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Standard Test Method for Laboratory Measurement of the Insertion Loss of Pipe Lagging Systems[1]

This standard is issued under the fixed designation E1222; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the measurement of the insertion loss of pipe lagging systems under laboratory conditions.

1.2 A procedure for accrediting a laboratory for purposes of this test method is given in Annex A1.

1.3 The values stated in SI units are to be regarded as standard. The values given in parentheses are provided for information only and are not considered standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C423 Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method

C634 Terminology Relating to Building and Environmental Acoustics

E90 Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements

E548 Guide for General Criteria Used for Evaluating Laboratory Competence (Withdrawn 2002)[3]

2.2 *ANSI Standards:*

S1.4 Specification for Sound Level Meters[4]

S1.6 Preferred Frequencies and Band Numbers for Acoustical Measurements[4]

S1.11 Specification for Octave Band and Fractional-Octave-Band Analog and Digital Filters[4]

3. Terminology

3.1 *Definitions*—Terms used in this standard are defined either in Terminology C634 or within this standard. The definition of terms explicitly given within this standard take precedence over definitions given in Terminology C634. The definitions within Terminology C634 and this standard take precedence over any other definitions of defined terms found in any other documents, including other documents referenced in this standard.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *pipe lagging system, n*—an arrangement of noise insulating materials used to cover a pipe to reduce noise radiating from it.

4. Summary of Test Method

4.1 Noise is produced inside a steel pipe located within a reverberation room using band-limited white noise as a test signal. The noise must be produced by a loudspeaker or acoustic driver located at one end of the pipe. Average sound pressure levels are measured within the reverberation room for two conditions, one with sound radiating from the bare pipe and the other with the same pipe covered with a lagging system. The insertion loss of the lagging system is the difference in the sound pressure levels measured with sound radiating from the bare and lagged pipe, with an adjustment for changes in room absorption due to the presence of the lagging system. The results may be obtained in a series of 100-Hz wide bands or in one-third octave bands from 500 to 5000 Hz. Using 100-Hz wide bands will improve the signal-to-noise ratio in the

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org..

reverberant room. This is frequently necessary when measuring specimens having high insertion loss.

5. Significance and Use

5.1 The insertion loss of a pipe lagging system depends upon the lagging system materials, the method used to apply the materials, the pipe wall thickness, the size and shape of the bare and lagged pipe, and the mechanisms causing noise radiation from the pipe. Insertion losses measured using this test method should be used with some caution. In the laboratory, measurements must be made under reproducible conditions, but in practical usage in the field, the conditions that determine the effective insertion loss are difficult to predict and they may lead to slightly different results. Insertion losses measured with this test method can be used successfully for acoustical design purposes. Insertion losses measured with this test method are most useful for pipes and lagging systems which are similar to those used in the laboratory configuration.

5.2 This test method may be used to rank-order pipe lagging systems according to insertion loss or to estimate the field insertion loss of pipe lagging systems installed in the field.

5.3 This test method assumes that pipe wall stresses resulting from different methods of supporting the test pipe in the laboratory do not have a significant effect upon the measured insertion loss.

5.4 Pipe lagging systems typically have small insertion loss, and sometimes negative insertion loss, at frequencies below 500 Hz. The results obtained at frequencies below 500 Hz may be somewhat erratic. Sound sources used with this test method normally have a low frequency limit in the range from 300 to 500 Hz. For these reasons, the lowest band of frequencies for which results are required is centered at 500 Hz.

6. Interferences

6.1 Flanking transmission may limit the maximum insertion losses which can be reliably measured using this test method. The test pipe and reverberation room shall be constructed and arranged so as to minimize the possibility of transmission by paths other than through the test specimen. Flanking transmission should be at least 10 dB lower than the power transmitted through the test specimen into the reverberation room. Appendix X1 presents one procedure for assessing flanking transmission.

