is shown on figure 515.5A-3.

3.2 Test Parameters.

For acoustic testing of external stores, the associated levels and definitions are shown in table 515.5A-IV.

TABLE 515.5A-I. Overall sound pressure levels and durations.

TYPICAL APPLICATION	TEST LEVEL (OASPL) dB	DURATION (Min)
Transport aircraft at locations not close to jet exhausts	130	30
Transport aircraft, in internal materiel bays close to jet exhausts	140	30
High performance aircraft at location not close to jet exhausts	145	
High performance aircraft in internal materiel bays close to jet exhausts	150	30
Air-to-air missile on medium performance aircraft (i.e., q<1200 psf (57456 Pa)).	150	30
Air-to-ground missile on medium performance aircraft (i.e., q<1200 psf (57456 Pa)).	150	15
Ground materiel in enclosed engine runup areas	135	30
High performance aircraft in internal materiel bays close to reheat exhaust and gun muzzles or in nose cones	160	30
Airborne rocket most locations but excluding booster or engine bays	140	8
Air-to-air missile on high performance aircraft (i.e., q<1800 psf (86184 Pa)).	165	30
Air-to-ground missile on high performance aircraft (i.e., q<1800 psf (86184 Pa)).	165	15
Airborne rocket booster or engine bays	140	8

TABLE 515.5A-II. Cavity resonance test conditions.

Test level

$$B_0 = 20 \log(q) + 76.4 \text{ dB} \qquad (\text{ref } 20\ \mu\text{Pa})$$

$$f_N = \frac{6.13\left[(N-0.25)\left(2.4-\frac{M^2}{2}\right)\right]^{0.5}}{0.57(L)(C)+\left(2.4-\frac{M^2}{2}\right)^{0.5}} \qquad \text{Hz}$$

Test duration: T=1 hour per resonance frequency

Definitions

f_N = Resonance frequency for the N^{th} mode (where N=1, 2, 3, ...) up to 500 Hz
(where f_1>500 Hz use only this mode)

N = Mode number

C = Speed of sound at altitude of flight (m/s)

L = Length/radius of opening exposed to air stream (m). Identify a second set of resonance frequencies by using the distance parameter L as the depth of the cavity.

M = Mach number

q = Flight dynamic pressure when cavity is open (Pa). (See method 514.5 for guidance on defining “q.”)

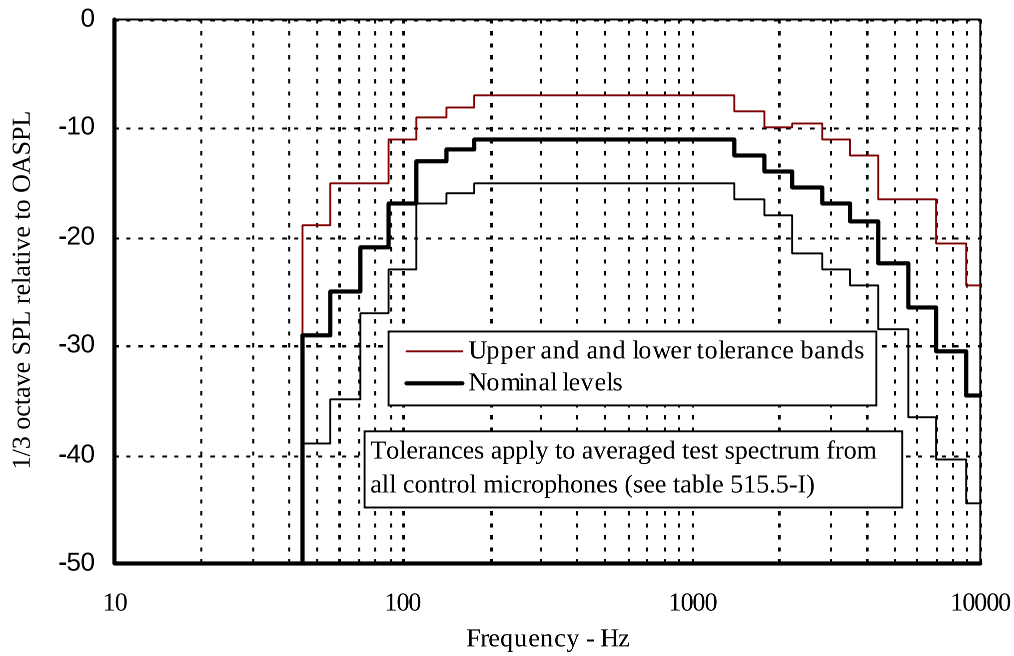

FIGURE 515.5A-1. Applied test spectrum.

