Designation: E1332 – 16

Standard Classification for Rating Outdoor-Indoor Sound Attenuation[1]

This standard is issued under the fixed designation E1332; 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.

INTRODUCTION

This classification is part of a set of ratings for the sound isolating properties of materials, building elements, and structures. It is based on A-weighted reduction of a transportation noise source. Other ratings include Classification E413 that rates the ability of a partition to reduce speech and other sounds within a limited frequency range, and Classification E989 that provides a rating method for comparing the impact-insulation properties of floor-ceiling assemblies.

1. Scope

1.1 The purpose of this classification is to provide a method to calculate single-number ratings that can be used for assesing the isolation for the outdoor sound provided by a building or comparing building facade specimens including walls, doors, windows, and combinations thereof, including complete structures. These ratings are designed to correlate with subjective impressions of the ability of building elements to reduce the penetration of outdoor ground and air transportation noise that contains strong low-frequency sound.[2] These ratings provide an evaluation and rank ordering of the performance of test specimens based on their effectiveness at controlling the sound of a specific outdoor sound spectrum called the reference source spectrum.

1.2 In addition to the calculation method, this classification defines some ratings not defined in other standards. Other standards may define additional ratings based on the method of this classification.

1.3 The rating does not necessarily relate to the perceived aesthetic quality of the transmitted sound. Different facade elements with similar ratings may differ significantly in the proportion of low and high frequency sound that they transmit and the spectra of sources can vary significantly. It is best to use specific sound transmission loss values, in conjunction with actual spectra of outdoor and indoor sound levels, for making final selections of facade elements.

1.4 Excluded from the scope of this classification are applications involving noise spectra differing markedly from that shown in Table 1. Thus excluded, for example, would be certain industrial noises with high levels at frequencies below the 80 Hz one-third octave band, relative to levels at higher frequencies, and any source, including some transportation sources, that does not have a spectrum similar to that in Table 1. However, for any source with a spectrum similar to that in Table 1, this classification provides a more reliable ranking of the performance of partitions and facade elements than do other classifications such as Classification E413.

1.5 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.6 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

C634 Terminology Relating to Building and Environmental Acoustics

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

E413 Classification for Rating Sound Insulation

E966 Guide for Field Measurements of Airborne Sound Attenuation of Building Facades and Facade Elements

[1] This classification is under the jurisdiction of ASTM Committee E33 on Building and Environmental Acoustics and is the direct responsibility of Subcommittee E33.03 on Sound Transmission.

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[2] This classification may be used in conjunction with Test Method E90 or Guide E966.

[3] 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.

TABLE 1 Reference Source Spectrum

One-third Octave Band Center Frequency, Hz	Sound Level, dB
80	103
100	102
125	101
160	98
200	97
250	95
315	94
400	93
500	93
630	91
800	90
1000	89
1250	89
1600	88
2000	88
2500	87
3150	85
4000	84

E989 Classification for Determination of Impact Insulation Class (IIC)

2.2 *ANSI Standard:*

ANSI S1.4 Part 1 – American National Standard Electroacoustics Sound Level Meters – Part 1 Specifications[4]

2.3 *ISO Standard:*[5]

ISO 532 Acoustics–Method for Calculating Loudness Level[4]

3. Terminology

3.1 The following terms used in this classification have specific meanings that are defined in Terminology C634: *airborne sound, decibel, impact insulation class, octave band, outdoor-indoor transmission loss, sound insulation, sound isolation, sound level, sound transmission loss.*

3.2 *Definitions:*

3.2.1 *apparent outdoor-indoor transmission class, AOITC(θ), n—of a building façade or façade element*, a single-number rating calculated in accordance with Classification E1332 using measured values of apparent outdoor-indoor transmission loss at a specified angle θ or range of angles.

3.2.2 *apparent outdoor-indoor transmission loss, AOITL(θ), dB, n—of a building façade or façade element*, the value of outdoor-indoor transmission loss obtained on a test façade element as installed, in a specified frequency band, for a source at a specified angle θ or range of angles as measured from the normal to the center of the specimen surface, without flanking tests to identify or eliminate extraneous transmission paths.

3.2.2.1 *Discussion*—All the sound power transmitted into the receiving room through both direct and flanking paths is attributed solely to the physical area of the test specimen. If flanking transmission is significant, the AOITL will be less than the actual OITL for the specimen.

