

10ème Congrès Français d'Acoustique

Lyon, 12-16 Avril 2010

Evolving Acoustical Standards and Criteria for Green and High Performing Buildings in North America

Jack B. Evans¹

¹ JEAcoustics, 1705 W Koenig Ln, Austin, Texas 78756 USA, Evans<at>JEAcoustics.com

Building design standards and criteria in recent years have evolved and new standards have been introduced to increase sustainability and enhance operations in new facilities. Acoustical and noise control criteria are incorporated into new standards and criteria for green and high performing buildings as Environmental Quality (EQ). Governmental legislation and regulation have created or modified some standards. In many cases, non-governmental organizations (NGO) have written or sponsored voluntary standards, of which some NGO standards have been adopted into governmental regulations, building codes or ordinances. As they evolve, some of the standards are converging or being harmonized for adoption by government in regulations and codes. Standards and Criteria covered include:

Leadership in Energy and Environmental Design (LEED); created by U.S. Green Building Council (USGBC),

Standard for the Design of High-Performance Green Buildings except Low-Rise Residential Buildings, ASHRAE Standard 189.1, new in 2010,

Guidelines for Design and Construction of Health Care Facilities, Facility Guidelines Institute (FGI), new edition in 2010, Health Insurance Portability and Accountability Act (HIPAA), U.S. Department of Health and Human Services, new enforcement procedures in 2010

Energy Star, Guiding Principles for Federal Leadership in High Performance and Sustainable Buildings, U.S. EPA, 2006 American National Standard Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools, ANSI/ASA S12.60-2002 (R2009), a new revision that may be incorporated into International Building Code (IBC).

Les normes et critères de construction ont évolué au cours des dernières années et de nouvelles normes sont apparues pour améliorer la qualité environnementale et l'exploitation des nouveaux espaces. Les critères d'acoustique et de réduction du bruit font partie de ces nouvelles normes et nouveaux critères pour les bâtiments Verts ou à Haute Performance Environnementale. Les textes législatifs et réglementaires ont créé ou modifiées certaines normes mais dans bien des cas des organismes non gouvernementaux ont écrit ou financé des normes volontaires. Dans certains cas ces normes ont été adoptées dans les textes réglementaires, codes du bâtiment ou décrets. Au fur et à mesure de leur évolution, certaines de ces normes convergent ou sont harmonisées pour être incluses dans les textes réglementaires.

1 Introduction

High performing buildings designed for sustainable construction and operation also have acoustical considerations for indoor environmental quality. Evolving changes in standards, regulations, criteria and rating systems affect indoor acoustics. Some standards and ratings specify acoustical criteria, but others only imply need for acoustical considerations. Several important regulations and standards in effect in North America are introduced and discussed herein. References to originating entities and where to find more detailed information are also provided.

2 Leadership in Energy and Environmental Design (LEED)

2.1 About USGBC and LEED

The U.S Green Building Council (USGBC) is a private, non-profit organization with building designers and constructors, corporations, elected officials environmentalists and other concerned individuals. The stated mission



is “to transform the way buildings and communities are designed, built and operated, enabling an environmentally and socially responsible, healthy, and prosperous environment that improves the quality of life.

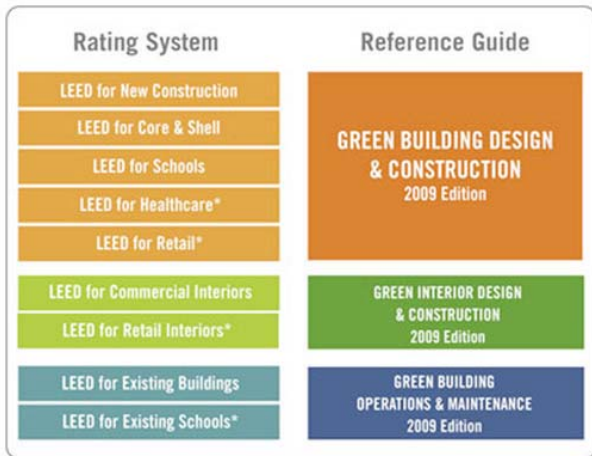
LEED is an internationally recognized voluntary green building certification system, developed by USGBC, “that provides building owners and operators a framework for identifying and implementing practical and measurable green building design, construction, operations and maintenance solutions.” Individuals who demonstrate understanding of green practices and principles and LEED requirements may become Accredited Professionals (AP). Certification of a project results in green, silver, gold or platinum recognition.¹



