SURFACE VEHICLE STANDARD

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Horn - Forward Warning - Electric - Performance, Test, and Application

RATIONALE

Test of performance of horns by several manufacturers revealed that the predominant frequency was sometimes higher than the standard specified maximum of 2800 Hz, while all horns contained a rich spectrum of harmonic frequencies, starting below 500 Hz and reaching beyond 2800 Hz. To better describe such frequency content, definitions of excitation and fundamental frequencies, low and high sound frequency zones are added.

Added requirements for low and high frequency content will ensure that the horn sound is not concentrated in a narrow frequency band and will increase audibility of the horn signal in presence of masking sounds. Low frequency zone limit of 700 Hz will ensure at least five harmonics in the specified band ending at 3500 Hz.

The upper limit for predominant frequency increase from 2800 to 3500 Hz can only be supported when low frequency sound components are added to the requirements.

Low frequency requirement helps distinguish the horn sound from the warning sirens and back up alarms.

Rest time between successive sound measurements is added to avoid horn overheating.

Distance between horn and microphone is specified at 2.4 m to avoid near field measurements at low frequencies.

Moved predominant frequency definition from Requirements to Definitions section.

Replaced magnetic tape recorder with sound recorder to remove an obsolete term.

Clarified confusing g and displacement values in vibration test.

1. SCOPE

The scope of this SAE Standard is the definition of the functional, environmental, and life cycle test requirements for electrically operated, operator controlled forward warning horn devices, primarily intended for use on self-propelled, work machines as defined by SAE J1116 (limited to categories of (1) construction and (2) general purpose industrial).

1.1 Purpose

The purpose of this document is to define a set of performance requirements for electric warning horns, independent of machine usage. The laboratory tests defined in this document are intended to provide a uniform and repeatable means of verifying whether or not a test horn meets the stated requirements. For on-machine requirements and test procedures, refer to ISO 9533.

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For more information on this standard, visit
https://www.sae.org/standards/content/J1105_202208/

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J184 Qualifying a Sound Data Acquisition System

SAE J1116 Categories of Off-Road Self-Propelled Work Machines

2.1.2 ANSI Accredited Publications

Copies of these documents are available online at http://webstore.ansi.org/.

ANSI S1.4 Specifications for Sound Level Meters

ANSI S1.40 Specification for Acoustical Calibrators

2.1.3 ISO Publications

Copies of these documents are available online at https://webstore.ansi.org/.

ISO 12103-1 Road vehicles - Test dust for filter evaluation

2.1.4 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM B117 Method of Salt Spray (Fog) Testing

ASTM C423-02a Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method

ASTM E1050-98 Standard Test Method for Impedance and Absorption of Acoustical Materials Using a Tube, Two Microphones and a Digital Frequency Analysis System

2.1.5 Military Publications

Available from U.S. Government, DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-2179, http://assist.daps.mil or http://stinet.dtic.mil.

MIL-STD-810B Environmental Test Methods 510 and 514.1

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J994 Alarm - Backup - Electric Laboratory Performance Testing

SAE J1211 Handbook for Robustness Validation of Automotive Electrical/Electronic Modules

SAE J1455 Recommended Environmental Practices for Electronic Equipment Design in Heavy-Duty Vehicle Applications

SAE J1849 Emergency Vehicle Sirens

2.2.2 ANSI Accredited Publications

Copies of these documents are available online at http://webstore.ansi.org/.

ANSI S1.1 Acoustical Terminology

ANSI S1.13 Methods for the Measurement of Sound Pressure Levels

ANSI S1.2 Physical Measurement of Sound

2.2.3 ISO Publications

Copies of these documents are available online at https://webstore.ansi.org/.

ISO 9533 Earthmoving Machinery - Machine Mounted Forward and Reverse Audible Warning Alarm - Sound Test Method.

3. DEFINITIONS

3.1 FORWARD WARNING HORN SYSTEM

The forward warning horn system for purposes of this document consists of a horn and an actuating switch (see Figure 1). The horn is defined as an operator controlled audible warning device.

