(R) Emergency Vehicle Sirens

RATIONALE

This revision of SAE J1849 was developed during the second phase of a planned three-phase process. Phase one was performed to further develop test procedures and minimum performance requirements for electronic siren systems with a single speaker and electromechanical sirens. Phase two was conducted to specify an additional acoustical test for siren systems with a large speaker or a large speaker array. The intent of phase three will be to specify tests and performance requirements for individual siren components so that an electronic siren system, created from components tested accordingly, will meet the acoustical performance requirements developed during phase one.

The primary goal of phase one was to further develop the measurement methods for siren performance specified in Title 13, Article 8 of the California Code of Regulations and previous versions of SAE J1849. As an outcome of phase one, the acoustical measurement methods are specified in more detail and reduce the uncertainty in the results. These methods produce data that are less dependent on the design of the sirens tested, and are more indicative of the sound levels produced across the entire frequency range of the measured signals. Phase one also produced a more comprehensive set of environmental tests than these other documents, acoustical performance re-testing subsequent to these environmental tests, and a specified procedure for the signal frequency measurement.

The required warm-up period for the SPL measurement was increased to 10 min in phase one. Measurement results obtained after a ten-minute warm-up period are much less sensitive to the magnetic circuit design of the siren loudspeaker under test (with respect to its thermal properties), since most loudspeakers have more closely approached thermal equilibrium after warming up for 10 min. A 10 min warm-up period also produces measurement results that better represent siren performance during periods of extended use on emergency vehicles. Since the SPL decreases with time as the loudspeaker heats, a longer warm-up period results in measured SPL values that are lower than those measured after only one minute.

Acoustical measurement instruments indicate SPL values obtained by averaging continuously over a given period specified by the exponential-time averaging constant, which is commonly referred to as the averaging time. For time-varying signals such as a siren signal, the averaging time will have a direct effect on the range of the fluctuations that occur during the measurement. In order to obtain results derived from the SPL produced across the entire frequency range of the measured signal, a long-term average SPL measurement is specified. This measurement replaced the measurement of the minimum, relatively instantaneous rms value of the SPL. The long-term averaging time was chosen to minimize the range of fluctuations observed when determining the average SPL produced across the entire frequency range of the siren signal measured.

Requirements for the SPL measured with the long-term time setting are lower than those measured with the fast time setting since the former measurement averages over the entire signal cycle, which includes more low level portions of the signal that occur over a wider frequency bandwidth. For measurements done with the fast time setting, the requirements for the SPL of faster cycling signals are lower than the requirements for slower cycling signals. This is due to the fact that a much wider bandwidth is sampled over the averaging time used with this setting for faster cycling signals than relatively slower signals. Therefore, with all other parameters equal, a faster cycling signal will produce lower measured maximum rms levels since more low-level portions are included in the sampled signal.

To reduce the uncertainty in the acoustical measurements, mechanical level recorders are not specified. These recorders are subject to overshoot, and have variable controls (e.g., writing speed) with nonstandardized settings that can affect the measurement results by changing the effective averaging time of the measurement. Measurements of the SPL produced by a siren off the device axis can be performed by continuously rotating the loudspeaker on a turntable while measuring the SPL at a fixed point. However, using a continuously rotating turntable makes it difficult to accurately determine the SPL produced by a siren loudspeaker as a function of angle since the SPL also varies with time in a cyclic manner. More accurate results are obtained with the turntable paused at each specified angle for a period at least as long as the siren cycle or the instrument averaging time, whichever is longer.

The goal of phase two was to develop a test that would determine whether the SPL measured for a given large speaker or speaker array at 3.00 meters can be considered to approximate a far field measurement result. Procedures for performing this test and reducing the acquired data are described in 5.11. Requirements for the test results are specified in 6.11.

The procedures for the vibration and corrosion tests specified in 5.2 and 5.3 respectively were revised to cite SAE J575 with no exceptions.

Electromagnetic Radiated and Conducted Emissions testing has been updated to reference CISPR 25 as the new radiated and conducted emissions test method since SAE 1113-41 is obsolete.

FOREWORD

Data obtained from measurements of siren performance depend on not only the characteristics of the siren tested, but additionally on the test procedures and the characteristics of the measurement instrumentation and test environment. These additional factors must be well defined and controlled to obtain reliable data. Detailed test methods are described here, which include specifications for a laboratory environment, to minimize the measurement uncertainty and obtain accurate and reproducible measurement results. Such results are necessary to qualify the performance of all sirens as equally as practicable. Requirements have been established based on the laboratory-measured performance of sirens that have been effective in emergency service.

Whether a person will hear, recognize, and react quickly enough to the warning sounds produced by a siren during an emergency depends on many factors in addition to the sound pressure level (SPL) it produces in a controlled test environment. Reflection, scattering and attenuation caused by objects such as buildings, trees, road surfaces and vehicles contribute to sound propagation losses. Absorption of sound by the atmosphere itself also results in losses. Windows, soundproofing and other materials that are part of a vehicle further decrease sound levels. Background noises also interfere with the audibility of acoustical signals, an effect called masking. Siren sounds are masked by traffic and community noise, and noise produced by car stereos, air conditioning, wind and rain. There are also variations in how well different people can detect, identify and localize sounds, which are partly due to their ability to hear as a function of frequency. Finally, how effectively someone can react to a detected sound depends on the proximity and speed of the emergency vehicle, the speed of their vehicle, and their reflexes.

Emergency vehicle sirens do not produce sounds that are loud enough to warn effectively in all circumstances. A report prepared for the U.S. Department of Transportation by Bolt, Beranek, and Newman Inc. concluded that the sound levels produced by sirens would have to be increased greatly, to the point where these levels would be intolerable to the community, to be loud enough to warn effectively in all ordinary circumstances. There is no assurance that all other motorists will always hear, recognize, or react quickly enough to the warning sounds produced by a siren to take appropriate action. It is necessary for emergency vehicle operators to watch for the reaction of other motorists to the siren and be prepared to maneuver accordingly. Sirens have been effective in calling for the right-of-way by an emergency vehicle, but must always be used in conjunction with effective visual warning devices and operated only by properly trained personnel who are aware of the limitations noted here.

There is an additional concern for emergency vehicle operators and others exposed to siren noise. Sounds produced by emergency vehicle sirens are loud enough to increase the risk of temporary or permanent hearing loss. Appendix A contains information regarding occupational hearing loss and exposure to siren noise.

Appendix B is a data sheet that includes Tables B1 through B5C and descriptive statements for use when documenting test results. It outlines the data that must be recorded when performing the measurements specified in this document, except for the data acquired from the additional acoustical test for siren systems with a large speaker or a large speaker array. Those data are outlined in the data sheet provided in Appendix C.