2.2 Development and Implementation of LEED

LEED rating systems are developed for several facility types through an open consensus-based process. Leed committees are comprised of practitioners and experts from the building design and construction industry. They develop benchmarks for design, construction and operation, recognizing performance in a) sustainable site development, b) water savings, c) energy efficiency, d) materials selection and e) indoor environmental quality, including acoustics.

LEED V3 launched April 2009 with a transition period for V2 projects. Effective January 2010 all new projects are registered under V3. The Green Building Certification Institute (GBCI) assumed the administration responsibility for LEED certification under V3 for commercial and institutional projects. The process includes registration, preparation of application, submittal, application review and if successful, project certification.



* These rating systems are under development or in pilot. Once they are available supplements will be sold for the new LEED 2009 Reference Guides.

Figure 1 : USGBC LEED Rating Systems and References

Commercial buildings are eligible for certification under *i)* LEED for New Construction, *ii)* LEED for Existing Buildings (renovation/addition), *iii)* LEED for Commercial Interiors (tenant improvement), *iv)* LEED for Schools, *v)* LEED for Healthcare, *vi)* LEED for Retail and *vii)* LEED for Core & Shell rating systems. There are also non-commercial rating systems, *viii)* LEED for Homes and *ix)* Neighborhood Development (pilot phase).

LEED for Schools	IEQ 9: Enhanced Acoustical Performance
Exterior Noise	Design Building Shell to meet STC in ANSI S12.600-2002, except windows which must meet STC-35
Sound Isolation	Classroom & Core Learning Space Partitions meet STC in ANSI S12.60-2002
Room Noise Levels	Permissible continuous building systems background noise criteria in Classroom and Core Learning Spaces ≤ 40 dBA (also ref: ASHRAE Applications, 2007)
Design considerations include reducing noise from exterior to interior spaces, between spaces within the building, and within the classroom space. External to internal noise transmission can be reduced by orienting classrooms away from external noise sources and using thick and/or massive materials in walls and roofs. Windows should be well-sealed and have adequate air gaps between sheets of glass. See IEQ Prerequisite 3: Minimum Acoustical Performance for more potential technologies and strategies.	

Table 1 : Acoustical Criteria in LEED for Schools V3

There are specific acoustical criteria for Indoor Environmental Quality (IEQ Credit 9, 1 point) in the LEED for Schools and LEED for Healthcare. In addition, it is possible to obtain credits under the Innovation in Design category (ID) for all LEED rating systems (other facility

types).² Schools IEQ Credit 9, 1 point, available for Enhanced Acoustical Performance, reference ANSI S12-60. Healthcare has two IEQ credits, reference HIPAA and FGI Guidelines, 1 point for Speech Privacy and 1 point for Acoustical Finishes & Details and Environmental Noise.³

3 ASHRAE 189.1 Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential

3.1 About Standard 189.1 (2009)

Standard 189.1 is a model code for high-performance and sustainability in design and construction of commercial buildings. It was developed jointly by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), the Illuminating Engineering Society (IES) and the U.S. Green Building Council (USGBC). The standard underwent four public reviews. It was published in final form January 2010 and is now available as ANSI/ASHRAE/USGBC/IES Std 189.1-2009. The standard is designed to be adopted in building codes as mandatory, with minimum requirements for design of sustainable buildings covering environmental responsibility, resource efficiency, occupant comfort/well-being and community sensitivity.⁴

3.2 Application to Building Design and Acoustics

Std. 189.1 applies to new buildings and their systems, new portions of buildings and new systems in existing buildings, with the exception of residential spaces of 3 stories or less. There is an earlier Standard 90.1 to provide minimum energy efficiency and design. Standard 189.1. Is intended to exceed the minimum energy requirements of 90.1 and address other characteristics of high-performance green buildings for siting, design and construction. There are specific requirements for indoor environmental quality, including environmental tobacco smoke control, outdoor air delivery monitoring, thermal comfort, low-emitting materials, lighting and acoustical control.