TABLE 515.5A-III. 1/3 Octave band levels for figure 515.5A-1.

1/3 octave center frequency Hz	Upper tolerance limit dB	Nominal level dB	Lower tolerance limit dB	1/3 octave center frequency Hz	Upper tolerance limit dB	Nominal level dB	Lower tolerance limit dB
50	-19	-29	-39	800	-7	-11	-15
63	-15	-25	-35	1000	-7	-11	-15
80	-15	-21	-27	1250	-7	-11	-15
100	-11	-17	-23	1600	-8.5	-12.5	-16.5
125	-9	-13	-17	2000	-10	-14	-18
160	-8	-12	-16	2500	-9.5	-15.5	-21.5
200	-7	-11	-15	3150	-11	-17	-23
250	-7	-11	-15	4000	-12.5	-18.5	-24.5
315	-7	-11	-15	5000	-16.5	-22.5	-28.5
400	-7	-11	-15	6300	-16.5	-26.5	-36.5
500	-7	-11	-15	8000	-20.5	-30.5	-40.5
630	-7	-11	-15	10000	-24.5	-34.5	-44.5

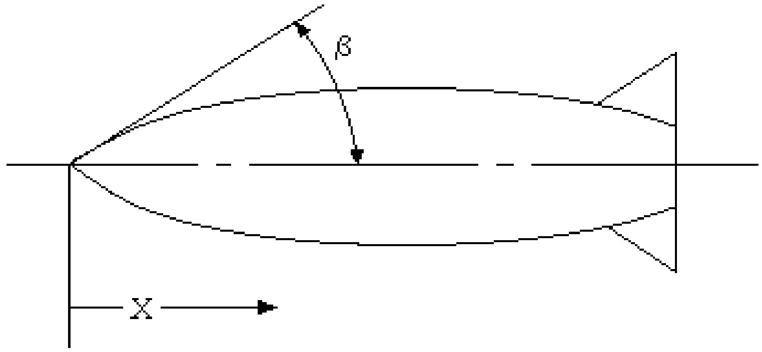

FIGURE 515.5A-2. Typical store profile.

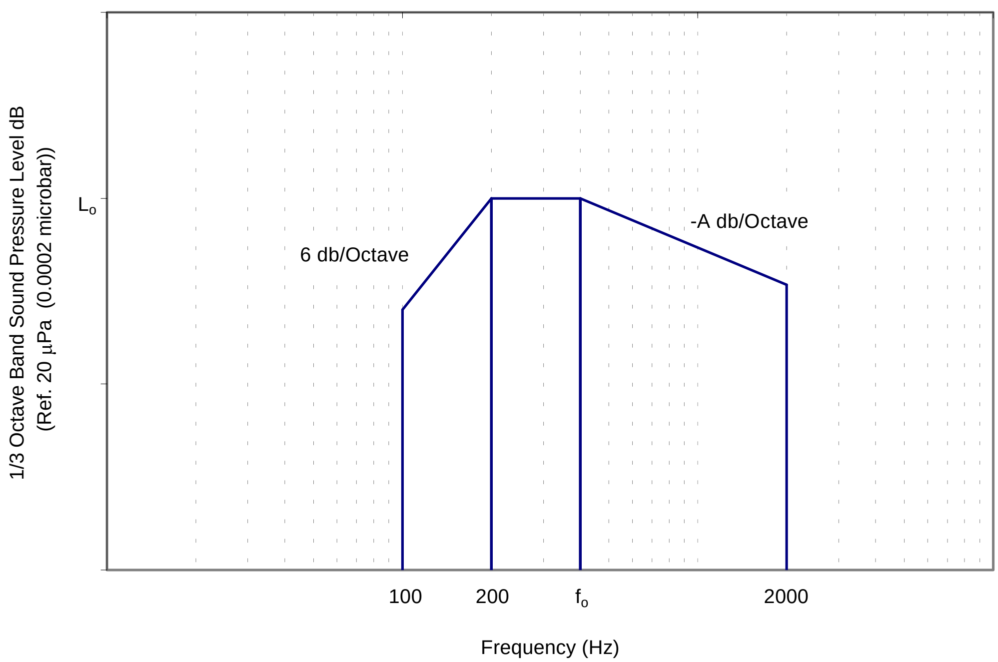

FIGURE 515.5A-3. One-third octave band spectrum for assembled externally carried aircraft stores.