Appendix D contains information regarding an Excel workbook that is available to reduce the data acquired during the additional acoustical test for siren systems with a large speaker or a large speaker array according to the data reduction procedures described in 5.11.3.

1. SCOPE

This SAE Recommended Practice provides laboratory test procedures, requirements and guidelines for electronic siren systems with a single loudspeaker, and electromechanical sirens for use on authorized emergency vehicles, which call for the right-of-way. Test procedures and performance requirements for individual system components are not included in this version. Results obtained for a siren system with a speaker array that is greater than 0.5 m in any dimension shall apply to the system only when the array is in the same spatial configuration as tested (i.e., the same speaker separation and orientation).

2. REFERENCES

2.1 Applicable Publications

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 724-776-4970 (outside USA), www.sae.org.

SAE J336 Sound Level for Truck Cab Interior

SAE J575 Test Methods and Equipment for Lighting Devices and Components for Use on Vehicles Less than 2032 mm in Overall Width

SAE J759 Lighting Identification Code

SAE J994 Alarm—Backup—Electric Laboratory Performance Testing

SAE J1113-21 Electromagnetic Compatibility Measurement Procedure for Vehicle Components—Part 21: Immunity to Electromagnetic Fields, 30 MHz to 18 GHz, Absorber-Lined Chamber

2.1.2 ANSI Publications

Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ANSI S1.1-1994 (R 2004) Acoustical Terminology

ANSI S1.4-1983 (R 2006) Specification for Sound Level Meters

ANSI S1.15-1997/Part 1 (R 2006) Measurement Microphones—Part 1: Specifications for Laboratory Standard Microphones

ANSI S1.40-2006 Specification for Acoustical Calibrators

ANSI S1.42-2001 (R 2006) Design Response of Weighting Networks for Acoustical Instruments

2.1.3 IEC Publications

Available from IEC, 3, rue de Verambe, P.O. Box 131, 1211 Geneva 20, Switzerland, Tel: +41-22-919-02-11, www.iec.ch.

IEC 61094-1 (2000-07) Measurement Microphones—Part 1: Specifications for Laboratory Standard Microphones

IEC 61094-4 (1995-11) Measurement Microphones—Part 4: Specifications for Working Standard Microphones

CISPR 25, 2nd Ed 2002-08 Radio Disturbance Characteristics for the Protection of Receivers Used On Board Vehicles, Boats, and on devices – Limits and Methods of Measurement

2.1.4 DOT Publication

Available from the National Technical Information Service, Springfield, VA 22161.

Effectiveness of Audible Warning Devices on Emergency Vehicles. Report No. DOT-TSC-OST- 77-38. R.C. Potter, S.A. Fidell, M.M. Myles and D.N. Keast. Work performed by Bolt, Beranek and Newman, Inc. for the U.S. Department of Transportation, Washington, DC 20590; August 1977

2.1.5 Other Publications

NIOSH publications available from NIOSH, Cincinnati, OH 45226.

Criteria for a Recommended Standard: Occupational Noise Exposure Revised Criteria 1998. DHHS (NIOSH) Publication No. 98-126. National Institute for Occupational Safety and Health, Cincinnati, OH 45226-1998; June 1998

Preventing Occupational Hearing Loss - A Practical Guide. DHHS (NIOSH) Publication No. 96-110. National Institute for Occupational Safety and Health, Cincinnati, OH 45226-1998; October 1996

Hearing Protector Device Compendium. National Institute for Occupational Safety and Health, Cincinnati, OH 45226-1998. Available online at http://www.cdc.gov/niosh/topics/noise/hpcomp.html

Health Hazard Evaluation Report HETA 81-059-1045, Newburgh Fire Department, Newburgh, New York, Tubbs, R.A., Flesch, J.P., National Institute for Occupational Safety and Health, Cincinnati, OH 45226-1998; February 1982

Health Hazard Evaluation Report HETA 84-493-1583, General Services Administration, Washington, DC., Flesch, J.P., Tubbs, R.A., National Institute for Occupational Safety and Health, Cincinnati, OH 45226-1998; April 1985

2.2 Related Publications

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

2.2.1 California Code of Regulations

Available from Barclays Law Publishers, South San Francisco, CA 94111.

California Code of Regulations Title 13, Article 8

3. DEFINITIONS

3.1 Siren

A device or system for producing acoustical signals that continuously vary in frequency and call for the right-of-way of an emergency vehicle. These signals, and the electrical signals that produce them, are generally referred to as siren signals.

3.2 Electronic Siren Amplifier

A device that is powered by the electrical system of the vehicle and produces an electrical signal that drives an electronic siren speaker. The amplifier also includes any controls for siren operation.

3.3 Electronic Siren Speaker

A transducer that converts the electrical signal from an electronic siren amplifier into acoustical energy. An electronic siren speaker includes the electroacoustical transducer and all mechanisms or housings required to couple and control the transducer acoustical output.

3.4 Electronic Siren System

A siren that is the combination of an electronic siren amplifier and an electronic siren speaker or speakers.

3.5 Electromechanical Siren

A siren that converts electrical energy into acoustical energy without the use of an electronic power amplifier. An example of such a siren is a motor-driven rotor spinning inside a fixed stator.

3.6 Cycling Period

The time required for the siren signal to sweep from the lowest to the highest fundamental frequency and back to the lowest fundamental frequency.

3.7 Sound Pressure Level (SPL)

Defined in ANSI S1.1-1994 as ten times the logarithm to the base ten of the ratio of the time-mean-square pressure of a sound, in a stated frequency band, to the square of the reference sound pressure in gases of 20 μPa.

3.8 A-Weighted Sound Pressure Level

A sound pressure level that has been measured with an A-weighting filter that meets the requirements of ANSI S1.42-2001.

3.9 Fast Time Setting

A setting available on sound level meters and other acoustical measurement instruments that provides the exponential-time averaging constant specified in ANSI S1.4-1983 for the fast exponential-time averaging characteristic.

3.10 Long-Term Time Setting

Any setting on a sound level meter or other acoustical measurement instrument that provides an exponential-time averaging constant of at least 20 s.

3.11 Device Axis

For single speaker systems, the axis that passes through the center of the sound emitting opening of the siren speaker. For systems with a speaker array, the device axis is the axis that passes through the center of the array. The device axis is parallel to the forward facing direction of the siren speaker(s) as installed on a vehicle according to the instructions provided by the manufacturer.

3.12 Wail Mode

Siren mode of operation that produces the wail signal. (specified in 6.1.2.1.)

3.13 Yelp Mode

Siren mode of operation that produces the yelp signal. (specified in 6.1.2.2.)

3.14 Maximum rms Level Hold Function

A detector output function of the acoustical measurement system that holds the maximum true rms level measured and outputs this level to the meter (e.g., “max hold” or “hold” functions in rms mode).

