BUILDING EXCELLENCE

Minneapolis Public Schools

Effective January 2011

ACOUSTICAL DESIGN GUIDELINES
for
SCHOOL CONSTRUCTION PROJECTS

MPS MINNEAPOLIS PUBLIC SCHOOLS

Urban Education. Global Citizens.

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MINNEAPOLIS PUBLIC SCHOOLS

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Introduction

Excessive noise and reverberation interfere with speech intelligibility, resulting in reduced understanding and reduced learning. Studies identify that many classrooms foster poor speech intelligibility. It is estimated that many classrooms have a speech intelligibility of 75% or less. This means that only 75% of the words read from a list can be understood by normal-hearing listeners in a classroom. The mission of the Noise Advisory Committee and these guidelines is to create more productive learning environments in the Minneapolis Public Schools (MPS) by creating spaces with improved acoustical quality. It is believed that when this is accomplished, a direct impact on learning outcomes will be made.

The purpose of these guidelines is to provide the construction and renovation design team with reasonable acoustic performance standards and to help identify potential noise problems and solutions. These guidelines are to be a reference for architects, engineers and facility planners to use in the design of new school buildings and in renovation. They are to be used as an aid in the understanding of desirable acoustical conditions in classrooms. They are not to replace the services or responsibilities of the design team or an acoustical consultant. The focus of these guidelines is on classrooms and other teaching spaces. They do not address the special design criteria for performance spaces such as music rooms and auditoriums. Professional acoustical consultants should be involved with the development of these spaces.

The following Acoustical Design Guidelines are an outline of performance standards to be implemented to provide improved acoustical quality in new school and major renovation projects. The guidelines are separated into three sections: Environmental Noise, Architectural Systems and Mechanical Systems. In order to obtain the goal of improved acoustical quality, all three should be considered together in the planning and design phase. Each component can have a direct impact on or relationship to the other. Appendix (A), (B) and (C) are design recommendations provided for each section to give examples of strategies that can be used to meet the standards. These guidelines are to be implemented without jeopardizing items in the MPS Indoor Air Quality Guideline. Exceptions to these guidelines should not to be made without prior approval from MPS.

Section 1: Environmental Noise

The location for new school sites and additions to existing facilities should be evaluated to determine whether interior performance standards could be accomplished at that location and at what dollar cost. These factors should be considered prior to final selection of a proposed site. Design recommendations for this Section are identified in Appendix A of these guidelines.

Environmental Performance Standards

- Noise from any source at a proposed property for a new school or an addition to an existing school should not exceed an average of *60 dBA (L_{50}) or 65 dBA (L_{10})* during the time of day the school is in session.

Environmental noise monitoring should be completed to determine that the site is suitable. Sites exceeding these standards are acceptable if a sound reduction plan is submitted to and approved by MPS. The Site Evaluation Worksheet is to be used as a guideline when evaluating the feasibility of site from a noise perspective (Appendix D).

Section 2: Architectural Systems

Architectural systems should be designed to provide improved acoustical quality. In order to accomplish this, considerations for speech intelligibility, reverberation time, sound transmission and impact isolation need to be incorporated into the design. By focusing design criteria on controlling reverberation time and sound transmission, speech intelligibility of approximately 90% can be achieved. Numerous design techniques can be used to accomplish this, including the location of teaching spaces, the size and shape of the room, building surfaces, etc. Noise criterion (NC) will also have an impact on speech intelligibility and will be addressed in Section 3 of these guidelines.

The reverberation time of a room is the time it takes for sound to decay by 60 dB once the source has stopped. Reverberation is caused by sounds reflecting off hard surfaces. The cumulative result of many strong reflections is long reverberations times. Reverberation masks the sound of the spoken message and increases background sound levels. The longer the reverberation time, the greater the impact on speech intelligibility.

Sound is transmitted between rooms through several paths including walls, floors ceilings, doors, plenums, chases, mechanical penetrations and ductwork. Architectural systems should be designed to minimize the transmission of sound. The amount of sound transmitted through a building component is dependent on the Sound Transmission Class (STC) of the building component. It is also dependent upon the area of the component, the quality of construction and the acoustical characteristics of the receiving room. STC is a laboratory rating of the amount of sound isolation provided by a building component.