TABLE 515.5A-IV. Suggested acoustic test levels for assembled externally carried aircraft stores.

$A = 6$ dB/Octave when $f_0 > 400$ Hz

$A = 2$ dB/Octave when $f_0 \leq 400$ Hz

Functional Test

$L_0 = 20 \log (q_1) + 11 \log (X) + 7 \log (1-\cos \beta) + G + H$ (dB) (see Notes 1, 5, 6, 7.)
$f_0 = 600 \log (X/R) + C$ (see Notes 2, 3.)

Endurance Test

$L_0 = 20 \log (q_2/q_1) + 2.5 \log (N/3T)$ + functional level (dB) (see Notes 1, 5, 6, 7.)
$f_0 = 600 \log (X/R) + C$ (see Notes 2, 3.)

Definitions

q_1 = captive flight dynamic pressure (lbs/ft^2) ≤ 1800

q_2 = 1200 psf or maximum captive flight dynamic pressure (whichever is lower) (lbs/ft^2)

N = maximum number of anticipated service missions (minimum N = 3)

R = local radius of store in inches (see Note 4.)

X = distance from nose of store along axis of store in inches

T = test time in hours (minimum T=1 hour unless otherwise specified)

C = -200 for locations (1) within one (D) of the aft end of the store, or (2) aft of a flow reentry point. (See Note 8);
= 400 for all other locations

D = maximum store diameter in inches (see Note 4.)

β = local nose cone angle at X equals $1/\tan\beta = (R/X)$ (see figure 515.5A-2)

G = 72 unless measured data shows otherwise

E = 96 unless measured data shows otherwise

F = 84 unless measured data shows otherwise

H = 0 for $0.85 < M < 0.95$;
=-3 dB for all other values of M

M = Mach number

TABLE 515.5A-IV. Suggested acoustic test levels for assembled externally carried aircraft stores (continued).

Representative parametric values to be used for captive flight when specific parameters are not available:

Store Type	N Endurance	Local Nose Cone Angle Degrees	q max	f_0 Nose Section	f_0 Middle Section	f_0 Aft Section
Air-to-Air Missile	100	69	1600	500	1000	500
Air-to-Ground Missile	3	12	1600	800	630	630
Instrument Pod	500	69	1800	500	1000	500
Reusable Dispenser	50	11	1200	630	1000	400
Demolition Bomb	3	24	1200	500	1000	630
Flat Nose Store	3	90	1200	400	630	315

Notes:

1. Raise computed L_0 level by 3 dB for a store carried in a TER cluster rack; by 5 dB for an MER cluster rack.

2. If calculated f_0 is above 2000 Hz, use upper frequency limit of 2000 Hz. If calculated f_0 is below 200 Hz, use 200 Hz.

3. Round off f_0 upward to a one-third octave center band frequency.

4. For stores that do not have circular cross-sections, use the radius in the formulas that is the radius of the circle that circumscribes the cross-section of the store.

5. For locations on flat nose stores ($80° \leq \beta \leq 90°$) where $X < 100$:

Functional test: $L_0 = 20 \log (q_1) - 6 \log (X) + E + H$

Endurance test: $L_0 = 20 \log (q_2) - 6 \log (X) + E + 2.5 \log (N/3T) + H$

6. For long cylindrical section > 2D, use for locations more than one D afterward into the cylindrical section:

Functional test: $L_0 = 20 \log (q_1) + F + H$

Endurance test: $L_0 = 20 \log (q_2) + F + 2.5 \log (N/3T) + H$

7. For changing radius section either aft of a long cylindrical section or when X > 100 on a flat nose store, redefine X so that X = 1 at the beginning of this section.

Functional test: $L_0 = 20 \log (q_1) + 11 \log (X) + F + H$

Endurance test: $L_0 = 20 \log (q_2) + 11 \log (X) + F + 2.5 \log (N/3T) + H$

8. A flow reentry point is the furthest upstream (forward) point of a store cross section change which results in a flow component toward the store centerline as opposed to flow away from or parallel to the store centerline.