6.2 The background noise in each test band must be at least 10 dB below measured sound pressure levels for that band.

7. Apparatus

7.1 *Reverberation Room*—The sound field in the reverberation room shall approximate a diffuse field when the test specimen is in place. The requirements for the reverberation room are in Test Method C423. The volume of the test room shall be 56.6 m^3 or greater.

7.1.1 The average sound absorption coefficients of the room, excluding sound absorption by air and the test specimen, measured in accordance with Test Method C423, shall be less than 0.06 over the test frequency range when the test specimen is in place.

7.1.2 Diffusing devices such as rotating and stationary diffusing surfaces are useful for creating an adequate diffuse sound field.

7.2 *Pipe:*

7.2.1 *Construction*—The standard test pipe shall be at least 3.96 m long and mounted horizontally within the reverberation room. It shall be a nominal 305 mm diameter carbon steel pipe with a nominal wall thickness of 6.35 mm.

7.2.2 Other pipes may be used but they shall have a wall thickness of at least 6.35 mm, a nominal diameter of at least 152 mm, and shall be at least 13 diameters long.

7.2.3 *Installation*—Potential flanking transmission can be minimized if both ends of the pipe are outside of the reverberation room. For this reason, this is the preferred method of installing the pipe. Alternately, the loudspeaker end of the pipe may be located outside of the reverberation room. In this case, the other end of the pipe within the reverberation room must be carefully constructed and mounted to avoid flanking transmission. Any method of terminating the pipe may be used provided that adequately low levels of flanking transmission are achieved. It is usually necessary to cap the end of the pipe within the reverberation room with heavy structure and to vibration-isolate the pipe end from the reverberation room floor or ceiling. The cap may be a blind flange, at least twice as thick as the pipe wall, welded to the end of the pipe.

7.2.4 No solid connections may exist between the surfaces of the reverberation room and the pipe or test specimen. A flexible, nonhardening, knife grade mastic, such as available for sealing high-pressure ducts, should be used to seal the gaps where the pipe passes through walls.

7.3 *Loudspeaker:*

7.3.1 *Type*—The loudspeaker may be a horn-driver combination or a direct radiator (cone type) loudspeaker. Normally, only acoustic drivers with horns will have sufficient output for the tests when high insertion losses are being measured.

7.3.2 *Installation*—The loudspeaker shall be placed on the open end of the pipe outside the reverberation room. The horn of the loudspeaker must be structurally isolated from any contact with the pipe wall.

7.4 *Reference Sound Source:*

7.4.1 A reference sound source is needed to permit adjustments for the change in sound absorption within the reverberation room due to the lagging system.

7.4.2 The sound from the reference source shall be broadband noise without significant single-frequency components. The maximum sound power level of any single frequency component within a band should be at least 5 dB below the sound power level for that band.

7.4.3 The source level in any band shall have a maximum short-term time-variation of no greater than 2 dB measured with the slow dynamic characteristic of a sound level meter or the equivalent.

7.4.4 The source shall be physically small, with a maximum dimension of less than 0.61 m.

7.4.5 The reference source may be a loudspeaker; if so, it should be driven with bands of white noise and its sound power output should be within the limits prescribed in 7.4.3.

7.4.6 A preferred reference sound source is a modified centrifugal fan, directly connected to a motor with stable speed characteristics. The sound power level of this source as a function of frequency is adequately constant for this test method.[5]

7.4.7 The source should have a resilient mounting which is suitably designed to prevent transmission of vibrations to the structure on which it is mounted.

8. Test Specimen

8.1 The test specimen shall be a pipe lagging system installed on the bare pipe following normal mounting procedure. The system should be lapped and seamed following a procedure similar to the one used in the field.

8.2 If the pipe lagging system is usually installed with a seam, the test specimen shall have at least one seam around the circumference and one longitudinal seam.

8.3 The test specimen should be sealed where it butts to the walls of the reverberation room or the capped end of the pipe. The flexible mastic used to seal gaps around the pipe is also recommended for this purpose. The mastic should not harden with age so as to cause flanking.