Design recommendations for this Section are identified in Appendix B of these guidelines. Examples of room surface modeling strategies that could be used to accomplish the performance standards are identified in Appendix E of these guidelines.

Architectural Performance Standards

- Architectural systems should be designed and constructed to achieve the following reverberation times (RT) in an unfurnished and unoccupied room:

Space Type	RT
Classrooms/Teaching Spaces	<= 0.6 Seconds
Media Center	<= 0.6 Seconds
Industrial Arts	<= 1.0 Second
Cafeteria	<= 1.0 Second
Commons/Non-Teaching	<= 1.0 Second
Corridors	<= 1.0 Second
Private Offices	<= 0.6 Seconds
Open Offices	<= 0.6 Seconds
Conference room	<= 0.6 Seconds
Gymnasium	1.0 thru 1.4 Seconds

The RT requirements identified in this document refer to the RT60 at the octave band centered at 500 Hz. The RT in the octave band centered at 125 Hz shall be no more than 1.7 times the RT at 500Hz, and the RT in the octave band centered at 4000 Hz shall be no more than 0.8 times the RT at 500 Hz.

- Architectural systems should be designed and constructed to provide a Field Sound Transmission Class (FSTC) of *45* in teaching spaces. Sound isolation values for teaching space walls should be designed at an STC 50.

Section 3: Mechanical Systems

Mechanical systems should be designed to provide improved acoustic quality. High ambient noise from mechanical equipment can be disruptive to the learning environment and decrease speech intelligibility. Noise Criterion (NC) is a rating system for the quietness of a room and is typically associated with HVAC noise, but includes all ambient noise present in a room when it is measured. Minimizing the Noise Criterion rating of mechanical systems in teaching spaces will contribute to improved speech intelligibility. Design recommendations for this Section are identified in Appendix C of these guidelines.

Mechanical Performance Standards

- Mechanical Systems are to be designed and constructed to achieve the following maximum Noise Criterion (NC).

Space Type	NC
Classrooms/Teaching Spaces	35
Media Center	35
Industrial Arts	35
Cafeteria	35
Commons/Non-Teaching	35
Corridors	35
Private Offices	35
Open Offices	35
Conference room	35
Gymnasium	45

Note: Field evaluation of NC values can be measured by using a sound level meter. The NC rating is approximately 6 dBA less than the measured decibel level using an "A" - weighted scale.

END OF GUIDELINES

Appendix A

Design Recommendations (Environmental Noise)

Appendix A

Design Recommendations (Environmental Noise)

1. School sites near airports, freeways, high-traffic roadways or industrial operations are likely to have noise levels exceeding the performance standards. When feasible, sites should be located away from these types of environmental noise sources.

2. The school should be located on the site in a manner to provide maximum separation from major noise sources, i.e. airports, freeways, etc.

3. Building envelope construction should be sufficient to ensure that architectural and mechanical performance standards can be obtained (as defined in Section 2 & 3). Specific design techniques and construction materials may be necessary to isolate acoustically sensitive areas from exterior sound. Weak points in sound isolation are commonly the roof, windows, glazing, doors, mechanical penetrations and vents.

4. Playgrounds should be located away from interior teaching spaces. (Exception: Tot lots in relation to kindergarten classrooms)

5. The school's noise impact on the neighboring community from mechanical systems must not exceed established Noise Standards (Minnesota Rules Chapter 7030.0040 & City of Minneapolis: Code of Ordinances, Chapter 389) for the location of the facility and its Noise Area Classification (Minnesota Rules Chapter 7030.0050). Cooling towers, emergency generators, chillers, condensing units, etc., should not be located close to neighboring structures without making provisions to meet regulatory noise standards. The designer should verify compliance with noise standards for the facility. The applicable regulatory noise standards are as follows:

	Daytime		Nighttime	
Noise Area Classification	L_{50}	L_{10}	L_{50}	L_{10}
1. Residential	60	65	50	55
2. Commercial	65	70	65	70
3. Industrial	75	80	75	80

END OF APPENDIX A

Appendix B

Design Recommendations (Architectural Systems)

Appendix B

Design Recommendations (Architectural Systems)

1. Floor plans should be developed isolating spaces likely to generate disruptive noise levels from traditional teaching spaces. Spaces that should be isolated include but are not limited to: mechanical rooms, restrooms, industrial arts areas, music areas, auditoriums, gymnasiums, multipurpose rooms and cafeterias.

