SAE International™ SURFACE VEHICLE STANDARD

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Alarm—Backup—Electric Laboratory Performance Testing

Foreword—This document has been modified to include additional system voltages and reduce the upper limit of the acceptable frequency range. Additional modifications have been made to clarify ambiguous sections of the Standard. Rationale for the modifications is included at the end of this document.

1. Scope—The scope of this SAE Standard is the definition of the functional, environmental, and life cycle test requirements for electrically operated backup alarm devices primarily intended for use on off-road, 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 backup alarms, 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 alarm meets the stated requirements. For on machine requirements and test procedures, refer to SAE J1446.

2. References

2.1 Applicable Publications—The following publications form a part of the specification to the extent specified herein. Unless otherwise indicated, the latest revision of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J184—Qualifying a Sound Data Acquisition System
SAE J1116—Categories of Off-Road Self-Propelled Work Machines
SAE J1446—On-Machine Alarm Test and Evaluation Procedure for Construction and General Purpose Industrial Machinery

2.1.2 ANSI PUBLICATIONS—Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002.

ANSI S1.4—Specification for Sound Level Meters
ANSI S1.40—Specification for Acoustical Calibrators

2.1.3 ASTM PUBLICATION—Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM B 117—Method of Salt Spray (Fog) Testing

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2.1.4 MIL SPECIFICATION—Available from Defense Printing Service, Detachment Office, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.

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 document.

2.2.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J1105—Performance, Test and Application of Electric Forward Warning Horn
SAE J1211—Recommended Environmental Practices for Environmental Electronic Equipment
SAE J1455—Recommended Environmental Practices for Electronic Equipment Design (Heavy-Duty Trucks)
SAE J1849 – Emergency Vehicle Sirens

2.2.2 ANSI PUBLICATIONS—Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002.

ANSI S1.1—Acoustical Terminology
ANSI S1.13—Methods for the Measurement of Sound Pressure Level

3. Definitions

3.1 Free Field—A free field, for the purposes of this document, is defined as a space with no reflecting surface within 15 m of the sound source in any direction.

3.2 Horizontal Reflecting Plane—A horizontal reflecting plane is defined as flat ground with a surface no rougher than an asphalt road. A paved parking lot with no reflecting surfaces within 15 m would be an acceptable horizontal reflecting plane for the tests outlined in this document.

3.3 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 alarm.

3.4 Sample Alarm—A sample alarm shall consist of an alarm randomly drawn from the production population.

3.5 Predominant Sound Frequency—The predominant sound frequency of the alarm shall be defined as the frequency that produces the highest A-weighted sound pressure level. This frequency may or may not correspond to the fundamental frequency produced by the alarm.

3.6 Test Voltages—The nominal, extreme low, and extreme high system test voltages are defined for each system voltage in Table 1. All voltages are ±0.2 V, measured at the input terminals of the alarm when the alarm is operating.

3.6.1 TEST VOLTAGE TABLE

NOTE— On multi-voltage alarms, use the extreme low system voltage from the lowest system voltage included in the multi-voltage range, and the extreme high system voltage from the highest included voltage range, and all included nominal voltages, unless otherwise specified.

TABLE 1—TEST VOLTAGES

System Voltage[1]	Nominal System Voltage	Extreme Low System Voltage	Extreme High System Voltage
12 (IC)	14.0	9.0	16.0
24 (IC)	28.0	18.0	32.0
36 (E)	42.0	27.0	42.0
42 (IC)[2]	49.0	32.0	56.0
48 (E)	56.0	36.0	56.0
72 (E)	84.0	54.0	84.0
80 (E)	94.0	60.0	94.0

1. IC – Internal Combustion E – Electric (Battery Powered)
2. New European Electrical System

The Extreme High System Voltages for System Voltages of 36, 48, 72, and 80 volts are equal to the Nominal System Voltages because these are battery powered (e.g., fork lifts) and will not be subjected to possible alternator failures causing excessively high voltages as in the 12, 24, and 42 volt internal combustion electrical systems.

3.7 **Test Sequence—**All functional and performance tests shall be conducted in the order in which they are presented. The same sample alarm shall be used for all of the Functional, Environmental, and Life Tests.

4. ***Instrumentation—***Persons technically trained and experienced in current techniques of sound measurement should select and operate the equipment. Sound 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.