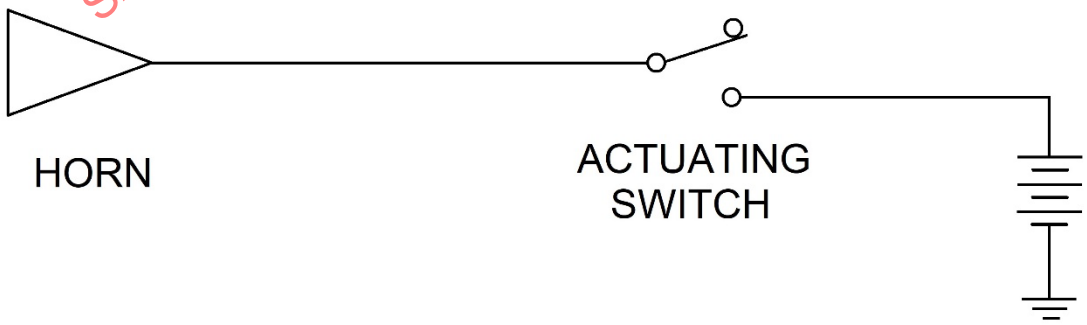

Figure 1 - Forward warning horn system schematic

3.2 FREE FIELD

A free field, for the purposes of this document, is defined as an essentially open, acoustically non-reflective space such as an anechoic chamber or outdoors. No more than one reflective surface (other than a hard floor or ground surface, see 6.2) may be present, and that surface must be more than 15 m from the sound source.

3.3 HORIZONTAL REFLECTING PLANE

A horizontal reflecting plane is defined as a hard reflecting flat ground surface (e.g., concrete or non-porous asphalt). A paved parking lot with consideration to the free field requirements of 3.2 would be an acceptable horizontal reflecting plane for the tests outlined in this document.

3.4 ZERO DEGREE AXIS

A line known as the "zero-degree axis" is defined to correspond to the centerline of the sound producer, perpendicular to and extending outward from the output face of the horn.

3.5 SAMPLE HORN

The sample horn shall consist of a horn randomly drawn from the production population. The same sample horn shall be used for all of the functional, environmental, and life tests.

3.6 EXCITATION FREQUENCY

The frequency at which the horn system is electrically or mechanically operated in order to generate sound. The sound frequency may be different from the excitation frequency due to resonant and filtering effects in the system.

3.7 FUNDAMENTAL SOUND FREQUENCY

The first harmonic in a series of harmonic frequencies produced by the horn. Each harmonic frequency is a multiple of the fundamental frequency. If a harmonic series cannot be identified, the fundamental frequency shall be defined as the lowest significant sound frequency generated by the horn.

3.8 HIGH SOUND FREQUENCY ZONE

The range of sound frequencies produced by the horn from 700 to 3500 Hz, excluding 700 Hz.

3.9 LOW SOUND FREQUENCY ZONE

The range of lower sound frequencies produced by the horn from 250 to 700 Hz, including 700 Hz.

3.10 PREDOMINANT FREQUENCY

The frequency that produces the highest A-weighted sound pressure level.

3.11 NEAR FIELD

A zone, surrounding a sound source, within which, sound level measurements cannot be accurately measured. For the requirements of this document the depth of the near field zone is equal to twice the wavelength of the lowest significant frequency of the test horn to be measured.

3.12 TEST VOLTAGES

The nominal, extreme low, and extreme high system test voltages are defined for each system voltage in Table 1. All voltages are in volts, measured at the input terminals of the horn, when the horn is operating.

NOTE: The nominal operating voltage(s) must be indicated on the horn. On multi-voltage horns the upper and lower nominal operating voltages appropriate for the horn shall be marked on the horn (see Table 1) for example a 12-to-36-V horn must be marked 12 to 36 V.