2. Second floor spaces should be located over similar use lower floor spaces. For example, corridor over corridor, restroom over restroom. In particular, avoid restrooms or corridors over classrooms.

3. Sound isolation values for teaching space walls should be designed at STC 50. This value may need to be increased based on adjacent noise sources. Buffer spaces can also be used to accomplish this.

4. Flooring systems should be designed and constructed to minimize impact noise and footfall noise.

5. Teaching space ceilings should be acoustically absorbent with a minimum Noise Reduction Coefficient (NRC) 0.60. A minimum of 75% of the ceiling space should be absorptive. Depending upon NC values, the room design and other room surfaces, these values may need to be increased to meet performance standards.

6. Alternatives to carpet use should be explored. Deviation from the District Floor Covering Policy cannot be made without prior approval from MPS.

7. Full height partitions should be sealed, top, side and base along both sides with caulking. Where the partition seals to a rough, textured or corrugated surface, special closure strips may be required in addition to caulking. Where drywall is elevated off the floor to meet IAQ Guidelines, sufficient caulking should be used to accomplish an STC 50.

8. Teaching space partition walls should be insulated and extend to the ceiling deck.

9. Noise generated by lighting systems should not exceed Noise Criteria Standards established in Section 3 of these guidelines.

10. Electrical/data/technology outlets should not be installed back to back. Back to back outlets should be separated by at least one stud space. Holes in boxes and along perimeters should be sufficiently caulked or fire caulked.

11. Teaching space doors should have a solid core and have all sides acoustically gasketed. If possible, doors should be staggered so that they are not directly opposite or adjacent in a corridor.

12. CMU partitions for acoustical purposes should be constructed from dense aggregate blocks with grout-filled core spaces. All exposed surfaces should be sealed with two coats of paint. On double partitions, inner surfaces can remain unpainted.

13. Penetrations through walls (i.e., ductwork, conduit or plumbing) should be sealed with caulking or fire caulking.

14. Wherever sealant or caulking is specified for acoustical purposes, butyl or silicone-base, non-hardening type should be used.

15. Pipe or conduit runs inside, or penetrations through a double-stud partition, must not rigidly tie the two stud sets together. The interconnecting element should be vibration isolated, either by means of a flexible connection, or by packing around the penetration on one side with sponge neoprene or fiber glass so contact is not made with the wall surface. Additional vibration isolation may be required for plumbing.

16. In toilet rooms adjacent to teaching spaces, all plumbing partitions should have 3-1/2" batt insulation between both sets of studs.

17. Sound isolation values for operable partitions should be specified for an STC 50. Pass doors are typically not acceptable.

18. Lockers mounted common to teaching space walls should be specified with a resilient mount.

END OF APPENDIX B

Appendix C

Design Recommendations (Mechanical Systems)

Appendix C

Design Recommendations (Mechanical Systems)

Location of Mechanical Rooms

1. Mechanical rooms should be isolated from teaching spaces and other quiet spaces. Where feasible, they should be located on grade level.

2. Mechanical equipment should not be in direct contact with the structure. Equipment should have spring and inertia isolation. Other attachments should be resilient.

3. Mechanical systems should provide no perceivable vibration in any occupied portion of the building.

4. Penetrations between mechanical rooms and occupied spaces should be minimized or indirectly routed from mechanical rooms to occupied spaces.

5. Where mechanical equipment is located above grade or on a roof, ensure that the construction under the equipment is sufficient to meet the performance standards.

6. Suspended ceilings offer modest reduction of mechanical equipment noise. Mechanical equipment should not be located above teaching space ceilings.

7. Mechanical room walls should be sufficient to meet performance standards. The construction of solid masonry walls with an STC 60 is a good rule. This value may need to be increased based on adjacent room usage.