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

4.2 As an alternative to making direct measurements using a sound level meter, a microphone or sound level meter may be used with a magnetic tape 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 magnetic tape recorder frequency response from flat response, especially at lower frequencies, must not affect the overall reading by more than ±0.5 dB.

4.3 A sound pressure level calibrator meeting the requirement of ANSI S1.40 (accuracy within ±0.5 dB).

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

4.5 A voltage measuring system accurate to ±100 mV over the range of extreme system voltages for the tested system voltage(s).

4.6 Vibration apparatus.

4.7 Environmental chamber.

4.8 Dust chamber.

4.9 Rain, steam, and corrosion chamber.

***5. Sound Pressure Level Test Setup*—**Sound pressure level Test - Two acceptable test methods will be described for measuring alarm sound pressure level.

5.1 Test Method 1—The alarm is located in a free field or an equivalent fully anechoic room. The microphone is directed toward the alarm sound output opening along the zero degree axis and at the distance specified by the test requirements.

5.2 Test Method 2—This is an alternative method for testing an alarm sound pressure level without the aid of an anechoic room. The alarm is located in a free field except for a horizontal reflecting plane and an acoustical barrier partition. The acoustical barrier partition must be constructed.

5.2.1 REQUIRED MATERIALS FOR ACOUSTICAL BARRIER—Unless otherwise specified, all dimensional tolerances are ±10 mm.

a. Two pieces of particle board 900 mm x 1200 mm x 16 mm ± 2 mm thick
b. Two Tripods adjustable to 1200 mm high
c. Three each 200 mm x 200 mm x 90 degree sheet metal shelf brackets.
d. Two sections of sound absorbing foam of dimensions 1200 mm x 1350 mm and a thickness of 50 mm or greater. The sound absorbing foam should have an absorption efficiency of at least 50% at 50 Hz rising to at least 75% at 1000 Hz and greater.

5.2.2 CONSTRUCTION OF ACOUSTICAL BARRIER—Using the three 200 mm shelf brackets and screws, center and attach one of the 900 mm x 1200 mm particle boards perpendicular to the other 900 mm x 1200 mm base board to yield a 900 mm high wall as shown in Figure 1. 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 particle board with the sound absorbing foam as shown in Figure 1.

5.2.3 ALARM AND MICROPHONE LOCATIONS—Secure the alarm and microphone to their tripods. Position the alarm and microphone on opposite sides of and equidistant from the sound barrier at a height of 1200 mm ± 10 mm above the horizontal reflecting plane. The distance between the two devices is specified in 6.3 of the Functional Test Requirements.

5.3 Allowable Background Noise Level—While the sound pressure level test is in progress, the sound pressure level due to all sources other than the alarm device shall be at least 15 dB (A) lower than the sound pressure level of the alarm. This precaution reduces the effect of background noise on the sound pressure level test results.

5.4 Sound Level Meter Settings—The sound level meter shall be set for fast response or equivalent and have the A-weighting network installed when checking sound pressure levels.

5.5 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:

5.5.1 THE MICROPHONE—The type of microphone, its directional response characteristics, and its orientation relative to the ground plane and source of noise.