9. Test Signal

9.1 The loudspeaker shall be driven with bands of white noise. To avoid nonlinearities, the total sound pressure level shall not exceed 160 dB inside the pipe.

9.2 The sound pressure level in the test band on the interior of the pipe shall have a maximum short-term time-variation in any band no greater than 2 dB measured with the "slow" dynamic characteristic of a sound level meter or the equivalent. If necessary, longer time averages may be used.

9.3 *Test Frequency Bands:*

9.3.1 *Constant Bandwidth Method*—The test signal shall be contiguous 100 Hz (±10 Hz), wide bands of white noise with arithmetic center frequencies over the nominal range from 500 to 5000 Hz. Optionally, bands centered at 300 and 400 Hz may also be used.

9.3.2 *One-third Octave-band Method*—The test signal shall be contiguous one-third octave bands of white noise at the preferred one-third octave band center frequencies from 500 to 5000 Hz. Optionally, one-third octave bands from 315 to 5000 Hz may be used.

10. Measuring Instruments

10.1 The minimum instrumentation required for this test method is as follows:

10.1.1 A monitoring microphone located inside the test pipe,

10.1.2 One or more room measurement microphones located in the reverberation room,

10.1.3 Microphone amplifiers that satisfy the requirements of ANSI S1.4 for Type 1 or better sound level meters with the exception that A and B-weighting networks are not required, and

10.1.4 A level meter, graphic level recorder, or other device from which the sound pressure level can be read or recorded. The averaging time of the instruments shall be sufficient to permit the determination of the average sound pressure level with adequate precision.

10.2 Measuring filters are required and depend upon the method selected:

10.2.1 *Constant Bandwidth Method*—Nominal 100-Hz wide constant bandwidth filters with arithmetic center frequencies consistent with the test signal frequency range.

10.2.2 *One-third Octave-Band Method*—A one-third octave filter set satisfying the requirements of ANSI S1.11 for Order 3 or higher, Type 1 or better. The nominal center frequencies of the filters shall be the same as the test signal center frequency.

10.3 A narrow band analyzer is optional. It may be useful for monitoring spectral uniformity of the sound within the pipe.

11. Procedure

11.1 Install the lagging specimen on the pipe.

11.2 Select microphone positions within the reverberation room. The locations shall be at least one-half wavelength away from any solid surface at the lowest test frequency.

11.3 Using the reference sound source, measure the average sound pressure levels in each test band within the reverberation room. Turn off the reference sound source.

11.4 Drive the loudspeaker at the end of the pipe with the test signal and measure the average sound pressure levels in each test band within the reverberation room. Measure the sound pressure levels generated by the test signal at the monitoring microphone inside the pipe.

11.5 Remove the test specimen from the pipe while maintaining the entire equipment set-up including all source and measuring instrument settings as far as practical. A precision step attenuator may be used to temporarily lower the test signal driving the loudspeaker while removing the test specimen. It is of the utmost importance to make no changes in the loudspeaker position.

11.6 Return the test signal to the previous setting.

11.7 Compare the sound pressure levels generated by the test signal at the monitoring microphone with the spectrum measured in 11.4. If the test signal, with sufficient time averaging, differs by more than 2 dB in any test band from that measured in 11.4 with the test specimen in place, begin the procedure again.

11.8 Measure the average sound pressure levels in each test band within the reverberation room. Turn the test signal off.

11.9 Repeat step 11.3 for the bare pipe.

[5] The sole sources of supply of the sound sources known to the committee at this time are Brüel and Kjäer Instruments, Inc., 185 Forest St., Marlborough, MA 01752 (Model 4204); ILG Industries, 2850 North Pulaski Road, Chicago, IL 60641; Electric France (E.D.F.), Department Acoustique et Vibrations, 17, Av. de la Liberation, 92 Clamart, France (Model NOVACEM); and, Acculab, 3201 Ridgewood Drive, Columbus, OH 43220.. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.