8. Glass fiber blankets are not suitable sound barriers. They only reduce sound reflected from a surface.

HVAC Equipment Selection

1. Specifications should require mechanical equipment suppliers to submit sound ratings (as per AMCA 300) for their equipment. This information may be necessary for use in acoustic models. This applies especially to equipment that may be situated above ceilings in spaces requiring noise levels below NC 35.

2. Terminal units (VAV, CV, etc.) generate more noise if the total pressure drop across the device is increased. In order to minimize noise generation, select units with a low operating pressure drop.

3. Fans should be selected for and operated at maximum efficiency, which usually results in quietest operation.

4. Air handling units should incorporate the fan and motor on a spring base within a minimum 16 gauge metal acoustical cabinet. These models avoid the problems that sometimes occur

through rigid connection to a fan assembly. Note: according to the MPS Indoor Air Quality Guideline, exposed internal insulation inside air handling units is not allowed. All air handling units should contain double wall construction with insulation in between the two walls.

5. Unit ventilators, fan coil units, heat pumps and ductless split systems in teaching spaces should be avoided. These units contain fans and sometimes compressors that are loud and difficult to treat due to their position in the room.

6. Laboratory fume hood exhaust fans should be selected for low tip speed and maximum efficiency for quiet operation. This equipment should be located remotely from the fume hood to minimize noise in the classroom.

7. In general, low speed equipment is quieter in operation than high-speed equipment. Depending upon the equipment's location in relation to teaching spaces, low speed equipment may need to be used to meet performance standards.

8. When available, select equipment with the motor mounted inside the cabinet.

9. When capacities must be modulated, variable speed drives are quieter than other forms of capacity adjustment. Motors should be selected to be compatible with variable speed drives in order to minimize equipment sound levels.

Installation of Mechanical Equipment

1. Rotating or reciprocating machinery should be mounted on vibration isolators that provide a required 95% efficiency.

2. Variable frequency drives should be mounted with vibration isolators that provide a required 95% efficiency.

3. Isolators should be selected on the basis of machine speed, the type of structure supporting the equipment and structural spans.

4. Piping and electrical connections must be ensured not to short circuit vibration isolation devices. Electrical connections may need to be resilient with flexible conduit. Pipe connections should be made through neoprene pipe connectors.

5. Sound traps should be located in a section of duct where a uniform velocity profile across the duct prevails. The air velocity at the face of the trap should not exceed 1000 ft./min.

6. Noise generated in diffusers decreases if the velocity is reduced. Manufacturer catalogs give the noise level of their products for a given velocity and blade setting. Diffuser selection should be based on noise generated, throw/diffusion capabilities and if a VAV system is used, the high CFM versus low CFM conditions.

7. Dampers should preferably be located a minimum of five feet upstream of diffusers and be followed by externally lined ductwork or a plenum to absorb aerodynamic noise.

Mechanical Equipment above Ceilings

1. Where mechanical equipment is located above ceilings, the sound levels radiated by all the equipment through the ceiling should be less than those required by the room's NC standard.

2. Use neoprene or spring hangers to suspend motor driven equipment above ceilings.

3. Ensure that equipment does not touch the ceiling or ceiling hangers.

4. Whenever feasible, equipment serving teaching spaces should be located outside of the area, i.e. VAV boxes, heat pumps, etc.

5. All ceiling components should be considered when designing ceilings. Much of an acoustical tile ceiling will be made up of grilles, diffusers and lights. Attenuation furnished by these elements should equal or exceed the ceiling attenuation in order not to compromise the acoustical integrity of the ceiling.

Ductwork

1. Noise generated by air movement in a given section of ductwork is proportional to the velocity in the duct. A small increase in duct air velocities may cause a large increase in noise generation.

2. Velocities should be selected which meet ASHRAE standards for the area served by the duct and over which the duct passes.

3. Ductwork should be designed to promote smooth aerodynamic flow. Turbulence produces noise and may cause ducts to vibrate. Architectural plans should be designed to accommodate required duct lengths and diameters for this purpose. Mechanical engineers should be consulted during initial architectural planning.