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

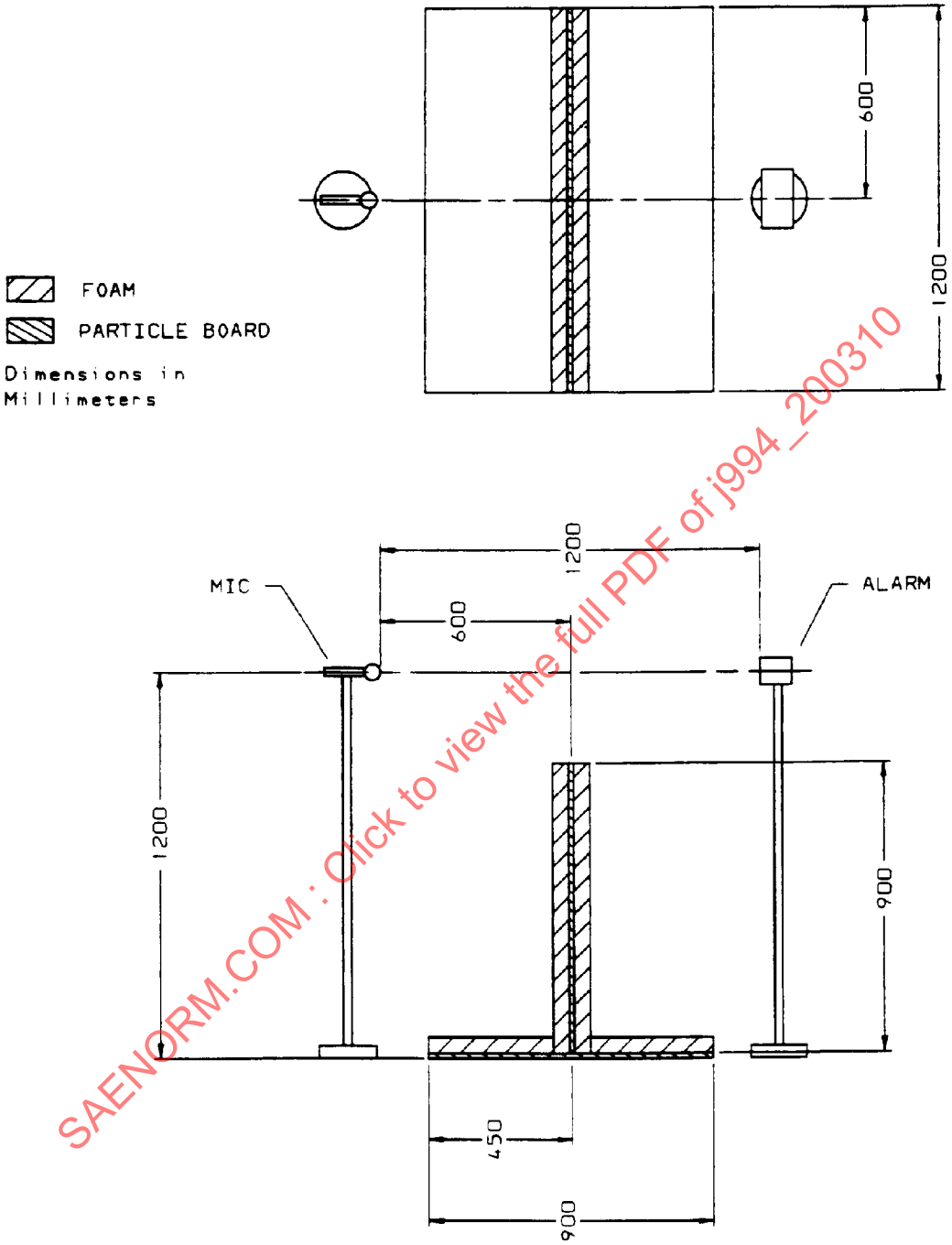

FIGURE 1—ACOUSTICAL BARRIER DIMENSIONS FOR TEST METHOD 2

5.5.3 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.

***6. Functional Test Requirements*—**Unless otherwise specified, data measurements will be taken during a minimum test period of 1 min operation at ambient temperature of 25 °C ± 11 °C and nominal system voltage(s) (± 0.2 VDC) for the tested system voltage(s) in Table 1.

6.1 Predominant Sound Frequency—Measure and record the predominant sound frequency of the alarm. The predominant sound frequency of the alarm shall be defined as the frequency that produces the highest A-weighted sound pressure level. The acceptable frequency range is 700 to 2800 Hz.

6.2 Cyclic Pulsation Rate and Duty Cycle—Measure and record the rate of cyclic sound pressure level pulsations from the alarm and the duration of the "on" and "off" intervals. The cycles of sound pressure level pulsations from the alarm shall be 0.8 to 1.8 Hz. The duration of the "on" interval shall be equal to that of the "off" interval within ±20%, as defined by the formula: ("on" interval minus "off" interval) divided by ("on" interval plus "off" interval), multiplied by 100%.

6.3 Sound pressure level—Measure and record the sound pressure level of the alarm at all nominal system voltages included in the voltage range of the alarm using the methods of 5.1 or 5.2. The microphone shall be placed on the zero axis of the alarm at a distance of 1.2 m ± 0.01 m from the front face of the alarm. The sound pressure level shall be any of the following:

Type A - 112 dB (A)
Type B - 107 dB (A)
Type C - 97 dB (A)
Type D - 87 dB (A)
Type E - 77 dB (A)
Type F – Other

(Sound pressure level rating in dB (A) must be imprinted on the alarm.)