3.15 Normal rms Level Function

A detector output function of the acoustical measurement system that outputs the true rms level measured to the meter.

4. IDENTIFICATION CODE AND MARKINGS

4.1 Identification Code

Emergency vehicle sirens or siren system components shall be marked with the code that indicates the function or functions for which the device was originally designed in accordance with SAE J759. This code also indicates the general location on/in a vehicle where the siren or siren system component should be permanently mounted. The code “EVS1” is for devices that mount in the interior of the vehicle, including the trunk or any other dry compartment, code “EVS2” is for devices that mount outside the vehicle, except under the hood, and code “EVS3” is for devices that mount under the hood.

4.2 Markings

All devices shall be marked using characters that are 3.0 mm or greater in height. After all of the appropriate environmental testing has been performed and the marking areas have been cleaned using a mild soap solution and towel, markings on labels must be clearly visible and legible, and the label shall remain reliably affixed to the device. All electronic siren system components shall be marked to indicate that they meet the requirements specified in SAE J1849 only when used with each other, and shall not be interchanged with components of other systems.

4.2.1 Electromechanical Sirens

The name of the manufacturer, the model number, the input voltage, operating current, mounting orientation, and the identification code shall be marked.

4.2.2 Electronic Siren Speakers

The name of the manufacturer, the model number, mounting orientation, and the identification code shall be marked.

4.2.3 Electronic Siren Amplifiers and Associated Controls

The name of the manufacturer, the model number, the operating (power supply) voltage and current, and the identification code shall be marked. If the amplifier and controls are separate components, each component shall be labeled as a part of a system and the identification code shall be marked on each component.

5. TESTS

Personnel should be required to wear hearing protectors when exposure to acoustical noise equals or exceeds the NIOSH recommended exposure limit (see Appendix A). Hearing protectors should attenuate noise sufficiently to keep exposure at the ear below this recommended limit. During testing, personnel should wear hearing protection any time the siren is activated in their general vicinity. For all of the tests described as follows, the sirens tested shall be new, undamaged and randomly drawn from the production population. Five sirens, which will be referred to as Siren #1 through Siren #5, shall be used for the tests. Each siren shall be physically marked with its designated number. Siren #1 shall be subjected to the entire acoustical test. The other four sirens shall be subjected to the SPL measurement only at the measurement angle of 0 degrees. After all four of these sirens have been subjected to this SPL measurement:

Siren #2 shall be subjected to the radiated electromagnetic immunity, radiated emissions and conducted emissions tests, in the order written.
Siren #3 shall be subjected to the vibration, corrosion, dust and moisture tests, in the order written. Only those tests that are applicable based on the intended mounting location, which is indicated by the identification code, of the siren are required.
Siren #4 shall be subjected to the durability test.
Siren #5 shall be subjected to the extreme temperature tests. Only those tests that are applicable based on the intended mounting location, which is indicated by the identification code, of the siren are required.

After the tests mentioned above are complete, all four of these sirens shall again be subjected to the SPL measurement only at the measurement angle of 0 degrees. For all tests, the ambient laboratory temperature shall be in the range 18 °C to 30 °C except where noted otherwise.

Multiple variations of electronic siren amplifiers may be grouped into product families. Representative models may be tested to obtain family wide approval as long as model numbers or other codes are arranged to define such families, the amplification and signal generation circuitry are identical in the family, and the test report lists each specific model variation. The manufacturer shall have on record the details of each variation, and state why the performance of the untested model(s) should not be significantly affected by the variation. Untested electronic siren systems that include an electronic siren amplifier from a different electronic siren system that has met the requirements of SAE J1849 do not need to be subjected to the electromagnetic compatibility tests, which are described in 5.6, 5.7, and 5.8. In addition, these amplifiers are exempt from the temperature soaks, and the signal frequency and AC voltage measurements are not required, during the extreme temperature tests of such systems. However, the electronic siren loudspeakers shall be operated and temperature soaked according to the procedures specified for these tests.

5.1 Acoustical Test

This test is required for all devices with identification code EVS1, EVS2 or EVS3.

Siren #1 shall be subjected to the entire acoustical test. Siren #2 through Siren #5 shall be subjected to the SPL measurement only at the measurement angle of 0 degrees before environmental testing. After the applicable environmental tests are complete, Siren #2 through Siren #5 shall again be subjected to the SPL measurement only at the measurement angle of 0 degrees.

5.1.1 Acoustical Test Equipment and Facilities

5.1.1.1 Acoustical Measurement System

The system shall meet the Type I requirements for a sound level meter specified in ANSI S1.4-1983. It shall have fast and long-term time settings, and maximum rms level hold and normal rms level functions. The microphone shall meet the Type WS2F, or Type WS3F specifications of IEC 61094-4, or the Type LS2F specifications of IEC 61094-1 or ANSI S1.15-1997/Part 1.

All of these microphone types are nominal one-half-inch diameter or smaller microphones with a free-field sensitivity that is approximately independent of frequency in the widest possible frequency range.

5.1.1.2 Sound Level Calibrator

The acoustical calibrator or pistonphone shall meet the requirements of ANSI S1.40-2006. The SPL the sound level calibrator is stated to produce shall be accurate within a tolerance of ±0.35 dB.

5.1.1.3 Test Speaker

Audio speaker that shall be used to qualify the anechoic room. This speaker shall have a closed-back design (non-dipole) and an operational transducer with a diameter between 0.14 m and 0.21 m that shall be used for the room qualification.

5.1.1.4 Anechoic Room

Test room with surfaces that absorb essentially all of the incident sound energy over the frequency range of interest, thereby affording nearly free-field conditions over the measurement surface. The anechoic room shall maintain nearly free-field conditions from 500 Hz to 6300 Hz. Nearly free-field conditions are considered established when the SPL at positions –0.30 m, –0.15 m, 0.15 m, and 0.30 m ± 0.02 m relative to the fixed microphone location used for siren measurements, on the device axis of the test speaker aligned for a measurement angle of 0 degrees (see 5.1.2.2), do not deviate by more than ±1.0 dB from the inverse distance law for SPL. This criteria must be met with a one-third-octave bandwidth noise stimulus at the following one-third-octave center frequencies: 500 Hz, 630 Hz, 800 Hz, 1000 Hz, 1250 Hz, 1600 Hz, 2000 Hz, 2500 Hz, 3150 Hz, 4000 Hz, 5000 Hz, and 6300 Hz. The room shall meet these requirements initially with the test speaker aligned for a measurement angle of 0 degrees, and also with the speaker rotated horizontally 50 degrees from the initial orientation (i.e., measurement angle of 50 degrees). An angle of 50 degrees is used to decrease the level of the sound radiated directly to the microphone, and increase the level of the sound directed toward the chamber side walls. When qualifying the anechoic room, the front most part of the speaker shall be aligned with the front edge of the speaker mount. All deviations in the measured SPL from the inverse distance law for a given orientation shall be calculated relative to the SPL measured at the fixed microphone location used for siren measurements.