4. In order to reduce the incidence of duct generated noise, the following points may be considered:

   - A duct attached to the discharge of a fan should be straight for a minimum of 2.5 X the fan diameter before incorporating an elbow.
   - Elbows following a scroll centrifugal fan should turn in the same direction as the fan scroll.
   - Parallel bladed dampers should be avoided.
   - Ducts should not be sized with aspect ratios greater than 2:5:1 unless extra bracing is used externally.
   - When ducting air through an elbow whose width in the radius of the turn is two or more times its height, turning vanes should be used for the complete arc of the turn.

5. Use flexible connections to connect motor drive equipment to ductwork.

6. Ductwork that is common between two adjacent spaces should contain sound traps to inhibit crosstalk.

7. If a sound trap is inserted in a duct in the mechanical room and the duct then passes through the mechanical room wall to an occupied space, the section of the duct between the sound trap and the mechanical room wall may need to be treated to avoid noise breaking into the quiet duct.

Piping and Circulation Systems

1. Piping should be routed over corridors and other areas with lower sensitivity to noise.

2. Black steel piping provides greater resistance to flow noise than copper and pvc. Victaullic type fittings should not be substituted for vibration isolation connections or flexible connections.

3. Flow velocities generally should not exceed seven feet per second to insure quiet operation.

4. Sufficient air vents should be provided to clean trapped air and diminish sound resulting from air entrained in the heating medium.

5. Pumps near peak efficiency should be selected. Plumb inlets and size pumps to avoid cavitation.

6. Pumps may need to be mounted on a concrete inertia base, supported by spring isolators. In-line pumps are difficult to isolate for vibration.

7. All pipe connections to pumps and other rotating equipment should be made through a flexible connector.

Plumbing

1. Acoustically sensitive areas should not share a common wall with a plumbing wall.

2. Cast iron drain waste and vent piping offer superior noise attenuation characteristics as compared to plastic or copper piping.

3. Siphon jet fixtures are quieter in operation than blowout fixtures.

4. Domestic water pressure should be reduced to the Minnesota Plumbing Code requirement of 80 psi. Water hammer arresters are to be used as needed.

5. All domestic water risers serving fixtures with flush valves or solenoid valves should be provided with shock arresters or other method to eliminate water hammer.

END OF APPENDIX C

Appendix D

Site Evaluation Worksheet

Appendix D

Site Evaluation Worksheet

Environmental noise monitoring should be completed to determine if a site is suitable from a noise perspective. Noise from any source at a proposed site for a new school or an addition to an existing school should not exceed an average of 60 dBA (L_{50}) or 65 dBA (L_{10}) during the time of day that school will be in session. Sites exceeding these standards are only acceptable if a plan for sound reduction is submitted and approved by MPS. This worksheet is to be used as a guide during the evaluation of a proposed site and in comparison to other proposed sites. A sketch drawing of the proposed site is to be made on the back of this form.

Proposed Site Location: (address or block area) ____________________

____

____

Type of Area (circle): residential commercial industrial other ____________

Description of Noise Influences: (roads, air traffic, adjacent facilities, etc.) ____________

____

____

Distance/Frequency of Noise Influences: ____________________

____

Noise Monitoring Data

A type one sound level meter should be used to measure average decibel levels on the proposed site. A minimum of four property line locations should be tested with two-hour averages calculated for each location. It is recommended that sampling periods start at 10:00 AM and 2:00 PM. Sampling locations are to be identified on the site drawing.

Date of Monitoring: ____________ **Survey By:** ____________________

Instrument Used: ____________ **Calibration (circle):** yes no

Activity During Monitoring: ____________________

	Test Location	Sampling Period	L_{50}	L_{10}
1				
2				
3				
4				

Site Exceeds Performance Standard (circle): yes no

Sound Reduction Plan Required (circle): yes no

Comments: ____________________

____

____

Appendix E

Room Surface Modeling Examples

Appendix E

Room Surface Modeling Examples

The following three scenarios are shown as examples of how a Reverberation Time (RT) of <=0.60 seconds can be achieved in a 900 SF classroom with varying qualities of ACT ceilings. These examples show how the varying absorption coefficients of different ceiling tiles will affect the RT's in the space. All of the examples below make the following assumptions about the other surfaces in the classroom:

Ceiling: ACT ss noted in each example below. Twelve 2' X 4' lighting fixtures are assumed for each space. If you have gypsum board soffits for ductwork, you will need to place additional absorption (such as absorptive wall panels) in the space to achieve the RT of 0.60 seconds. Also, if you use a ceiling tile with an absorption coefficient lower than that shown in the examples below, you will need to place additional absorption on the walls.