Unless otherwise stated, the tolerance on sound pressure level measurements is ±4 dB (A).

In the case of a Type F alarm, the Manufacturer's stated sound pressure level shall serve as the nominal dB(A) rating to which the ±4 dB tolerance is applied to.

6.4 Sound Pressure Level Change With Voltage—Measure and record the sound pressure level at the extreme operating voltages for the tested system voltage(s) in Table 1. The sound pressure level shall not vary more than ±8 dB from the baseline data given in 6.3.

6.5 Off-Axis Sound Levels

6.5.1 HORIZONTAL MOUNTING SURFACE—All sound pressure level measurements are made at a radius of 1.2 m ± 0.01 m from the sound producer. The initial measurement is on the zero degree axis. Twelve additional measurements are taken at 15 degrees ± 2 degree intervals from –90 to +90 degrees through the horizontal plane by rotating the alarm as shown in Figure 2.

For each location described previously, measure the sound pressure level using either Test Method 1 or Test Method 2 of Section 5. Record the data in Column 2, the form shown in Figure 3. The values recorded in Column 3 of the form are obtained by subtracting the sound pressure level at the zero degree axis from the sound pressure level at each angular position. The data from Column 3 is plotted on the chart of Figure 4 to obtain the profile of sound variation as a function of direction from the alarm. Fill in the blanks and check the appropriate boxes at the tops of the form and the profile sheets.

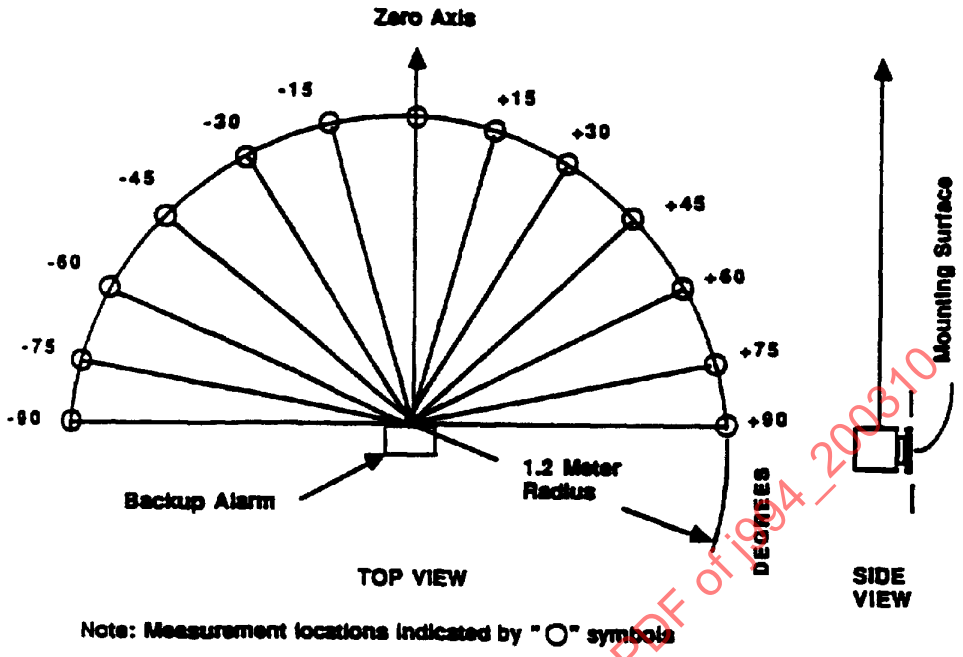

FIGURE 2—BACKUP ALARM SOUND PRESSURE LEVEL MEASUREMENT LOCATIONS—MOUNTING SURFACE HORIZONTAL

6.5.2 VERTICAL MOUNTING SURFACE—The alarm is next rotated 90 degrees about the zero axis, as shown in Figure 5. Repeat the procedure of 6.5.1.

This document does not specify any limitations on sound variation as a function of direction from the alarm but does require that the sound variation profiles be made available upon request.

6.6 Alarm Activation Delay—Measure and record the delay between power application and alarm activation. The Alarm Activation Delay shall be defined by the time difference between power application to the input terminals of the alarm and electrical signal appearing across the terminals of the sound transducer. The Alarm Activation Delay shall be no more than 500 ms.