5.1.1.5 Speaker Mount

A test base that is 30.0 cm x 30.0 cm x 1.5 cm ± 1.0 cm shall be used to mount the siren speaker and test speaker.

5.1.1.6 Direct Current Power Supply

The power supply shall be regulated to ±1% with a maximum ripple of 75 mV peak-to-peak.

For electromechanical sirens, the power supply shall not allow the voltage to fall more than 10% below the initial supply voltage while the siren is energized and held at its highest operating frequency.

5.1.1.7 DC Current Measurement System

The system shall be able to perform DC current measurements that are accurate within a tolerance of ±5%.

5.1.1.8 DC Voltmeter

The voltmeter shall be able to perform DC voltage measurements that are accurate within a tolerance of ±1%.

5.1.1.9 Oscilloscope for Signal Frequency Measurement

A digital-sampling oscilloscope with adjustable time cursors, a minimum sampling bandwidth of 1 MHz, and storage capability for at least three cycles of the yelp signal shall be used.

5.1.2 Acoustical Test Procedures

5.1.2.1 Laboratory Environmental Requirements

The temperature, barometric pressure, and relative humidity of the anechoic room shall be recorded and held to as nearly constant values as practicable during the SPL measurements. These ambient environmental conditions shall not be outside of the ranges recommended by the manufacturer of the acoustical measurement equipment. In addition, the relative humidity shall be less than 80% and the barometric pressure shall be in the range 950 mbar to 1050 mbar.

5.1.2.2 Microphone and Siren Speaker Setup

Place the speaker mount in the anechoic room so that the siren speaker shall be at least 1 m from any surface, including the absorptive surfaces of the room. Secure the siren speaker on the speaker mount so that the front-most part of the speaker is aligned with the front edge of the mount and the speaker device axis is in the horizontal plane. Neither the speaker mount nor the securing equipment should interfere with the acoustical output or operation of the siren. Set up the microphone facing the speaker, 3.00 m ± 0.02 m from the front-most part of the speaker on its device axis. The device axis shall pass through the center of, and be perpendicular to, the diaphragm of the microphone. This relative orientation between the microphone and speaker constitutes a measurement angle of 0 degrees. The microphone shall be at least 1 m from any surface, including the absorptive surfaces of the room.

The siren speaker shall be connected to the siren amplifier in such a way that the voltage difference between the output terminals of the amplifier and the terminals of the speaker shall not exceed ±1%.

5.1.2.3 Acoustical Measurement System Calibration

Calibrate the acoustical measurement system with the acoustical calibrator or pistonphone set at a design-center frequency in the range from 200 Hz to 1000 Hz. The A-weighting filter shall not be used during the calibration. The system shall be calibrated on the same range setting that will be used during the measurement. Correct the applied sound level for the ambient barometric pressure and the equivalent load volume. For calibrations performed above 300 Hz, also apply the correction necessary to compensate for the difference between the free-field response and pressure response of the microphone.

Set the level indicated on the measurement system to be within ±0.1 dB of the corrected level.

5.1.2.4 Power Supply Voltage

Set the DC power supply voltage to 13.6 V ± 0.2 V for devices that are designed to operate on nominal 12-V electrical systems (sometimes referred to as 14-V systems), 27.2 V ± 0.3 V for devices that are designed to operate on nominal 24-V systems, and 40.8 V ± 0.5 V on devices that are designed to operate on nominal 42-V systems. When setting the power supply voltage, measure this voltage at the junction between the power cables supplied by the manufacturer for the amplifier and the terminals of the power supply.

5.1.2.5 SPL Measurements

Operate the siren continuously in the yelp mode for a ten-minute warm-up period. Immediately following this period, SPL measurements shall be performed at the following angles (±2 degrees) relative to the device axis in the order written: 0 degrees (only angle required for Siren #2 through Siren #5), 10 degrees, 20 degrees, 30 degrees, 40 degrees, 50 degrees, –50 degrees, –40 degrees, –30 degrees, –20 degrees, –10 degrees. These angles shall be realized by rotating the speaker mount. The axis of rotation shall be the vertical axis that passes through the center of this mount. A negative sign is used to denote angles measured with the device axis rotated clockwise from its initial zero-degrees orientation.

In the yelp mode, measure the A-weighted SPL with the fast time setting and the maximum rms level hold function of the acoustical measurement system. Record the SPL reading to the nearest tenth of a decibel.

At each angle, repeat this measurement in the wail mode before rotating the speaker to the next angle.

The maximum rms level hold function shall be reset immediately before each such SPL measurement is performed after all other equipment adjustments have been done.

After all of the measurements done with the fast time setting in both the yelp and wail modes have been completed, change to the long-term time setting and the normal rms level function of the acoustical measurement system. Measure the A-weighted SPL with the long-term time setting in the wail and yelp modes at the same measurement angles, and in the same order, specified for the fast time setting measurements. Each time a new measurement is started, wait for a period equal to the exponential-time averaging constant of the measurement. Then observe the fluctuations of the meter for at least one complete siren signal cycle. If the range of the fluctuations is greater than 1.0 dB, a longer time setting shall be used. Once the fluctuations have stabilized within this range, record the SPL reading estimated from the arithmetic mean of the maximum and minimum values observed to the nearest tenth of a decibel.

If it is necessary to adjust the measurement angle by entering the anechoic chamber, the siren may be turned off each time a new angle is set. However, the siren shall not be off any longer than 1 min, and shall have been on for at least 30 s immediately prior to performing a measurement. After the tests of the yelp and wail signals have been completed and the loudspeaker temperature has returned to the ambient laboratory temperature, other signals may be measured by repeating the described procedure.

5.1.2.6 Signal Frequency Measurement

Determine the lowest and highest fundamental frequencies of the wail and yelp signals. Connect the oscilloscope input to the AC output of the acoustical measurement system. For wail, adjust the time base of the oscilloscope so that one complete cycle of the fundamental frequency (lowest or highest) being measured occupies no less than one half of the display. Measure the half-period of this frequency by adjusting the cursors to be aligned with the zero-crossing of the initial rising and falling edges. Calculate the lowest and highest fundamental frequencies and the frequency range of the siren signal. When measuring the yelp signal, sample and store at least three cycles of the signal in the oscilloscope. Using the method described above for wail, calculate the lowest and highest fundamental frequencies and the frequency range of the yelp signal that has been stored.

5.1.2.7 Signal Cycling Period Measurement

Measure the cycling period of both the wail and yelp signals.

5.1.2.8 DC Current Measurement

This test is for informational purposes only. There are no performance requirements.