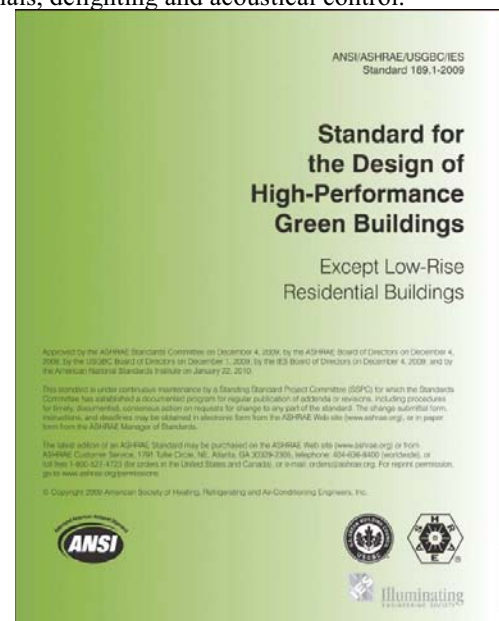


Figure 2 : ASHRAE Green Building Standard 189.1

Section 8.3.3, Acoustic Control, covers exterior and interior sound. Included parameters include: a) Outdoor-Indoor Transmission Class (OITC), ASTM E1332, and b) Sound Transmission Class (STC), ASTM E90 and E413. Section 8.4.2 Materials limits emissions or VOC contents for many building materials, including adhesives and sealants, ceiling and wall systems, including references to acoustical sealants, wall insulation, ceiling panels, etc.⁵

Std. 189.1	8.3.3 Acoustical Control
Exterior Sound	Design Building Envelope to meet Outdoor-Indoor Transmission Loss (OITC) ≥ 40 or Composite STC (STCc) ≥ 50 . Fenestration (windows) OITC or STC ≥ 30
Interior Sound – Wall & Floor-Ceiling Assemblies	Dwelling Units: STCc ≥ 50 Hotels, Motels, Nursing Homes and Healthcare Patient Rooms: STCc ≥ 45 Classrooms at Toilets/Showers, STCc ≥ 53 Classrooms at Music, Cafeteria, Gym/Pool, Mechanical Rooms, STCc ≥ 60
Reference Standards	OITL according to ASTM E1332 STC according to ASTM E90 & E413

Table 2 : Acoustical Criteria in ASHRAE 189.1

4 FGI Guidelines for Design & Construction of Health Care Facilities

4.1 Guidelines for Design and Construction of Health Care Facilities, 2010

The Public Health Service first published uniform, code-level guidelines for design and construction of healthcare facilities in the United States in 1948. This public work was moved to the private sector in the 1980's. The Facilities Guidelines Institute (FGI) was founded in 1998 to periodically revise and publish the updates, relying on the work of the multidisciplinary Health Guidelines Revision Committee. The U.S. Department of Health and Human Services (HHS) funds a partnership between the American Hospital Association (AHA) and the American Institute of Architects (AIA) to manage and produce re-publication every four years. FGI Guidelines are adopted in building

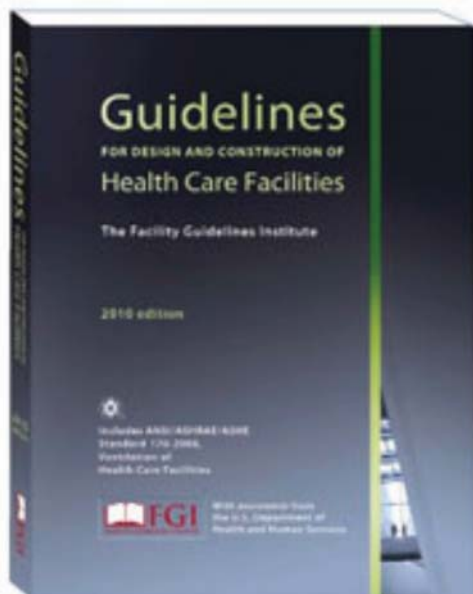


Figure 3 : FGI / ASHE Guidelines for Healthcare, ed. 2010

codes in 42 states and 7 federal agencies of the US, where it is enforced by regulation. FGI is voluntarily used or referenced in other US states in 15 other countries.