7. Environmental Tests—Unless otherwise specified, all data measurements will be taken during a minimum test period of 1 min operation at ambient temperature of 25 °C ± 11 °C and nominal system voltage(s) (±0.2 VDC) for the tested system voltage(s) in Table 1.

7.1 Low Temperature Test—Temperature soak the alarm in the environmental chamber at 40 °C ± 3 °C for a minimum of 2 hours prior to the following tests. Remove the alarm 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 alarm 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.

7.1.1 LOW TEMPERATURE, NOMINAL SYSTEM VOLTAGE—Within 2 minutes after removing the alarm from the environmental chamber, measure and record the sound pressure level and predominant sound frequency of the alarm for all included nominal system voltages within the voltage range of the alarm. The sound pressure level must be within ±8 dB (A) of the baseline data measured in 6.3. The predominant sound frequency must be within the range specified in 6.1.

Backup Alarm Sound Level Data Sheet

Manufacturer: _____ Date _____
Alarm Name & Model No.: _____ Sample No. _____
Zero Axis Sound Level (dBA) at 1.2 Meters _____
Test Method 1 ☐ Test Method 2 ☐
Alarm Mounting Position: Vertical ☐ Horizontal: ☐

Angle (Degrees)	Recorded Sound Level (See Note A) (dbA)	Sound Level Deviation (See Note B) (dbA)
-90		
-75		
-60		
-45		
-30		
-15		
0		0
+15		
+30		
+45		
+60		
+75		
+90		

NOTE A—All sound level measurements made at 1.2 m radius from the sound producer, as shown on Figures 2 and 4.

NOTE B—Subtract sound level measured at 0 degree axis from sound level measured at angle.