Table 1 - System test voltages

Nominal System Voltage	Normal System Voltage	Extreme Low System Voltage	Extreme High System Voltage
12 (IC)	13.6	9.0	16.3
24 (IC)	27.2	17.9	32.6
24 (E)	25.6	21.8	29.4
36 (E)	38.4	32.6	44.2
42 (IC)	47.6	38.0	53.0
48 (E)	51.2	43.5	58.9
72 (E)	76.8	65.3	88.3
80 (E)	85.3	72.5	98.1
96 (E)	102.4	87.0	117.8

IC – Internal Combustion, engine running for normal and extreme high voltages, engine off for extreme low voltage
E – Electric (Battery Powered)

NOTE: The nominal system voltages are calculated as 2.0 V per cell. The normal system voltages are calculated as 2.133 V per cell for electric (E) vehicles and 2.267 V for internal combustion (IC) vehicles. The difference accounts for the charging systems increasing the system voltage.

For electric vehicles, extreme high and low system voltages are calculated as 15% above and below normal system voltages, representing fully charged and discharged battery levels.

Internal combustion (IC) vehicles are subject to possible alternator failures causing excessively high voltages. For the IC vehicles at 12 and 24 nominal voltages, extreme high system voltages are calculated as 20% above their normal system voltage. The extreme low system voltage is calculated as 30% below the normal system voltage of an equivalent electric vehicle to represent a battery discharge condition with the engine off. The IC vehicles at 42 V nominal voltage are more tightly regulated as taken from the former revision of this standard.

4. TEST SEQUENCE

All functional and performance tests shall be conducted in the order in which they are presented. The same sample horn shall be used for all the functional, environmental, and life tests.

5. INSTRUMENTATION

Persons technically trained and experienced in current techniques of sound measurement should select and operate the equipment. Accepted engineering judgment, including an assessment of the “state-of-the-art” with respect to test equipment, facilities, and test personnel, should be used when establishing specific test procedures used to verify compliance with the requirements of this standard. When single-sided test parameters are specified, such as “minimum,” “maximum,” and “at least,” it is intended that the required specific parameter be met, with the constraint that deviations from the nominal parameter value (on the open-ended side) be minimized. When non-specific parameter tolerances are used, such as “approximately,” it is intended that deviations from the nominal parameter be minimized.

5.1 A sound level meter which meets the Type I requirements of ANSI S1.4.

5.2 As an alternative to making direct measurements using a sound level meter, a microphone or sound level meter may be used with a sound recorder and/or a graphic level recorder or indicator meter, provided the system meets the requirements of SAE J184 for the frequency range that is of primary concern. The deviations in the sound recorder frequency response from flat response, especially at lower frequencies, must not affect the overall reading by more than ±0.5 dB.

5.3 An acoustical calibrator that meets the requirements of ANSI S1.40 (accuracy within ±0.5 dB).

5.4 A temperature measuring system accurate to ±0.5 °C over the range of -40 to +85 °C.

5.5 A voltage measuring system accurate to ±0.1 V over the range of extreme system voltages for the tested system voltage(s).

5.6 Vibration apparatus.

5.7 Environmental chamber.

5.8 Dust chamber.

5.9 Rain, steam, and corrosion chamber.

6. SOUND PRESSURE LEVEL TEST SETUP

Two acceptable test methods are described for measuring the radiated sound pressure level of the horn.

6.1 Test Method 1

The horn is located in a free field or an equivalent fully anechoic room. The microphone is directed toward the horn sound output opening along the zero-degree axis and at the distance specified by the test requirements.

6.2 Test Method 2

This is an alternative method for testing a horn's sound level without the aid of an anechoic room. The horn is located in a free field except for a horizontal reflecting plane and an acoustical barrier partition. The acoustical barrier partition must be constructed.

6.2.1 Required Materials for Acoustical Barrier

Unless otherwise specified, all dimensional tolerances are ±10 mm.

Two pieces of particle board 900 x 1200 mm; 16 mm ± 2 mm thick.

Two tripods adjustable to 1200 mm high.

Three each 200 x 200 mm, 90-degree angle sheet metal shelf brackets.

Two sections of sound absorbing material of dimensions 1200 x 1350 mm and a thickness of 50 mm or greater.