With the siren in the yelp mode, measure the DC current in the power cable of the siren amplifier. For electromechanical sirens, measure the DC current in the power cable connected to the siren while the siren is energized and held at its highest operating frequency.

5.1.2.9 Stability Check

After the SPL measurements are done, check the calibration of the acoustical measurement system by repeating the procedure specified in 5.1.2.3. If the sensitivity of the measurement system has changed by more than ±0.3 dB, the measurements shall be re-done. If necessary, the stability check may be done at more frequent intervals.

5.1.2.10 Electromechanical Sirens

All tests of electromechanical sirens, except when noted, shall be made while operating the siren in the wail mode.

5.2 Vibration Test

This test is required for all devices with identification code EVS1, EVS2 or EVS3.

Siren #3 shall be subjected to the vibration test specified in SAE J575. Mount the siren in accordance with its mounting instructions by using its intended mounting hardware and brackets fastened securely to the table of the vibration test machine.

5.3 Corrosion Test

This test is required only for devices that mount outside the vehicle, including under the hood (devices with identification code EVS2 or EVS3).

Siren #3 shall be subjected to the salt exposure test specified in SAE J575.

5.4 Dust Test

This test is required only for devices that mount outside the vehicle, including under the hood (devices with identification code EVS2 or EVS3).

Siren #3 shall be subjected to the dust test specified in SAE J575.

5.5 Moisture Test

This test is required only for devices that mount outside the vehicle including under the hood devices. (those with identification code EVS2 or EVS3)

Siren #3 shall be subjected to the high-pressure hot-water test specified in SAE J994 with the exception, that after completion, the device shall be allowed to drain for at least one hour.

5.6 Radiated Electromagnetic Immunity Test

This test is required for all electronic siren amplifiers.

In the wail mode, Siren #2 shall be subjected to the radiated electromagnetic immunity test specified in SAE J1113-21. Sweep the field in frequency from 26 MHz to 1000 MHz at an amplitude of 10 V/m.

Continue to perform sweeps over this frequency range, but increment the field amplitude by 10 V/m each time before a new sweep is started until a change in the wail signal is observed. Record the field amplitude and frequency at which the change is observed and describe the change. A passive resistive load, which is a non-inductive resistor with a resistance within ±1% of the nominal impedance of the speaker used in the siren system, may be substituted for the siren loudspeaker. In this case, there shall be an alternative means to monitor the amplifier output for failure (e.g., monitor speaker or current probe).

Amplifiers that are an integral part of a speaker shall also be tested.

5.7 Radiated Emissions Test

This test is required for all electronic siren amplifiers.

Siren #2, while operating in the wail mode, shall be subjected to the radiated emissions test specified in CISPR 25 – IEC:2002. Measure and record the narrowband (with a peak detector) and broadband (with a quasi-peak detector) radiated disturbances for all of the frequency bands specified in CISPR 25 – IEC:2002. The passive resistive load specified in 5.6 may be substituted for the siren loudspeaker. Amplifiers that are an integral part of a speaker shall also be tested.

5.8 Conducted Emissions Test

This test is required for all electronic siren amplifiers.

All input power lead terminals (include both the positive and negative terminals) of Siren #2, while operating in the wail mode, shall be subjected to the conducted emissions test specified in CISPR 25 – IEC:2002. Measure and record the narrowband (with a peak detector) and broadband (with a quasi-peak detector) conducted disturbances for all of the frequency bands specified in CISPR 25 – IEC:2002. The passive resistive load specified in 5.6 may be substituted for the siren loudspeaker. Amplifiers that are an integral part of a speaker shall also be tested.

5.9 Durability Test

This test is required for all devices with identification code EVS1, EVS2 or EVS3.

Siren #4 shall be tested for 100 on-off cycles with a DC power supply voltage as specified in 5.1.2.4. For each cycle, the siren shall be operated continuously in the wail mode for 30 min, then turned off for a period of 30 min. For the duration of the test, the ambient laboratory temperature shall not fall below 18 °C.

5.10 Extreme Temperature Tests

These tests are required only for those devices specified with each particular temperature test.

5.10.1 Equipment for Extreme Temperature Tests

5.10.1.1 Environmental chamber

The environmental chamber(s) shall be capable of maintaining temperatures from –30 °C ± 3 °C to 90 ° ± 3 °C with the siren mounted and operating in the chamber. If necessary, more than one chamber may be used to satisfy the temperature range requirements.

5.10.1.2 AC Voltmeter

The voltmeter shall be able to perform true rms voltage measurements that are accurate within a tolerance of ± 1% from 500 Hz to 6300 Hz.

5.10.2 Procedures for Extreme Temperature Tests

Equipment not under test shall remain outside the chamber during all extreme temperature testing.

5.10.2.1 High Temperature Test for Devices with Identification Code EVS1 or EVS2

This test is required only for devices that mount anywhere except under the hood.

At ambient laboratory temperature, use the voltmeter to measure the AC voltage at the speaker terminals with Siren #5 in the yelp mode. The siren shall then be placed in the environmental chamber that has been pre-warmed to 65 °C ± 3 °C. The siren shall be off and allowed to soak at that temperature for a period of one hour. Then activate the siren for a period of five hours and maintain the temperature inside the chamber at 65 °C ± 3 °C. At the end of this period, use the voltmeter to re-measure the AC voltage at the speaker terminals with the siren in the yelp mode. Also measure the signal frequency of the wail in accordance with 5.1.2.6, but with an oscilloscope connected to the speaker terminals. Signal frequency and AC voltage measurements are not required for electromechanical sirens, which shall be temperature soaked and activated as described, but operated in the wail mode.

5.10.2.2 High Temperature Test for Devices with Identification Code EVS3

This test is required only for devices that mount under the hood.

Sirens comprised entirely of devices with code EVS3 shall be tested in accordance with 5.10.2.1, but with the environmental chamber pre-warmed and maintained at a temperature of 90 °C ± 3 °C. If at least one device does not have code EVS3, Siren #5 shall first be tested in accordance with 5.10.2.1. All devices except those with identification code EVS3 shall then be removed from the chamber, and the EVS3 devices shall be tested in accordance with 5.10.2.1, but the environmental chamber shall be pre-warmed and maintained at a temperature of 90 °C ± 3 °C. The voltage and frequency measurements need not be re-done if the only device with code EVS3 is an electronic siren speaker. Signal frequency and AC voltage measurements are not required for electromechanical sirens, which shall be temperature soaked and activated as described, but operated in the wail mode.

5.10.2.3 Low Temperature Test

This test is required for all devices with identification code EVS1, EVS2 or EVS3.