FIGURE 3—BACKUP ALARM SOUND PRESSURE LEVEL DATA SHEET

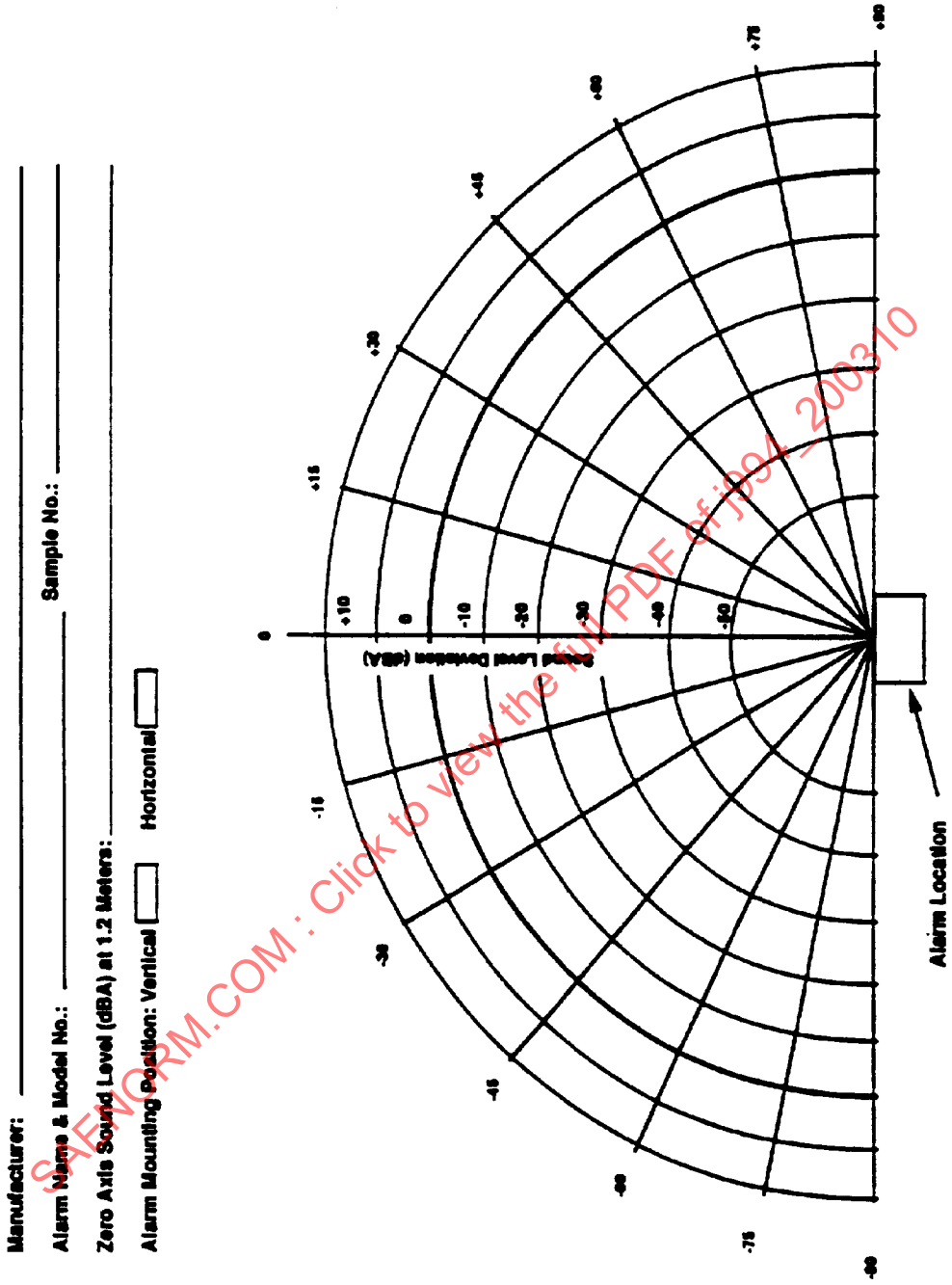

FIGURE 4—SOUND PRESSURE LEVEL DIRECTIONALITY CHART

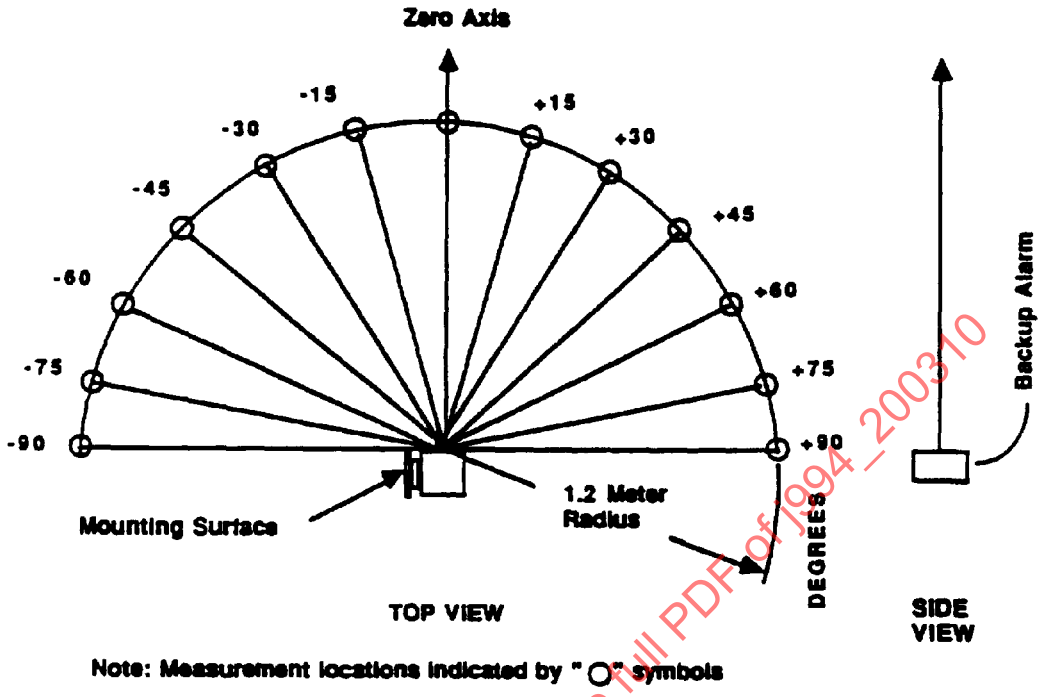

FIGURE 5—BACKUP ALARM SOUND PRESSURE LEVEL MEASUREMENT LOCATIONS—MOUNTING SURFACE VERTICAL

7.1.2 LOW TEMPERATURE, SYSTEM VOLTAGE EXTREMES—Within 2 min after removing the alarm from the environmental chamber, measure and record the sound pressure level and predominate sound frequency of the alarm for both extreme system voltages for the tested system voltage(s) in Table 1. The sound pressure level shall be within ±8 dB (A) of the baseline data for the respective nominal system voltage(s) measured in 6.3 that are closest to the extreme system voltage(s). Repeat 6.1. The predominant sound frequency shall be within the frequency range specified in 6.1.