The 2010 FGI Guidelines, published and effective in January 2010, is the first edition to provide comprehensive criteria for acoustics, speech privacy, sound systems and building vibration in all types of healthcare facilities. It also retains reference to HIPAA (see Sec. 6, below) from the previous 2006 edition.⁶

FGI Guide	Acoustical Criteria Categories
Exterior Noise	Exterior shell STC 25-30 less than outdoor day-night average level (Ldn)
Acoustical Finishes	Compares noise reduction coefficient (NRC) for common materials
Room Noise Levels	Permissible continuous building systems background noise criteria (NC & dBA)
Sound Isolation	Permissible room-to-room composite sound transmission class rating (STCc)
Speech Privacy	Closed Plan and Open Plan: separate ratings for normal, confidential and secure privacy (AI, PI, STI or SII)
Alarms, Call Systems, Paging	Establishes criteria for audibility, intelligibility and minimal annoyance and masking
Floor Vibration	Patient, operating & procedure rooms: ISO Operating Theatre (100 $\mu\text{m}/\text{sec}$), public circulation and administrative: ISO daytime (200 $\mu\text{m}/\text{sec}$)

Table 3 : Acoustical Criteria in FGI Guidelines (Also used in LEED for Healthcare)

4.2 Sound & Vibration for Health Care Facilities, Version 2.0, Including New Guidelines for NICUs

A reference standard, originally published to accompany the 2006 Guidelines, has been updated and cross-referenced to the 2010 edition of FGI Guidelines by ANSI S12WG44 and Joint Subcommittee on Speech Privacy & Healthcare Acoustics, TC-AA.NS.SC, a technical committee of the

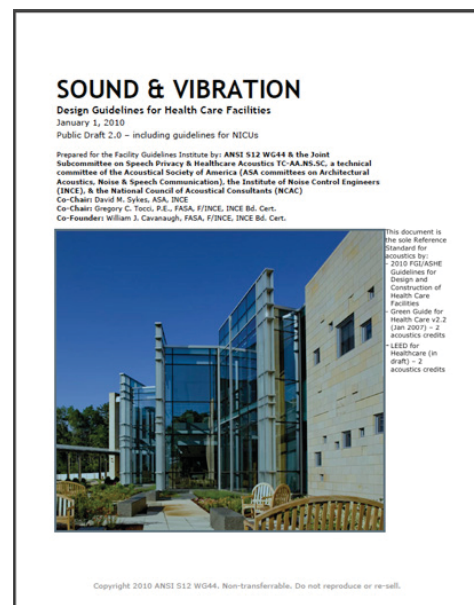


Figure 4 : Sound & Vibration V 2.0 Guidelines - sole Reference Standard for use with FGI Guidelines and LEED

Acoustical Society of America (ASA), the Institute of Noise Control Engineers (INCE) and the National Council of Acoustical Consultants (NCAC). The V 2.0 Sound & Vibration has been adopted as sole Reference Standard for 2010 FGI/ASHE Guidelines for Design and Construction of Health Care Facilities, LEED for Health Care Environmental Quality credits (USGBC, Sec. 2) and the Green Guide for Health Care Facilities.

4.3 Performance Parameters Covered

There are seven sections in FGI Guidelines, each with criteria tables, which have corresponding tables in Sound & Vibration, V2.0. This illustrates the breadth of acoustical, noise and vibration covered. They cover: a) exterior ambient sound, b) design room sound absorption coefficients, c) minimum and maximum noise in interior spaces, d) minimum sound isolation between enclosed rooms, e) speech privacy for enclosed rooms and open-plan spaces, f) speech privacy for open-plan spaces, g) sound transmission loss through barriers in NICUs and h) limits on footfall impact vibration in health care facilities.^{7, 8}