The sound absorbing material should have energy absorption efficiency (acoustic absorption coefficient) of at least 0.5 at 250 Hz, rising to no less than 0.95 at 1000 Hz, and a Noise Reduction Coefficient (NRC) rating of no less than 0.90.

6.2.2 Construction of Acoustical Barrier

Using the three 200 mm shelf brackets and screws, attach one of the two 900 x 1200 mm particle boards perpendicularly in the center of the other board to yield a 900 mm high wall as shown in Figure 2. Two brackets should be located 150 mm from the outside edge on one side of the upright board. The third bracket should be mounted in the center on the other side of the upright board. Cover the exposed particleboard with the sound absorbing foam as shown in Figure 2.

6.2.3 Horn and Microphone Locations

The horn to be tested shall be mounted in the manner specified by the horn manufacturer. The horn shall be rigidly fixed on a steel base (mounting fixture) the mass of which should exceed 30 times that of the horn to be tested. Secure the horn to the mounting fixture. When using test method 2, position the horn and microphone on opposite sides of and equidistant from the sound barrier at a height of 1.20 m ± 0.01 m above the horizontal reflecting plane. The distance between the horn and the microphone shall be 2.4 m. The sound level will be increased by 6 dB to adjust it to the reference distance of 1.2 m. The reference distance cannot be used directly because it may be in the near field for the low frequencies.

6.3 Allowable Background Noise Level

While the sound pressure level test is in progress, the sound pressure level due to all sources other than the horn device shall be at least 15 dB lower than the sound pressure level of the horn. This precaution reduces the effect of background noise on the sound level test results.

6.4 Sound Level Meter Settings

The sound level meter shall be set for fast response per ANSI S.1.4 Section 6 and have the A-weighting network installed when checking sound pressure levels.

6.5 Instrumentation Precautions

Proper usage of all test instrumentation is essential to obtain valid measurements. Operating manuals or other literature furnished by the instrument manufacturer should be referred to for both recommended operation of the instrument and precautions to be observed. Specific items to review include:

6.5.1 The Microphone

In selecting the type of microphone, its directional response characteristics and its orientation relative to the ground plane and source of noise should be considered.

6.5.2 Calibration

Field calibration should be made immediately before each test sequence. Internal calibration means are acceptable for field use, provided that external calibration is accomplished immediately before field use.

6.5.3 Windscreens

When using a windscreen, it should be calibrated for the type of noise source being measured and data corrected if necessary. It is recommended that measurements be made only when the wind speed is below 19 km/h.