ANNEX B

ADDITIONAL TECHNICAL GUIDANCE

1. REVERBERATION CHAMBERS.

1.1 A reverberation chamber is basically a cell with hard, acoustically reflective walls. When noise is generated in this room, the multiple reflections within the main volume of the room cause a uniform diffuse noise field to be set up. The uniformity of this field is disturbed by three main effects.

a. At low frequencies, standing modes are set up between parallel walls. The frequency below which these modes become significant is related to the chamber dimensions. Small chambers, below about 100 cubic meters in volume, are usually constructed so that no wall surfaces are parallel to each other in order to minimize this effect.

b. Reflections from the walls produce higher levels at the surface. The uniform noise field therefore only applies at positions within the central volume of the chamber; do not position test items within about 0.5 m of the walls.

c. The size of the test item can distort the noise field if the item is large relative to the volume of the chamber. It is normally recommended that the volume of the test item not exceed 10% of the chamber volume.

1.2 Noise is normally generated with an air modulator and is injected into the chamber via a coupling horn. Provision is made in the chamber design to exhaust the air from the modulator through an acoustic attenuator in order to prevent the direct transmission of high intensity noise to areas outside the test chamber.

2. PROGRESSIVE WAVE TUBES.

A parallel sided duct usually forms the working section of such a progressive noise facility. This may be circular or rectangular in section to suit the test requirements. For testing panels, a rectangular section may be more suitable while an aircraft carried store may be more conveniently tested in a duct of circular section. Noise is generated by an air modulator coupled into one end of the working section by a suitable horn. From the opposite end of the plain duct another horn couples the noise into an absorbing termination. Maximum absorption over the operating frequency range is required here in order to minimize standing wave effects in the duct. Noise then progresses along the duct and is applied with grazing incidence over the surface of the test item. The test item itself may be mounted within the duct in which case the grazing incidence wave will be applied over the whole of its external surface. Alternatively, the test item may be mounted in the wall of the duct when the noise will be applied to only that surface within the duct, e.g., on one side of a panel. The method used will depend upon the test item and its in-service application.

3. ACOUSTIC NOISE CHARACTERISTICS.

Radiated high intensity noise is subjected to distortion due to adiabatic heating. Thus, due to heating of the high pressure peaks and cooling of the rarefaction troughs, the local speed of propagation of these pressures are modified. This causes the peaks to travel faster and the troughs to travel slower than the local speed of propagation such that, at a distance from the source, a sinusoidal wave becomes triangular with a leading shock front. This waveform is rich in harmonics and therefore the energy content is extended into a higher frequency range. It can be seen from this that it is not possible to produce a pure sinusoidal tone at high noise intensities. The same effect takes place with high intensity random noise that is commonly produced by modulating an airflow with a valve driven by a dynamic actuator. Due to velocity and/or acceleration restraints on the actuator, it is not possible to modulate the airflow at frequencies greater than about 1 kHz. Acoustic energy above this frequency, extending to 20 kHz or more, therefore results from a combination of cold air jet noise and harmonic distortion from this lower frequency modulation.

4. CONTROL STRATEGIES.

Microphones are normally used to monitor and control the test condition. When testing stores and missiles, it is recommended that not less than three microphones be used to control the test. Some test items may be more effectively monitored on their vibration response; in which case, follow the monitoring requirements of method 514.5, as appropriate. Use a monitoring system capable of measuring random noise with a peak to rms ratio of up to 3.0. Correct pressure calibrated microphones used in reverberation chambers for random incidence noise, while correcting those used in progressive wave tubes for free field grazing incidence noise, and ensure both have a linear pressure response. Provide for averaging the outputs of the microphones to provide the spatial average of the noise for control purposes.

5. DEFINITIONS.

5.1 Sound Pressure Level.

The sound pressure level (Lp) is the logarithmic ratio of the sound pressures

$$Lp = 10 \log \frac{l}{l_0} = 20 \log \frac{P}{P_0}$$

expressed as:

where l_0 = reference intensity = 10^{-12} Wm^{-2}
and P_0 = reference pressure = 20×10^{-6} Pa

5.2 Third Octave Filters.

The center frequency, f_0, of a third octave filter is:

$$f_0 = (f_1 \times f_2)^{1/2}$$

where f_1 = lower -3dB frequency
and f_2 = upper -3dB frequency

The relationships between the upper and lower -3dB frequencies are:

$$\frac{(f_2 - f_1)}{f_0} = 0.23$$

$$f_2 = 2^{1/3} f_1$$

Standard third octave bands are defined in International Specification ISO 266. For other definitions relevant to random vibration and data analysis, refer to method 514.5 or to NATO STANAG 4370, AECTP 400, method 401.