5 American National Standard Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools, ANSI/ASA S12.60-2002 (R2009)

5.1 About the School Classroom Acoustics Standard

ANSI S12.60-2002 (R2009) is a voluntary standard for classroom acoustics, unless referenced by state code local ordinance or regulation. School systems may also require compliance in construction documentation by architects and engineers. The United States Access Board, an independent Federal agency with primary mission to achieve accessibility for people with disabilities, partnered with the Acoustical Society of America (ASA) on the development of a classroom acoustics standard, based on reducing educational barriers for children. Young students are adversely affected by lower levels of background noise and reverberation due to less development of hearing systems and smaller speech vocabulary. Students with hearing impairments or with different home language than the teaching language also risk educational difficulties. Acoustical Performance Criteria, Design Requirements and Guidelines for Schools was approved as ANSI/ASA S12.60-2002. Similar requirements are mandated as regulations, ordinances or codes in many countries around the world.^{9, 10} The standard was recently updated as R2009, with additional standards for portable classrooms.

ASA has published two companion manuals to assist architects with classroom acoustical design; Vol. 1 Design Manual and Vol. 2 Key Acoustical Issues in Learning.¹¹

5.2 Application to Building Design and Acoustics

The Classroom Acoustics standard provides criteria for reverberation decay time and for background noise, including continuous building systems noise, sound transmission from adjacent interior spaces and intrusive exterior environmental noise. These criteria are based on a general principal of achieving a 15 dB signal-to-noise ratio

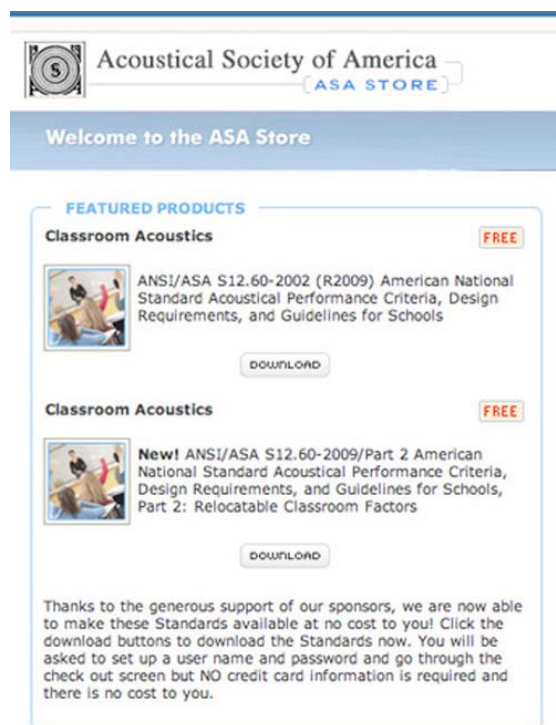


Figure 5 : Order page for (sponsored) ANSI S12.60 and companion Part 2 from ASA Store.

(SNR) for instructor speech. The standard’s criteria apply to all new classroom and learning space facility design and construction, and also to renovations when practical.¹²

S12.60-2002	Core Learning Space Requirements
Background 1	< 283 m ³ : 35 dBA, RT60 - 0.6 sec
Hr Noise and Reverberation	< 566 m ³ : 35 dBA, RT60 - 0.7 sec > 566 m ³ : 40 dBA (see Std. Annex C)
If noisiest 1-hour period is dominated by transportation noise, increase maximum limits by 5 dB	
Sound Isolation	Core Learning : Adjacent, STC 50 Common Use, Toilet, Bath, STC 53 Conference, Office Corridor, STC 45 Music, Mechanical, Cafeteria, STC 60 Classroom Doors, STC 30 Music Room Doors, STC 40
Open-plan classrooms do not meet sound isolation requirements of this standard	
Impact Insulation	Floor-Ceiling above, IIC 50 w/out carpet Gym, Dance or High-Impact, IIC 65-70 (new not recommended above classrooms)

Table 4 : Acoustical Criteria in S12.60-2002 Additional Requirements for Portable Buildings in R2009

6 Health Insurance Portability and Accountability Act (HIPAA)

6.1 About HIPAA

Public Law 104-191, The Health Insurance Portability and Accountability Act (HIPAA), was enacted by U.S. Congress in 1996. Title I protects health insurance coverage for workers and their families when they change or lose their jobs. Title II required establishment of standards for electronic transactions and identifiers for health providers,

insurance plans and employers. Title II also produced new standards for security and privacy of health data.^{13, 14}