3.2.3 *outdoor-indoor noise reduction, OINR or OINR(θ), dB, n—for a specified source angle of incidence or source sound distribution*, the difference between the time-average free-field sound pressure level at the exterior of a façade and the space-time average sound pressure level in a room of a building exposed to the outdoor sound through that façade.

3.2.3.1 *Discussion*—The outdoor-indoor noise reduction was previously referred to as the outdoor-indoor level reduction, OILR. If the result is measured for a source at a specific angle, or calculated based on outdoor-indoor transmission loss or apparent outdoor-indoor transmission loss, then the result is OINR(θ), a function of angle. If the result is calculated from values of transmission loss or is measured with a horizontal line source such as road or air traffic, the OINR is then not a function of horizontal angle though it may be a function of vertical angle for the horizontal line source.

3.2.4 *outdoor-indoor noise isolation class, OINIC or OINIC(θ), n—of an enclosed space exposed through a façade to an outdoor sound*, a single-number rating calculated in accordance with Classification E1332 using values of outdoor-indoor noise reduction.

3.2.5 *outdoor-indoor transmission class, OITC, n—of a building façade or façade element*, a single-number rating calculated in accordance with Classification E1332 using values of sound transmission loss.

4. Significance and Use

4.1 This classification provides a single number rating for transmission loss or noise reduction data that have been measured or calculated. This rating is based on the difference between the overall A-weighted sound level of the sound spectrum given in Table 1 and the overall A-weighted sound level of the spectrum that results from arithmetically subtracting the transmission loss or noise reduction data from this spectrum. The spectrum shape is an average of three spectra from transportation sources (aircraft takeoff, road, and diesel locomotive passby). A study showed that this classification correlated well with the A-weighted and loudness reductions (see ISO 532) calculated for each of the individual spectra used in developing the rating for the one-third octave band range of 50 to 5000 Hz. The calculated numeric value of the rating is based on the sound transmission loss or noise reduction values for a particular specimen and depends only on that data and the shape of the reference source spectrum used in the calculation. The values shown in Table 1 have an arbitrary reference level. Single-number ratings should always be used with caution. Specimens having the same rating can result in different indoor spectra depending on the variation of their transmission loss with frequency. Also, if the actual spectrum of the outdoor sound is different from that assumed in Table 1, the overall A-weighted outdoor-indoor noise reduction may be different from the OINIC. The strong low-frequency content of the spectrum in Table 1 means that specimen achieving a high rating must have strong low-frequency transmission loss. Use of this classification with the spectrum in Table 1 in situations where the source does not have a spectrum similar to Table 1 could result in requirements for more low-frequency transmission loss than is necessary for the application. Examples where

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

[5] Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.

this can occur are stage 3 jet aircraft, high-speed freeways with sound dominated by tire noise, and train passbys with sound dominated by horns.[6]

4.2 This classification requires sound transmission loss (TL), apparent outdoor-indoor transmission loss (AOITL(θ)), or outdoor-indoor noise reduction (OINR(θ)) data in one-third octave bands from 80 to 4000 Hz. Due to accuracy limitations given in Test Method E90 and Guide E966, measurements below the 100 Hz one-third octave band are not usually reported. Studies have shown that data in the 80 Hz one-third octave band are necessary to obtain acceptable correlations for transportation sound sources. For the purposes of this classification, measurements in the 80 Hz one-third octave band are deemed to be of acceptable accuracy.

4.3 Users of this classification should recognize that low frequency measurements of sound transmission loss may be affected by the test specimen size or the specimen edge restraints, or both, particularly for small modular specimens such as doors or windows. Consequently, the outdoor-indoor transmission class (OITC) may also be affected by these factors, resulting in some uncertainty of the field performance of assemblies bearing a rating number using this classification, but to what extent is unknown.

5. Procedure

5.1 The rating of a test specimen is calculated using third-octave data such as transmission loss or outdoor-indoor noise reduction in the range 80 to 4000 Hz. This would usually be measured in accordance with Test Method E90 or Guide E966, but might be estimated analytically.

5.2 The rating is calculated from the followingand rounded to the an integer value:

$$Rating = 100.13 - 10{*}\log\sum_{f} 10^{((L_f - D_f + A_f)/10)} \qquad (1)$$

where:

L_f = reference source spectrum,
A_f = A-weighting adjustment, and
D_f = Data at each one-third-octave frequency band, such as sound transmission loss or outdoor-indoor noise reduction.