Floor: VCT

Walls Gypsum board, with 64 SF of window glass assumed. Absorptive panels on the walls are assumed to be 2" thick fabric coved glass fiber panels with NRC .90 – 1.0.

Scenario #1

This utilizes ACT with NRC .55, with absorption coefficients as shown below:

125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	NRC
.35	.29	.51	.70	.71	.73	.55

With the ceiling tile shown above, you will need to add 160 SF of 2" thick absorptive panels (NRC .90 – 1.0) to the walls to reach RT 0.60 at 500 Hz.

Scenario #2

This utilizes ACT with NRC .70, with absorption coefficients as shown below:

125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	NRC
.32	.34	.76	.87	.86	.84	.70

With the ceiling tile shown above, you will not need to add any absorptive panels (NRC .90 – 1.0) to the walls to reach RT 0.60 at 500 Hz.

Scenario # 3

This utilizes ACT with NRC .95, with absorption coefficients as shown below:

125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	NRC
.48	.82	.90	.99	.99	.99	.95

With the ceiling tile shown above, you will not need to add any absorptive panels to the walls to reach RT 0.60 at 500 Hz. You can also add gypsum board soffits up to 150 SF and still reach a 0.60 second RT.

Note: You can get large variations in acoustical tiles with the same NRC. For example, one tile with an NRC of .95 may have an absorption coefficient of .90 at the 500 Hz octave band, while another may have an absorption coefficient of only .70 at the same frequency band. Generally speaking, it will be better to use a ceiling tile with a high absorption coefficient at the 500 Hz octave band.

Glossary

The following definitions are identified to provide a better overall understanding of acoustical basics. Not all definitions provided are used in this guideline.

A-Weighting (dBA)
The filtering of sound that attempts to replicates the human hearing frequency response. The human ear is most sensitive to sound at mid frequencies (500 to 4,000 HZ) and is progressively less sensitive to sound at frequencies above and below this range. A-weighted sound level is the most commonly used descriptor to quantify the relative loudness of various types of sounds.

Absorption
The attenuation (or reduction) of sound level that results when sound is controlled by a sound absorptive material such as glass fiber. In the case of sound absorptive materials used in the building industry, attenuation of sound is produced by conversion of molecular motion, which is sound, into thermal energy due to friction of air molecules with fibrous or cellular materials.

Acoustics
1. Acoustics is the science of sound, including its production, transmission and effects.
2. The acoustics of a room are those qualities that together determine its character with respect to the perception of sound.

Ambient Noise
Ambient noise encompasses all sound present in a given environment, usually a composite of sounds from many sources in the near and far.

Barriers
A structure, such as a wall, that blocks the line-of-site between a sound source and a receiver, thereby providing a barrier attenuation, i.e., a reduction of sound level at a receptor. Sound attenuation provided by barriers is principally related to the diffraction of sound over and around the barrier, and the sound transmission loss through the barrier material.

Decay Rate (dB/sec)
The rate at which sound will reduce when the noise source is removed

Decibel (dB)
Unit for reporting the level (magnitude) of sound. A change of 10 decibels is generally considered a doubling or a halving of the perceived loudness of a sound.

Flanking
The transmission of sound around the perimeter or through holes within partitions (or barriers) that reduces the sound isolation between areas. Examples of flanking paths within buildings are ceiling plena above partitions, ductwork, piping, and electrical conduit penetrations through partitions; back-to-back electrical boxes within partitions, window mullions, etc.

Frequency
Frequency is the number of oscillations or cycles per unit time. In acoustics, frequency usually is expressed in units of Hertz (Hz) where one Hertz is equal to one cycle per second.