6.2 History and Enforcement of HIPAA

HIPAA went into effect in 2004 and stipulates that speech privacy in healthcare facilities must be protected. However, until recently, no criteria had been approved for enforcement of the speech privacy provision. The Office for Civil Rights, a division of the U.S. Department of Health and Human Services (HHS), working with the U.S. Department of Justice, enforces HIPAA. Federal regulatory agencies like the Office for Civil Rights require practical, standards-based, criteria that do not compromise security considerations. To address the need for practical enforcement guidelines, new code-level criteria have been implemented by WEDI-SNIP (2005), FGI (2010), LEED for Healthcare (2009), and the Green Guide for Healthcare (2007), a group of agencies that agreed to “harmonize” enforcement criteria for speech privacy by adopting the same uniform Reference Standard. This Reference Standard, which covers speech privacy and all other aspects of acoustics in healthcare facilities, was developed between 2003-2009 by ANSI S12 WG44, a 500-member joint subcommittee of the ASA, INCE and the NCAC (TC-AA.NS.SC).¹⁵



Figure 6 : US HHS HIPAA Privacy Rule - Summary

Speech privacy is a function of multiple variables, chief among them being background noise and distance between source and receiver. Articulation Index (AI)¹⁶ and Speech Intelligibility Index (SII)¹⁷ are two, based on the relationship between decreasing speech intelligibility and increasing speech privacy. For example $AI < 0.05$, or less than 5% of syllables being intelligible, is considered confidential, whereas $AI \leq 0.15$ is considered acceptable or normal privacy for open offices. SII is similar, but expressed in percentiles, i.e. 39% is confidential and 75% is normal privacy.¹⁸

HHS issued an interim final rule to strengthen enforcement and increase penalties for violations of HIPAA, which became effective November 30, 2009. The

American Recovery and Reinvestment Act of 2009 (ARRA) included the Health Information Technology for Economic and Clinical Health (HITECH), of which Section 13410(d) increased maximum penalties to \$1.5 million for each violation. The acoustical privacy requirements are now subject to such enforcement.¹⁹

Refer to the new FGI “Acoustical Guidelines,” discussed in Sec. 4, above, for assistance with design implementation of HIPAA requirements.²⁰

7 Energy Star

7.1 About Energy Star

Energy Star was established as a joint program of the US Environmental Agency (EPA) and the U.S. Department of Energy (DOE) as a voluntary rating and resources system for energy efficient products and practices, including “Green Building,” or sustainable construction and high performance. Energy Star qualifies new and renovated buildings’ energy efficiency and awards the Energy Star label. Energy Star also awards the label to energy efficient products.

The program has divisions for products, (residential) new homes and home improvements, (commercial) buildings and plants and partner resources.

7.2 Application to Building Design and Acoustics

Acoustics, noise and vibration are not directly addressed by Energy Star. Energy Star provides guidelines for building design and energy managements. It also provides References for tools and resources, such as ways to rate building energy efficiency in comparison to similar type facilities, a portfolio manager to assist meeting energy performance goals and a database of expert help.



Figure 7 : US EPA & DOE Energy Star Label

The U.S. Energy Policy Act of 2005 and the Energy Independence and Security Act of 2007 included energy efficiency and sustainable design requirements for Federal (government) and other buildings. The “EPA Guiding Principals for Federal Leadership in High Performance and Sustainable Building” has been adopted by 18 federal agencies. Integrated design, energy performance and indoor environmental quality are covered, although there are no current acoustical standards or criteria.²¹

Although acoustics, noise and vibration are not directly addressed by Energy Star, acoustics may have secondary influences or relationships with energy efficiency and product selections. A new “Requirements for Audio/Video Equipment,” was released in November, 2009, and will be fully effective July 30, 2010, which recognizes, among other things, that loudspeaker amplifier wattage is a function of room volume and finishes.

Energy Star recognizes and refers to USGBC and LEED, the voluntary standard certification programs discussed in Section 8 above.

8 Evolving Reference Information

8.1 Standards, Criteria and Regulations Evolve

All of the standards, criteria and regulations presented herein have changed within the last year and are subject to continuing updates and evolution. Reference to jurisdiction or creating entity at time of use is wise.