7.1.3 ROOM TEMPERATURE CHECK—Subsequent to performing the measurements in 7.1.1 and 7.1.2, allow the alarm to warm up to 25 °C ± 11 °C for a minimum of 1 hour. Repeat 6.1 and 6.3. The alarm shall meet the sound pressure level requirements of 6.3. The predominant sound frequency shall be within the frequency range specified in 6.1.

7.2 High Temperature Test—Temperature soak the alarm in the environmental chamber at 85 °C ± 3 °C for a minimum of 2 hours prior to the following tests. Remove the alarm 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 alarm 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.

7.2.1 HIGH TEMPERATURE, NOMINAL SYSTEM VOLTAGE—Within 2 minutes after removing the alarm from the environmental chamber, measure and record the sound pressure level and predominant sound frequency of the alarm for all included nominal system voltages within the voltage range of the alarm. The sound pressure level shall be within ±8 dB (A) of the baseline data measured in 6.3. Repeat 6.1. The predominant sound frequency shall be within the range specified in 6.1.

7.2.2 HIGH TEMPERATURE, SYSTEM VOLTAGE EXTREMES—Within 2 minutes after removing the alarm from the environmental chamber, measure and record the sound pressure level and predominant sound frequency of the alarm for the extreme system voltages for the tested system voltage(s) in Table 1. The sound pressure level shall be within ± 8 dB (A) of the baseline data for the respective nominal system voltage(s) measured in 6.3 that are closest to the extreme system voltage(s). Repeat 6.1. The predominant sound frequency shall be within the frequency range specified in 6.1.

7.2.3 ROOM TEMPERATURE CHECK—Subsequent to performing the measurements in 7.2.1 and 7.2.2, allow the alarm to cool to 25 °C ± 11 °C for a minimum of 1 hour. Repeat 6.1 and 6.3. The alarm shall meet the sound level requirements of 6.3. The predominant sound frequency shall be within the range specified in 6.1.

7.3 Rain Test—Mount a sample alarm, not in operation, such that the zero axis of the alarm is horizontal. Subject all exposed sides of the alarm item to simulated blown rain for a minimum of 2 hours. Simulated blown rain is defined as having with a precipitation rate of 2.5 (+1.6/–0) mm 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 1 min after removal from the rain test, repeat 6.1 and 6. The sound pressure level shall meet the requirements of 6.3. The predominant sound frequency shall be within the frequency range specified in 6.1.

7.4 Vibration Test—A sample alarm, 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 alarm in operation.

7.4.1 RESONANCE SEARCH—Determine and record the resonant frequencies of the test item 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 item. Resonance of components is determined by visual observation, strain-gaging of components, observing signal interruptions of the electronic circuit, or a combination of these. See Figure 6.

7.4.2 RESONANCE DWELL—Vibrate the test item for 30 min at a 10 g (peak to peak) level at the most severe resonant frequency and at no more than three other significant resonant frequencies (if they were found) along each axis as determined in 7.4.1. For resonant frequencies below 27 Hz, vibrate at a constant amplitude of 6.76 mm as shown in Figure 6. If the resonance frequency changes during this test, immediately record its time of occurrence and adjust the frequency to maintain peak resonance. Record final resonance frequency.

7.4.3 VIBRATION CYCLING—Use a cycle time of 15 min to ascend to 500 Hz and descend to 27 Hz (refer to Figure 6). Vibration cycling will be along each axis (x-y-z) at 10 g (peak to peak) above 27 Hz. The total cycling time for each axis is 3 h minus the time spent on the axis for the resonant dwell test in 7.4.2 (MIL-STD-810B Method 514.1). During the final 15 minute cycle (on axis checked last), connect the power to the alarm to check that it functions continuously throughout the cycle. At the end of the vibration test, repeat sections 6.1 and 6.3. The alarm shall meet the sound pressure level requirements of 6.3. The predominant sound frequency shall be within the frequency range specified in 6.1.

7.5 Corrosion Test—Subject a sample alarm, not in operation, to a salt spray (fog) test in accordance with ASTM B 117. Duration of test is to be 50 hours. The test is to consist of a 24-hour exposure, followed by a 1-hour drying time, and then a second 24-hour exposure, followed by a 1-hour drying time. At the end of the last drying time repeat 6.1 and 6.3. The alarm shall meet the sound pressure level requirements of 6.3. The predominant sound frequency shall be within the frequency range specified in 6.1.

