Designation: E1332 – 22

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 assessing the isolation from 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 provides the definition of the outdoor-indoor transmission class which is not defined elsewhere within ASTM standards. Other standards such as Guide E966 define additional ratings based on the method of this classification, one of which is discussed in 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 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *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:*[3]

[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

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
E989 Classification for Determination of Single-Number Metrics for Impact Noise

2.2 *ANSI Standard:*[4]
ANSI S1.4-2014/Part 1/IEC 61672-1: 2013 Electroacoustics – Sound Level Meters – Part 1: Specifications

2.3 *ISO Standard:*[5]
ISO 532:1975 Acoustics–Method for calculating loudness level

3. Terminology

3.1 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.

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

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 The following definitions shall be used in interpretation of this classification for terms that do not appear in Terminology C634.

3.2.2 *outdoor-indoor noise reduction, OINR or OINR(θ), [dimensionless] 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.

3.2.2.1 *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 could be a function of vertical angle for the horizontal line source.

3.2.3 *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 (OINR or OINR(θ)).

3.2.3.1 *Discussion*—The OINIC is the overall A-weighted noise reduction that would occur if the source spectrum were that given in Table 1.

3.2.4 *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 (TL).

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 traffic, and diesel locomotive). A study showed that this classification correlated well with the A-weighted and loudness reductions (based on ISO 532:1975 in effect at the time) calculated for each of the individual spectra used in developing the rating for the one-third-octave band range of 50 Hz 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. Use single-number ratings 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

[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.

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

4.2 This classification requires data in one-third octave bands from 80 to 4000 Hz of sound transmission loss (TL) for outdoor-indoor transmission class (OITC), outdoor-indoor noise reduction (OINR(θ)) for outdoor-indoor noise isolation class (OINIC(θ)), or other data based on the rating definition for other ratings based on this classification.

4.3 Due to accuracy limitations given in Test Method E90 and Guide E966 (related to the volume of enclosed measurement spaces), measurements below the 100 Hz one-third-octave band were not reported prior to the development of this classification. Studies have shown that data in the 80 Hz one-third octave band are necessary to obtain acceptable correlations for transportation sound sources. Test Method E90 (when testing façade elements or exterior doors or windows) and Guide E966 now require the reporting of data in the 80 Hz one-third-octave band. For the purposes of this classification, such data are deemed to be of acceptable accuracy.

4.4 The low frequency measurements of sound transmission loss can 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) can 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. Basis of Classification

5.1 The rating of a test specimen is calculated using the reference source spectrum in Table 1 and one-third-octave-band data such as transmission loss or outdoor-indoor noise reduction in the range 80 Hz to 4000 Hz. This would usually be measured in accordance with Test Method E90 or Guide E966, but could be estimated analytically.

5.2 The rating is calculated from the following and rounded to the nearest integer value:

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

where:

L_f = reference source spectrum, at frequency f,
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.

TABLE 2 Worksheet for Calculating Outdoor-Indoor Ratings

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
Band Center Frequency, Hz	Reference Sound Spectrum, dB (L_f)	A-weighting Correction, dB (A_f)	Column 2 + Column 3	Specimen Test Data, dB	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.

5.3 Table 2 illustrates a general worksheet for use in calculating any of the ratings with columns numbered for clear reference in the instructions, and Table 3 shows a completed example worksheet for calculating OITC for the transmission loss data shown in column 5. The A-weighting adjustments in Column 3 are taken from ANSI S1.4/IEC 61672. Compute other ratings 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 42 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 (diesel engine, no horn), freeway traffic (spectrum more like low speed traffic), and aircraft (Stage 2 jet take-off maximum level) noise sources over the one-third-octave band center frequency range of 50 Hz to 4000 Hz, to the calculated OITC. Both OITC and A-weighted level reductions for the three source spectra were computed for the forty-two assemblies. For each source, the resulting 42 points were plotted with OITC on the Y axis and source A-weighted level reduction on the X axis, and a least squares line was fitted. The study gave the statistical data shown in Table 4.

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

[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.