



SURFACE VEHICLE RECOMMENDED PRACTICE

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Emergency Vehicle Sirens

RATIONALE

This document was revised to address the harmonization and revision of ANSI S1.4 to IEC 61672.

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.

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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 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 J336	Sound Level for Truck Cab Interior
SAE J575	Test Methods and Equipment for Lighting Devices 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 Accredited Publications

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

ANSI/ASA S1.1-2013	Acoustical Terminology
ANSI/ASA S1.4-2014/Part 1	American National Standard Electroacoustics - Sound Level Meters - Part 1: Specifications
ANSI/ASA S1.4-2014/Part 2	American National Standard Electroacoustics - Sound Level Meters - Part 2: Pattern Evaluation Tests

ANSI/ASA S1.4-2014/Part 3	American National Standard Electroacoustics - Sound Level Meters - Part 3: Periodic Tests
ANSI S1.15-1997/Part 1 (R2016)	Measurement Microphones - Part 1: Specifications for Laboratory Standard Microphones
ANSI S1.40-2006 (R2016)	Specifications and Verification Procedures for Sound Calibrators
ANSI S1.42-2001 (R2016)	Design Response of Weighting Networks for Acoustical Measurement

2.1.3 IEC Publications

Available from IEC Central Office, 3, rue de Varembe, P.O. Box 131, CH-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
IEC 61672-1 (2013-09)	Electroacoustics - Sound Level Meters - Part 1: Specifications
IEC 61672-2 (2013-09)	Electroacoustics - Sound Level Meters - Part 2: Pattern Evaluation Tests
IEC 61672-3 (2013-09)	Electroacoustics - Sound Level Meters - Part 3: Periodic Tests
CISPR 25:2016	Vehicles, Boats and Internal Combustion Engines - Radio Disturbance Characteristics - Limits and Methods of Measurement for the Protection of On-Board Receivers

2.1.4 DOT Publications

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.

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.

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>.

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.

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 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/IEC 61672 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 seconds.

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 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/IEC 61672. 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 1/2-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 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 $\pm$ 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 x 30.0 x 1.5 cm $\pm$ 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 $\pm 1\%$ 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 $\pm 5\%$.

5.1.1.8 DC Voltmeter

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