TEST SCHEDULE

Equipment	APPLICABLE TESTS: Resonance Search	Resonance Dwell	Sinusoidal Cycling	TEST TIME SCHEDULE (PER AXIS): Dwell Time at Each Resonance	Sinusoidal Cycling Time	Sweep Time 10-500-10 H_2
BACKUP ALARM SYSTEM	X	X	X	30 Min	3 H-Less Dwell Time	15 Min

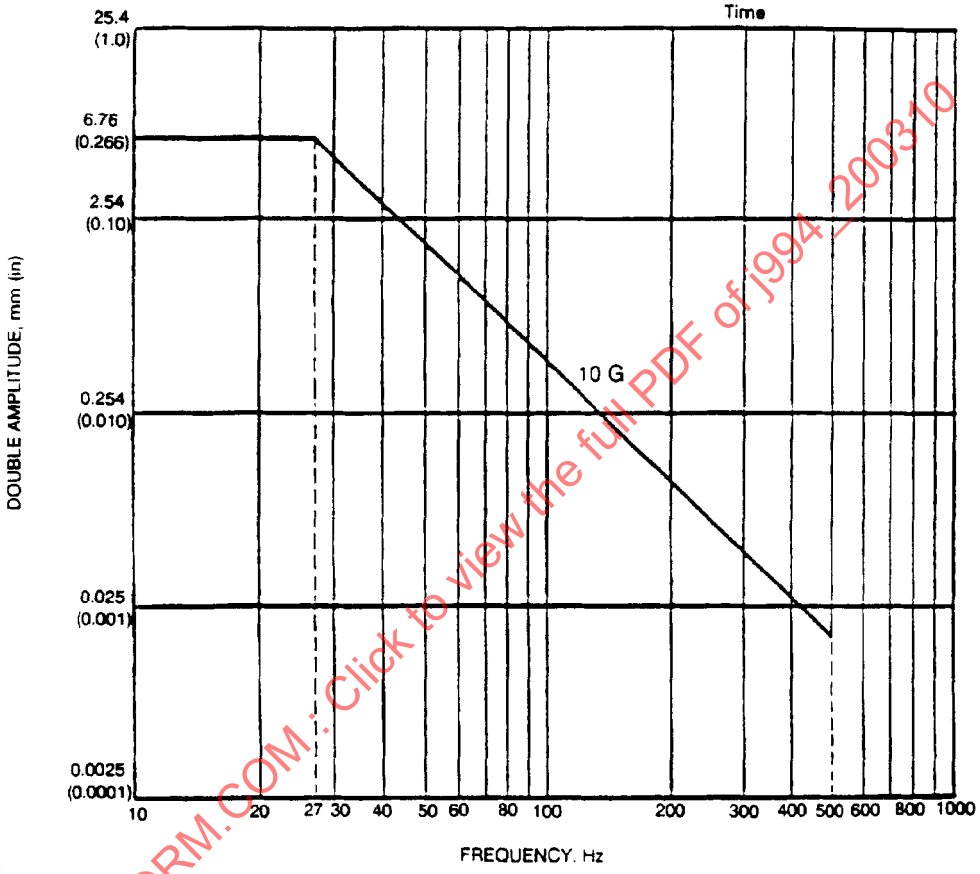

FIGURE 6—VIBRATION TEST

7.6 High Pressure Hot Water Test—Direct at a sample alarm, not in operation, a spray of hot water and detergent solution (consisting of at least 15 g of Tri-Sodium Phosphate per liter of water), at a minimum of +85 °C temperature, and a minimum of 6.9 MPa pressure delivered at a minimum of 18.9 liter/minute flow rate through a 15 degree spray angle nozzle, at the alarm sound opening at a maximum distance of 300 mm. Direct the spray back and forth across the alarm sound opening in a sweeping motion for a minimum of 10 seconds followed by a 30 second maximum drain time. Repeat the spray and drain cycle for a total of 50 cycles. At the end of the last drain period, repeat 6.1 and 6.3. The alarm shall meet the sound pressure level requirements of 6.3. The predominant sound frequency shall be within the frequency range specified in 6.1.