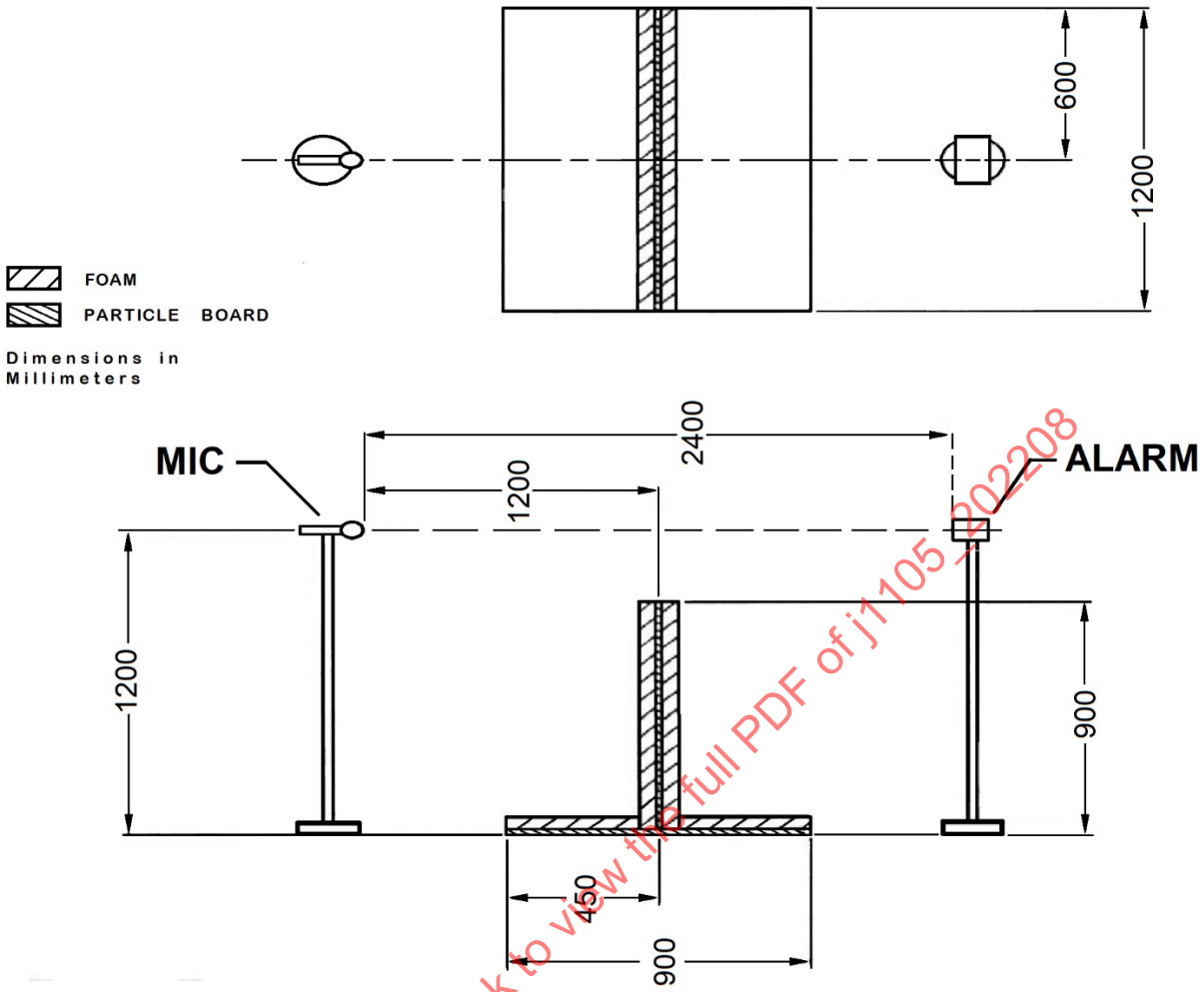

Figure 2 - Acoustical barrier dimensions for test method 2

7. FUNCTIONAL TEST REQUIREMENTS

Unless otherwise specified, data measurements shall be taken during a minimum test period of 5 seconds of operation at ambient temperature of 25 °C ± 1 °C and nominal system voltage(s) (±0.1 VDC) for the tested system voltage(s) in Table 1, with a rest period of 30 seconds between activations.

7.1 Predominant Sound Frequency

Measure and record the predominant sound frequency of the horn. The acceptable predominant frequency range is 250 to 3500 Hz.

7.2 Significant Sound Frequencies and Levels

Measure and record the sound levels and frequencies contained in the sound of the horn that have sound levels within 30 dB of the strongest tone in each frequency zone in accordance with 7.4 and 7.6.

7.3 Low and High Frequency Zones

To ensure a rich sound signature, recognizable as a forward horn, and detectable in presence of masking sounds, the horn sound shall contain tones in both low and high sound frequency zones.

7.4 Low Frequency Zone

The low frequency zone shall contain at least one tone within 25 dB of the predominant frequency. This tone can be the fundamental frequency tone, a harmonic, or a product of the excitation frequency that falls within the low frequency zone. This tone frequency should be equal to the frequency difference of two significant tones in the high frequency zone to support a fundamental tone recognition.

7.5 Product of Excitation Frequency

If the excitation frequency of the horn is below 250 Hz, the sound level of the tones within the low frequency zone should be at least 6 dB higher than any sound content below 250 Hz.

7.6 High Frequency Zone

The high frequency zone shall contain at least two tones within 15 dB of the predominant frequency tone. These tones shall be spaced at between 250 and 700 Hz, so that their frequency difference is equal to a significant frequency in the lower frequency range.