At ambient laboratory temperature, use the voltmeter to measure the AC voltage at the speaker terminals with Siren #5 in the yelp mode. The siren shall then be placed in the environmental chamber that has been pre-cooled to –30 °C ± 3 °C. The siren shall be off and allowed to soak at that temperature for a period of five hours. Activate the siren at the end of the five-hour period. Within five minutes of activation, re-measure the AC voltage at the speaker terminals with the siren amplifier in the yelp mode. Also measure the signal frequency of the wail in accordance with 5.1.2.6, except with an oscilloscope connected to the speaker terminals. Signal frequency and AC voltage measurements are not required for electromechanical sirens, which shall be temperature soaked and activated as described, but operated in the wail mode.

5.11 Additional Acoustical Test for Siren Systems with a Large Speaker or a Large Speaker Array

This test is required for siren systems with a speaker array that is greater than 0.5 m in any dimension. This test is also required for siren systems with a single speaker that has any dimension across the sound-emitting opening greater than 0.5 m. For both types of systems, this additional test shall be completed before the other acoustical tests described in 5.1, which are also required for these systems, are done.

5.11.1 Measurement Setup

The acoustical measurement system(s) shall meet the requirements specified in 5.1.1.1.

Use the test speaker described in 5.1.1.3 and the test described in 5.1.1.4 to check the anechoic room. The inverse-distance-law SPL criteria given in 5.1.1.4 for the anechoic room shall be met at the positions specified in 5.1.1.4 and at additional positions 1.40 m, 1.80 m, 2.20 m, 2.60 m, and 3.00 m ± 0.02 m relative to the fixed microphone location (that is 3.00 m from the speaker) used for the siren acoustical tests described in 5.1. All of these positions shall be on the device axis of the test speaker aligned for a measurement angle of 0 degrees. The anechoic room shall meet these requirements with the test speaker aligned for a measurement angle of 0 degrees. The anechoic room shall also meet the laboratory environmental requirements specified in 5.1.2.1.

The direct current power supply shall meet the requirements specified in 5.1.1.6. Set the power supply voltage as specified in 5.1.2.4.

Place the speaker mount(s) in the anechoic room so that the siren speaker(s) shall be at least 0.5 m from any surface, including the absorptive surfaces of the room. Secure the siren speaker(s) on the speaker mount(s) so that the front-most part of the speaker(s) is/are aligned with the front edge of the mount(s) and the device axis is in the horizontal plane. Neither the speaker mount(s) nor the securing equipment should interfere with the acoustical output or operation of the siren. Set up the measurement microphone facing the speaker/array, 3.00 m ± 0.02 m from the front-most part of the speaker/array on its device axis. The device axis shall pass through the center of, and be perpendicular to, the diaphragm of this microphone. Develop a positioning system to readily place the measurement microphone or its stand so that the measurement microphone is at a known measurement distance from the front-most part of the speaker/array on its device axis facing the speaker/array. This positioning system shall include all measurement distances at increments of 0.20 m ± 0.02 m between 4.40 m and 6.00 m (i.e., 4.40 m, 4.60 m, 4.80 m …6.00 m) from the front-most part of the speaker/array on its device axis. At all measurement distances, the measurement microphone shall be at least 0.5 m from any surface, including the absorptive surfaces of the room.

Set up a second microphone that will remain at a fixed location facing the speaker/array during the entire measurement process. This microphone, which will be referred to as the fixed microphone, shall be at least 1.0 m from any surface of the room and as far away from the speaker/array and device axis as practicable.

5.11.2 Measurement Procedures

Calibrate the acoustical measurement system(s) as described in 5.1.2.3 with a sound level calibrator that meets the requirements of 5.1.1.2.

Operate the siren continuously in the yelp mode for a ten-minute warm-up period. Immediately following this period, measure the A-weighted SPL with both microphones. Determine the SPLs and record them to the nearest hundredth of a decibel. In order to obtain this level of precision with some measurement systems, it is necessary to measure the DC voltage output of the measuring amplifiers instead of reading the moving coil meters on the front panels of these amplifiers. Record SPLs measured with the long-term time setting and the normal rms level function of the acoustical measurement system, and SPLs measured with the fast time setting and the maximum rms level hold function of the system. A blank data sheet provided in Appendix C can be used for this purpose. Each time a measurement is started, wait for a period equal to the exponential-time averaging constant of the measurement before reading and recording the data. The maximum rms level hold function shall be reset immediately before each such SPL measurement is performed after all other equipment adjustments have been done.

When all measurements are completed, turn the siren off and move the measurement microphone so that it is facing the speaker/array to a measurement distance of 4.40 m ± 0.02 m from the front-most part of the speaker/array on its device axis. Keep the fixed microphone at its fixed location and turn the siren back on. The siren shall not have been off any longer than 1 min, and shall have been on for at least 30 s immediately prior to performing a new measurement. Repeat the measurements and record the data with the measurement microphone at its new measurement distance and the fixed microphone at its fixed location. Continue to move the measurement microphone further from the speaker/array in increments of 0.20 m and repeat the measurements at each of the 0.20-meter incremental measurement distances between 4.40 m and 6.00 m from the front-most part of the speaker/array on its device axis until data have been acquired at all of these distances. Data shall be acquired with the fixed microphone every time data are acquired with the measurement microphone at a new measurement distance.

After the SPL measurements are done, check the calibration of the acoustical measurement system(s) by repeating the procedure specified in 5.1.2.3. If the sensitivity of either measurement system has changed by more than ±0.3 dB, the measurements shall be re-done.

5.11.3 Data Reduction Procedures (also see Appendix D)

For each given value of the measurement distance x, calculate an SPL correction C(x), given by

$$C(x) = SPL_F(3.00) - SPL_F(x) \quad \text{(Eq. 1)}$$

where SPL_F (3.00) is the SPL measured with the fixed microphone when the measurement microphone was at the initial 3.00-meter measurement distance from the speaker/array, and $SPL_F(x)$ is the SPL measured with the fixed microphone when the measurement microphone was at x.

For each value of x, calculate $SPL_C(x)$, which is an SPL corrected for heating effects, given by

$$SPL_C(x) = SPL_M(x) + C(x) \quad \text{(Eq. 2)}$$

where $SPL_M(x)$ is the SPL measured with the measurement microphone at x.