8.2 About USGBC and LEED

Additional information about LEED may be found at: <http://www.usgbc.org> .

USGBC Reference Guides are available: https://www.usgbc.org/Store/Publications/List_New.aspx?CMSPageID=1518

LEED certified and registered projects and case studies are documented in a USGBC searchable database directory: <http://www.usgbc.org/LEED/Project/CertifiedProjectList.aspx?CMSPageID=244&CategoryID=19&> .

8.3 About Standard 189.1 (2009)

The Green Standard is introduced and may be previewed or purchased in book or downloadable pdf format at <http://www.ashrae.org/publications/page/927> .

8.4 FGI Guidelines for Health Care Facilities, 2010

The Guidelines may be purchased in electronic (CD) or book format at <http://www.fgiguideguidelines.org>

This Reference Standard, Sound & Vibration V2.0 Guidelines may be ordered as a download pdf from <http://www.healthcareacoustics.org> .

8.5 About the School Classroom Acoustics Standard

The Classroom Acoustics Standard is available for download in pdf format at no cost at <http://asastore.aip.org/>

The two companion manuals may be found at <http://asa.aip.org/classroom.html> .

8.6 About HIPAA

More information about HIPAA is available at <http://www.hhs.gov/ocr/privacy/> <http://www.hhs.gov/ocr/privacy/hipaa/understanding/summary/index.html> .

8.7 About Energy Star

More information about Energy Star is available at http://www.energystar.gov/index.cfm?c=about.ab_index .

Acknowledgements

Remerciement – Marc Asselineau for review and abstract summarization translation.

Thank you – David Sykes for review and assistance with ANSI S12WG44 history and applications in FGI and USGBC documentation.

References

- 1 <https://www.usgbc.org>
- 2 Evans, JB, Himmel, CN, 2009. “Acoustical and Noise Criteria and Guidelines for Building Design and Operations,” *Proc. of 9th Intl. Conference for Enhanced Building Operations*, Austin, USA
- 3 Sykes, Cavanaugh and Tocci, The 2009-2010 LEED, AIA & ASHE criteria for healthcare facilities, *Proc. Of InterNoise 2009*, (278) Ottawa, CA
- 4 <http://www.ashrae.org/>
- 5 Ryherd, E and Lawrence, T, 2009, “Updated ASHRAE Guidelines and Standards on Sustainable Systems Design,” *Proc. of ASA*, San Antonio, USA.
- 6 <http://www.fgiguideguidelines.org>
- 7 ANSI S12 WG44, The Joint ASA/INCE/NCAC Subcommittee on Healthcare Acoustics & Speech Privacy, Cambridge, MA USA
- 8 *Ibid.*, Sykes, InterNoise 2009
- 9 Evans, JB 2004. Acoustical Standards for Classroom Design - Comparison of International Standards and Low Frequency Criteria. In *Proc. of the 11th International Meeting on Low Frequency Noise & Vibration*, Maastricht, The Netherlands. J. Low Frequency Noise, Vibration and Active Control.
- 10 Evans, J.B. 2004. Designing for Better Sound in Schools. *Texas Architect*, 54(1), January, pp. 52-58, Texas Society of Architects/AIA, Austin, TX.
- 11 ANSI S12.60-2002
- 12 <http://asa.aip.org/classroom.html>
- 13 U.S. Public Law 104-91
- 14 <http://aspe.hhs.gov/admsimp/pl104191.htm>
- 15 *Ibid.*, Sykes, InterNoise 2009
- 16 ANSI. 1969. S3.5-69, American National Standard “Methods for Calculation of the Articulation Index,” Standards Secretariat, ASA, New York.
- 17 ANSI 1997. S3.5-97, American National Standard “Methods for Calculation of the Speech Intelligibility Index,” Standards Secretariat, ASA, New York.
- 18 Bradley, J.S. 2009. “Comparisons of speech privacy measures,” *Proc. Of InterNoise 2009, Ottawa, CA* (pdf 191), Intl. Inst. of Noise Control Engineering.
- 19 <http://www.healthcareitnews.com/news/hipaa-violators-could-face-fines-15m>
- 20 www.healthcareacoustics.org
- 21 http://www.energystar.gov/index.cfm?c=green_buildings.green_buildings_index