7.7 Sound Pressure Level

Measure and record the sound pressure level of the horn at all nominal system voltages included in the voltage range of the horn using the methods of 6.1 or 6.2. The microphone shall be placed on the zero-degree axis of the horn at a distance of 2.4 m from the front face of the horn. The resulting sound pressure level shall be increased by 6 dB to scale it to the reference distance of 1.2 m, used to rate the horns. The horn shall be designated according to the types listed in Table 2. The measured sound pressure level for the sample horn must be within ±4 dB of the reported type. The sound pressure level rating in dB(A) and the associated type shall be clearly identified on the horn.

Table 2 - Sound level type rating at 1.2 m

Type J	117 dB(A)
Type K	112 dB(A)
Type L	107 dB(A)
Type M	97 dB(A)
Type N	87 dB(A)
Type O	Other; as specified by the manufacturer

Unless otherwise stated, the variation on sound pressure level measurements is ±4 dB of the stated type.

7.8 Sound Pressure Level Change with Voltage

Measure and record the sound pressure level at the extreme system voltages appropriate for the horn (see Table 1) for example a 12-to-24-V horn must be tested at extreme system voltages of 9 V and 32.6 V. The sound pressure level shall not vary more than ±8 dB from the baseline data measured in 7.7.

7.9 Horn Activation Delay

Measure and record the delay between power application and horn activation. The horn activation delay shall be defined by the time difference between power application to the input terminals of the horn and electrical signal appearing across the terminals of the sound transducer. The horn activation delay shall be no more than 100 ms.

8. ENVIRONMENTAL TEST REQUIREMENTS

Unless otherwise specified, data measurements shall be taken after a minimum of 5 seconds of operation at ambient temperature of 25 °C ± 11 °C and nominal system voltage(s) (±0.1 VDC) for the tested system voltage(s) in Table 1, with a rest period of 30 seconds between activations.

8.1 Low Temperature Tests

Temperature soak the horn in the environmental chamber at -40 °C ± 3 °C for a minimum of 2 hours prior to the following tests. Remove the horn from the environmental chamber to make measurements. Unless otherwise specified, it is required that the following measurements be made within 2 minutes of removing the horn from the environmental chamber. If all required measurements cannot be made within the 2-minute allotted time interval, the temperature soak must be repeated for an additional 1 hour prior to proceeding with additional measurements.

8.1.1 Low Temperature, Nominal System Voltage

Within 2 minutes after removing the horn from the environmental chamber, measure and record the sound pressure level of the horn for all included nominal system voltages within the voltage range of the horn (see Table 1). The sound pressure level must be within ±8 dB of the baseline data measured in 7.7. Repeat 7.1. The predominant sound frequency shall be within the frequency range specified in 7.1.

8.1.2 Low Temperature, Extreme System Voltages

Within 2 minutes after removing the horn from the environmental chamber, measure and record the sound pressure level of the horn for both extreme system voltages for the tested system voltage(s) in Table 1. The sound pressure level shall be within ±8 dB of the baseline data for the respective nominal system voltage(s) measured in 7.7 that is closest to the extreme system voltage(s) appropriate for the horn (see Table 1). For example, a 12-to-36-V horn requires baseline data for 12, 24, and 36 V, in this case the extreme voltages to be applied are 9 and 44.2 V.

8.1.3 Room Temperature Check

Subsequent to performing the measurements in 8.1.1 and 8.1.2, allow the horn to warm up to 25 °C ± 11 °C for a minimum of 1 hour. Repeat 7.7. The horn shall meet the sound pressure level requirements of 7.7. Repeat 7.1. The predominant sound frequency shall be within the frequency range specified in 7.1.

8.2 High Temperature Tests

Temperature soak the horn in the environmental chamber at 85 °C ± 3 °C for a minimum of 2 hours prior to the following tests. Remove the horn from the environmental chamber to make measurements. Unless otherwise specified, it is required that the following measurements be made within 2 minutes of removing the horn from the environmental chamber. If all required measurements cannot be made within the 2-minute allotted time interval, the temperature soak must be repeated for an additional 1 hour prior to proceeding with additional measurements.