5.3 Table 2 shows a general worksheet for use in calculating the rating, and Table 3 shows an example worksheet for calculating OITC. The figures in Column 3 for the A-weighting adjustments are taken from ANSI S1.4. Other ratings may be computed using the same worksheet substituting the appropriate data for the rating instead of the sound transmission loss.

6. Precision

6.1 A study[7] of forty-two sound attenuating gypsum board wall assemblies compared the calculated A-weighted sound reduction of each assembly, for three sound spectra used to develop the spectrum in Table 1, representing railroad, freeway, and aircraft noise sources over the one-third-octave band center frequency range of 50 to 4000 Hz, to the calculated OITC. The study gave the following statistical data:

TABLE 2 Worksheet for Calculating Outdoor-Indoor Ratings

Column 1	Column 2	Column 3	Column 4	Column 6
Band Center Frequency, Hz	Reference Sound Spectrum, dB (L_f)	A-weighting Correction, dB (A_f)	Column 2 + Column 3	Column 4 – Column 5
80	103	−22.5	80.5	
100	102	−19.1	82.9	
125	101	−16.1	84.9	
160	98	−13.4	84.6	
200	97	−10.9	86.1	
250	95	−8.6	86.4	
315	94	−6.6	87.4	
400	93	−4.8	88.2	
500	93	−3.2	89.8	
630	91	−1.9	89.1	
800	90	−0.8	89.2	
1000	89	0	89.0	
1250	89	0.6	89.6	
1600	88	1.0	89.0	
2000	88	1.2	89.2	
2500	87	1.3	88.3	
3150	85	1.2	86.2	
4000	84	1.0	85.0	

$$\text{Total Column 4 (dBA)} = 10 \log \sum_f 10^{(\text{Column } 4_f/10)}$$
$$= 100.13 \text{ dB}$$
$$\text{Total Column 6 (dBA)} = 10 \log \sum_f 10^{(\text{Column } 6_f/10)}$$
$$\text{Rating} = 100.13 - (\text{total Column 6})$$

where:
f = each one-third-octave frequency band.

TABLE 3 Example Worksheet Calculating OITC Specifically

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
Band Center Frequency, Hz	Reference Sound Spectrum, dB	A-weighting Correction, dB	Column 2 + Column 3	Specimen *TL*, dB	Column 4 – Column 5
80	103	−22.5	80.5	26	54.5
100	102	−19.1	82.9	26	56.9
125	101	−16.1	84.9	29	55.9
160	98	−13.4	84.6	29	55.6
200	97	−10.9	86.1	31	55.1
250	95	−8.6	86.4	32	54.4
315	94	−6.6	87.4	32	55.4
400	93	−4.8	88.2	30	58.2
500	93	−3.2	89.8	32	57.8
630	91	−1.9	89.1	36	53.1
800	90	−0.8	89.2	40	49.2
1000	89	0	89.0	44	45.0
1250	89	0.6	89.6	46	43.6
1600	88	1.0	89.0	48	41.0
2000	88	1.2	89.2	49	40.2
2500	87	1.3	88.3	47	41.3
3150	85	1.2	86.2	46	40.2
4000	84	1.0	85.0	50	35.0

$$\text{Total Column 4 (dBA)} = 10 \log \sum_f 10^{(\text{Column } 4_f/10)}$$
$$= 100.13 \text{ dB}$$
$$\text{Total Column 6 (dBA)} = 10 \log \sum_f 10^{(\text{Column } 6_f/10)}$$
$$\text{OITC} = 100.13 - (\text{total Column 6}) = 100.13 - 66.15 = 34$$

[6] Davy, J. L., "Insulating Buildings Against Transportation Noise," *Proceedings of ACOUSTICS 2004*, Gold Coast Australia, 3-5 November 2004.

[7] Walker, K. W., "Single Number Ratings for Sound Transmission Loss," *Sound and Vibration*, Vol. 22, July 1988.

Source	Slope, dB	Intercept, dB	Correlation	Standard Deviation, dB
Railroad	0.977	–2.4	0.990	1.2
Freeway	1.088	–2.5	0.981	1.6
Aircraft	1.099	2.8	0.961	2.4

NOTE 1—These results are valid only for spectra similar to those used and presented in the referenced study.

7. Keywords

7.1 A-weighting; aircraft; buildings; classification; facade; freeway; indoor; insulation; isolation; loudness; noise; outdoor-indoor noise isolation (OINIC(θ)); outdoor-indoor transmission class (OITC); outdoor; railroad; sound; traffic; transmission; transportation