For each value of x, convert $SPL_C(x)$ to a reciprocal sound pressure 1/p (x) using

$$\frac{1}{p}(x) = \frac{1}{10^{SPL_C(x)/20} \times (.00002)} \quad \text{(Eq. 3)}$$

For the range of x from 4.40 m to 6.00 m, use linear regression to determine the slope m=1/A, and the y-intercept b = -d /A of the linear equation

$$\frac{1}{p}(x) = mx + b = \frac{x - d}{A} \qquad \text{(Eq. 4)}$$

where d is the sum of acoustic center corrections for the microphone and the speaker/array in meters, and A is a constant. For x equal to 3.00 m and all values of x in the range from 4.40 m to 6.00 m in 0.20-meter increments, calculate $SPL_P(x)$, which is the SPL at x predicted by the fit, using

$$SPL_p(x) = 20\log\left[\frac{1}{\frac{x-d}{A}\times(.00002)}\right] \qquad \text{(Eq. 5)}$$

For the nine values of x in the range from 4.40 m to 6.00 m in 0.20-meter increments, calculate the fit residuals $r_i(x)$ by subtracting $SPL_C(x)$ from $SPL_P(x)$. Determine if outliers exist by calculating the root-mean-square error RMSE from these residuals using

$$RMSE = \left[\frac{\sum_{i=1}^{n} r_i^2(x)}{n}\right]^{1/2} \qquad \text{(Eq. 6)}$$

where n =9. Consider any residual more than twice as large as the RMSE to represent an outlier in the data. Remove outliers from the data and repeat the fitting process and outlier check with n<9 if necessary. If the RMSE is greater than 1.0 dB after all outliers have been removed, the data shall not be used to determine if the siren system meets the applicable requirements specified in 6.11.

6. REQUIREMENTS

6.1 Acoustical Performance Requirements

6.1.1 SPL Requirements

When measured in accordance with 5.1, the SPL produced by Siren #1 shall meet all of the minimum requirements listed in Table 1. The SPL produced by Siren #2 through Siren #5, which are tested only at the measurement angle of 0 degrees, shall meet the corresponding SPL requirement before any other tests (e.g., vibration) are performed, and shall not be reduced by more than 3 dB after these other tests are complete. When comparing the measured SPL values to the SPL requirements, the measured values shall be rounded to the nearest integer decibel value. For the purpose of this comparison, measured SPL values that contain a five or greater in the first place to the right of the decimal shall be rounded upward.

TABLE 1 - SPL REQUIREMENTS

Measurement angle (degrees from device axis)	A-weighted SPL (dB re 20 µPa) measured with the fast time setting for siren signals with cycling periods > 0.40 s	A-weighted SPL (dB re 20 µPa) measured with the fast time setting for siren signals with cycling periods ≤0.40 s	A-weighted SPL (dB re 20 µPa) measured with a long-term time setting
0	118	117	115
±10	117	116	114
±20	116	115	113
±30	115	114	112
±40	113	112	110
±50	111	110	108

6.1.2 Signal Cycling Period and Frequency Requirements

6.1.2.1 Wail

The cycling period of the wail signal shall be between 2.0 s and 6.0 s. The fundamental frequency of this signal shall not fall below 500 Hz nor rise above 2000 Hz. Its range shall be at least one octave, and it shall be perceived as being continuous in frequency with no clearly audible discrete steps between frequencies.

6.1.2.2 Yelp

The cycling period of the yelp signal shall be between 0.24 s and 0.40 s. The fundamental frequency of this signal shall not fall below 500 Hz nor rise above 2000 Hz. Its range shall be at least one octave, and it shall be perceived as being continuous in frequency with no clearly audible discrete steps between frequencies.

6.2 Vibration Test Requirements

Cracking or rupture of parts of Siren #3 affecting its mounting shall constitute a failure. If there is no failure Siren #3 shall be submitted to the subsequent tests (corrosion, dust and moisture) remaining in the sequence of tests specified for Siren #3 in section 5 and shall meet the SPL requirements as specified in 6.1.1 after completion of the moisture test.

6.3 Corrosion Requirements

After completing the Corrosion Test, Siren #3 shall be submitted to the subsequent tests (dust and moisture) remaining in the sequence of tests specified for Siren #3 in section 5 and shall meet the SPL requirements as specified in 6.1.1 after completion of the moisture test.

6.4 Dust Requirements

After completing the Dust Test, Siren #3 shall be submitted to the subsequent test (moisture) remaining in the sequence of tests specified for Siren #3 in section 5 and shall meet the SPL requirements as specified in 6.1.1 after completion of the moisture test.

6.5 Moisture Requirements

After completing the Moisture Test, Siren #3 shall meet the SPL requirements as specified in 6.1.1.

6.6 Radiated Electromagnetic Immunity Test Requirements

Document the frequency and field strength at which a change occurred in the wail signal of the Siren #2.

Include a description of the change in the documentation.

After completing the Radiated Immunity Test, Siren #2 shall be submitted to the subsequent tests (radiated emissions and conducted emissions) remaining in the sequence of tests specified for Siren #2 in section 5 and shall meet the SPL requirements as specified in 6.1.1 after completion of the conducted emissions test.

6.7 Radiated Emissions Test Requirements

Document the peak and quasi peak radiated disturbances measured for all of the frequency bands specified in CISPR 25 – IEC;2002. Refer to Appendix B, Table B2B. After completing the radiated emissions test, Siren #2 shall be submitted to the subsequent test (conducted emissions) remaining in the sequence of tests specified for Siren #2 in section 5 and shall meet the SPL requirements as specified in 6.1.1 after completion of the conducted emissions test.

6.8 Conducted Emissions Test Requirements

Document the conducted disturbances measured on all input power lead terminals (include both the positive and negative terminals) of the siren for all of the frequency bands specified in CISPR 25 –IEC;2002. Refer to Appendix B, Table B2C. After completing the Conducted Emissions Test, Siren #2 shall meet the SPL requirements as specified in 6.1.1.

6.9 Durability Requirements

After completing the Durability Test, Siren #4 shall meet the SPL requirements as specified in 6.1.1.

6.10 Extreme Temperature Tests Requirements

Wail and yelp signals must meet the signal frequency requirements specified in 6.1.2 when tested in extreme temperature conditions. The amplifier output voltage measured in these conditions must be within ±15% of the voltage measured at the ambient laboratory temperature. Electromechanical sirens shall operate as designed during and after exposure to the applicable extreme temperature tests specified in the subsections of 5.10. After completing the applicable extreme temperature tests, Siren #5 shall return to room temperature and meet the SPL requirements as specified in 6.1.1.

6.11 Additional Acoustical Test for Siren Systems with a Large Speaker or a Large Speaker Array Requirements

All of the following requirements are applicable to the data acquired with the fast time setting and the data acquired with the long-term time setting. The SPL measured at 3.00 m shall be within +/- 1.00 dB of the SPL predicted at 3.00 m from the fit parameters (i.e., SPL_P at 3.00 m) determined from the fit of the data in the range from 4.40 m to 6.00 m. In addition, the value of SPL_P at 3.00 m shall meet the applicable SPL requirement for a measurement angle of 0 degrees in Table 1. When comparing the value of SPL_P to the applicable requirement, the value shall be rounded to the nearest integer decibel value. For the purpose of this comparison, values that contain a five or greater in the first place to the right of the decimal shall be rounded up.