8.2.1 High Temperature, Nominal System Voltage

Within 2 minutes after removing the horn from the environmental chamber, measure and record the sound pressure level of the horn for all included nominal system voltages within the voltage range of the horn (see Table 1). The sound pressure level must be within ±8 dB of the baseline data measured in 7.7. Repeat 7.1. The predominant sound frequency shall be within the frequency range specified in 7.1.

8.2.2 High Temperature, Extreme System Voltages

Within 2 minutes after removing the horn from the environmental chamber, measure and record the sound pressure level of the horn for both extreme system voltages for the tested system voltage(s) in Table 1.

The sound pressure level shall be within ±8 dB of the baseline data for the respective nominal system voltage(s) measured in 7.7 that is closest to the extreme system voltage(s) appropriate for the horn (see Table 1). For example, a 12-to-48-V horn requires baseline data for 12, 24, 36 and 48 V, in this case the extreme voltages to applied are 9 and 58.9 V.

8.2.3 Room Temperature Check

Subsequent to performing the measurements in 8.2.1 and 8.2.2, allow the horn to cool to 25 °C ± 11 °C for a minimum of 1 hour. Repeat 7.7. The horn shall meet the sound level requirements of 7.7. The predominant sound frequency shall be within the frequency range specified in 7.1.

8.3 Rain Test

Mount a sample horn, not in operation, such that the zero-degree axis of the horn is horizontal. Subject all exposed sides of the horn to simulated blown rain for a minimum of 2 hours. Simulated blown rain is defined as having a precipitation rate of 2.5 (+1.6/–0) mm of water per minute (as measured with a vertical cylindrical collector having a height of approximately 100 mm and the inside diameter shall be a minimum of 140 mm, centered on the vertical axis of the test platform), delivered at an angle of 45 degrees from a nozzle with a solid cone spray. Within 2 minutes after removal of the horn from the rain test, repeat 7.7. The horn shall meet the sound pressure level requirements of 7.7 within 1 minute of activation of the device. The predominant sound frequency shall be within the frequency range specified in 7.1.

8.4 Vibration Tests

A sample horn, as mounted on the supports supplied, shall be bolted to the table of the vibration test machine and the test conducted as follows with the horn in operation at a cycle of 1 second of power and 4 seconds off.

8.4.1 Resonance Search

Determine and record the resonant frequencies of the horn for each position (x-y-z axis) by slowly varying the frequency of applied vibration through 10 to 500 Hz with sufficient amplitude to excite the horn. Resonance of components is determined by strain-gauging of components, observing signal interruptions of the electronic circuit, or a combination of these (see Figure 3). If an accelerometer is used its mass must be 2% or less of the mass of the unit under test.

8.4.2 Resonance Dwell

Vibrate the horn item for 30 minutes at a 10 g peak level as measured on the device at the most severe resonant frequency and at no less than three other significant resonant frequencies (if they were found) along each axis as determined in 8.4.1. For resonant frequencies below 27 Hz, vibrate at a constant displacement (double amplitude) of 6.76 mm as shown in Figure 3. If the resonance frequency changes during this test, immediately record its time of occurrence and adjust the frequency to maintain peak resonance. Record the final resonance frequency.

8.4.3 Vibration Cycling

Use a cycle time of 15 minutes to ascend to 500 Hz and descend to 27 Hz (see Figure 3). Vibration cycling will be along each axis (x-y-z) at 10 g (peak) above 27 Hz. The total cycling time for each axis is 3 hours, minus the time spent on the axis for the resonant dwell test in 8.4.2 (MIL-STD-810B Method 514.1). During the final 15-minute cycle (on axis checked last), connect the nominal system voltage to the horn. It must be applied through a switching device so that the horn receives power in cycles of 1 second on and 4 seconds off ±10%. Check that the horn functions continuously throughout the ‘on’ cycle. At the end of the vibration test, repeat 7.7. The horn shall meet the sound pressure level requirements of 7.7. The predominant sound frequency shall be within the frequency range specified in 7.1.