For speaker arrays, document the configuration of the speakers in the array, including the relative positions and orientations of the speakers. Records that describe the relative positions of the speakers must include the spacing between the speakers.

7. GUIDELINES

7.1 Installation

Devices should be mounted only in locations designated by the identification code. The manufacturer should provide the necessary mounting brackets and mechanical fasteners to properly secure the siren, and include a detailed installation guide that describes proper mechanical mounting and wiring of the siren. This guide should specify how to install the siren, provide warnings concerning the potential for hearing damage due to exposure to siren noise, and recommend that exposure to acoustical noise in the passenger compartment of the vehicle not equal or exceed the NIOSH recommended exposure limit (see Appendix A). The guide should also describe the proper use of external fuses, circuit breakers or other circuit protective devices, and other proper vehicle wiring techniques and practices. A wiring diagram and a list of the minimum wire gauges necessary for the safe operation of the siren should also be provided.

Siren amplifier controls should be placed within the convenient reach of the driver or, if intended for two man operation, the driver and passenger. In some vehicles, multiple control switches may be necessary for convenient operation from two positions. The driver should be able to manipulate the amplifier controls with minimal movement from his normal driving position and without loss of eye contact from the roadway.

Do not install the siren amplifier in the airbag deployment zone, since the amplifier can become a dangerous projectile during deployment.

The speaker or electromechanical siren should be positioned with the sound projecting opening pointing forward, parallel to the ground, and not obstructed by structural components of the vehicle such as the radiator. Mounting the siren under the hood and behind the radiator will result in a reduction of sound pressure levels at locations away from the vehicle and is not recommended.

In order to minimize the potential for hearing loss, exposure to acoustical noise in the passenger compartment of a moving vehicle with an operating siren should not equal or exceed the NIOSH recommended exposure limit (see Appendix A). To help achieve this goal, the speaker should be mounted as far from the vehicle occupants as possible, preferably in the front grille area. Acoustically insulated compartments, isolation mounts, or other methods of minimizing the noise level in the vehicle passenger area should be used. It is also recommended that the siren shall be operated with the windows closed. After the siren is installed, the SPL should be measured per SAE J336 at each riding position.

Operators should be warned about the potential for hearing damage that can be caused by exposure to siren noise.

Approaches used to minimize the potential for hearing loss may lead to the increased likelihood of loudspeaker damage during minor collisions, exposure of loudspeakers to snow, slush, mud, etc., and the inability to hear sirens on other emergency vehicles. Appropriate training of vehicle operators is recommended to alert them to these issues.

7.2 Siren Signals

The only requirements specified in SAE J1849 common to all siren signals are the SPL requirements. The wail and yelp signals, which are conventional siren signals recognized as such by the general public, also have cycling period and frequency requirements so that they may be recognized when heard. Other signals may be tested to meet the SPL requirements, but might not be recognized as siren signals when heard. Manufacturers shall note in the siren manual those signals that meet the SPL requirements.

8. NOTES

8.1 Marginal Indicia

A change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

PREPARED BY THE SAE EMERGENCY WARNING LIGHTS AND DEVICES STANDARDS COMMITTEE
APPROVED BY THE SAE LIGHTING COORDINATING COMMITTEE

APPENDIX A - OCCUPATIONAL HEARING LOSS AND EXPOSURE TO SIREN NOISE

A.1 Occupational exposure to noise can increase the risk of temporary or permanent hearing loss. Hearing loss often occurs cumulatively over time, and can eventually affect the understanding of speech. In general, the extent of hearing damage incurred over time depends primarily on the noise SPLs and the duration of exposure. A great deal of information regarding noise in the workplace and its effects is provided by the National Institute for Occupational Safety and Health (NIOSH), a federal agency that examines workplace hazards, in the *Criteria for a Recommended Standard: Occupational Noise Exposure Revised Criteria 1998*. Time-weighted average (TWA) noise SPL limits are given as a function of exposure duration. The higher the noise SPL, the shorter the duration of exposure allowed. The NIOSH recommended exposure limit, which should not be equaled or exceeded, is 85 dB (A-weighted) as an eight-hour TWA. Exposure to a particular noise SPL for a given duration is considered by NIOSH to be equivalent to a SPL that is 3 dB higher for half that duration. Table A1 summarizes the TWA A-weighted noise SPL limits as a function of exposure duration that produce exposures equivalent to the NIOSH recommended exposure limit. This limit is only meant to significantly minimize the excess risk due to occupational noise exposure of developing a maximum acceptable hearing impairment that still allows for speech discrimination. Exposure to noise in the workplace lower than the recommended limit does not entirely eliminate the risk of hearing loss resulting from occupational noise exposure, or other factors such as aging, exposure to noise encountered outside of the workplace, and hazards such as ototoxic chemicals.

TABLE A1 - SOUND PRESSURE LEVEL LIMITS
A-weighted noise sound pressure level (SPL, in dB re 20 μPa) limits as a function of exposure duration that produce exposures equivalent to the NIOSH recommended exposure limit of 85 dB (A-weighted) as an 8 hour TWA, which should not be equaled or exceeded.

Duration of exposure per day (h)	TWA A-weighted SPL (dB)
8	85
4	88
2	91
1	94
1/2	97
1/4	100
1/8 (7 min and 30 s)	103
1/16 (3 min and 45 s)	106
1/32 (1 min and 53 s)	109

This NIOSH publication also includes information regarding hearing loss prevention programs and the use of personal hearing protection devices such as earplugs, earmuffs, and ear-canal caps. Hearing loss prevention programs are designed to quantify the nature and extent of hazardous noise exposure, monitor the effects of this exposure on hearing, and implement engineering or administrative controls to reduce noise exposure. *Preventing Occupational Hearing Loss - A Practical Guide* discusses hearing loss prevention programs in detail. It contains names, addresses, and phone numbers of associations that can provide assistance in contacting professionals who can be hired to administer or participate in a hearing loss prevention program, or perform noise measurements. Additional information concerning personal hearing protection devices is provided in the *Hearing Protector Device Compendium*, which includes data for many different hearing protectors sold in the United States.

Sirens produce noise that is loud enough to significantly increase the risk of temporary or permanent hearing loss. Health Hazard Evaluation Report HETA 81-059-1045 recommends that siren loudspeakers be located in the front of the vehicle so that the vehicle itself isolates personnel from the noise. *Health Hazard Evaluation Report HETA 84-493-1583* states that locating the siren speakers in the front grille area minimizes driver noise exposure in an ambulance. With the siren loudspeaker installed in the grille area, A-weighted SPLs in the driver cab were measured to be 16.3 dB to 22.0 dB lower than levels measured with the loudspeaker installed on the cab roof. This study also demonstrated that closing vehicle windows attenuates siren noise SPLs measured with an A-weighting in the ambulance driver cab by 7.1 dB to 12.8 dB.