Hertz (Hz)
Frequency measure in units of cycles per second. See frequency.

Inverse Square Law
The law of physics that teaches for every doubling of distance from the point source the level of the originating signal will diminish by 6 dBA.

L_{eq} (Equivalent Noise Level)
Measure used to express the average sound level (typically express in dBA) over a given period of time.

L_{max}
Measure used to express the maximum sound level over a time period.

L_n Statistical Noise Levels
Sound levels (typically expressed in dBA) exceeded "n" percent of the time. Common statistical levels are L_{10} (level exceeded 10% of the time), L_{50} (level exceeded 50% of the time), and L_{90}. (level exceeded 90% of the time).

Octave Band
Groups of frequencies defined by standards where the upper frequency of each band is equal to twice the lower frequency of the next higher band. Octave bands are usually named by their center frequency. The full complement of octave bands in the audible frequency range is as follows: 31.5, 63, 125, 250, 500, 1,000, 2,000, 4,000, 8,000 and 16,000 Hz.

1/3 Octave Band
Frequency band encompassing 1/3 of one octave. Three successive 1/3 octave bands make one full octave.

Noise
Unwanted sound.

Noise Criteria (NC)
Background noise level of a room, typically associated with HVAC noise but includes all ambient noise present in room when measured.

Examples of typical NC ratings:

Below NC 15:	Quiet studio
NC 15 – NC 25:	Quiet library or classroom
NC 25 – NC 35:	Typical Office
NC 35 – NC 45:	Noisy Office

Noise Reduction (NR)
The amount of noise that is reduced through the introduction of sound absorbing materials.

Noise Reduction (NR)
The level by which a sound is reduced from one space to another through a wall, floor or ceiling. (See Transmission Loss)

Noise Reduction Coefficient (NRC)
The average of the absorption coefficients (α) for the frequency bands 250 Hz, 500 Hz, 1000 Hz, and 2000 Hz. Commonly used to describe the average absorption of acoustical materials such as ceiling tiles and wall panels.

Reverberation
Reverberation is the persistence of sounds in an enclosed space resulting from multiple reflections from room surfaces.

Reverberation Time (RT60)
The reverberation time of a room is the time it takes for sound to decay by 60 dB once the source of sound has stopped. Reverberation time is inversely related to sound absorption and is a way to measure the amount of absorption in a room.

Sabin
A unit of absorption having the dimensions of square feet or square meters, as appropriate. A quantity of the amount of absorption equal to the surface area (SA) of a material multiplied by its absorption coefficient (α).

Signal
A sound carrying useful information or information of interest. The signal could be a test tone, speech, music.

Signal to Noise Ratio (SNR)
A measure of useful signal to unwanted noise.

When computed using sound levels in units of dB, it is a subtraction and not a ratio. SNR = $L_s - L_N$ where L_s is the level of the signal and L_N is the level of the noise at the listeners ear. (See Inverse Square Law)

Sound Absorber
An apparatus or material that reduces the amount of sound reflected back into the environment once the incident sound wave hits it. The most common type of absorber is porous material. Once the sound enters the porous material, its sound energy is dissipated as heat. Also see absorption.

Sound Isolation
Ability of an object or material to inhibit sound from passing through it. Typically isolating material should be nonporous. Mass increases the isolation of materials.

Sound Pressure Level, (SPL or L)
Measure of sound in units of decibels. O dB is considered to be the lower threshold of human hearing. Most often Sound Pressure Levels are expressed in A-weighted SPL (dBA). See also A-weighted.

Sound Reduction Plan
A plan of action to be submitted by the design team to address property noise levels exceeding the Environmental Performance Standard of 60 dBA (L_{50}) or 65 dBA (L_{10}). The plan may include strategies for sound isolation, building layout or envelope construction to combat noise sources. The plan should identify how performance standards can be accomplished on a site exceeding the environmental performance standard.

Sound Reinforcement
Electronic amplification of an acoustic sound source, such as a talker. Sound reinforcement systems typically use microphones, amplifiers and loudspeakers.

Sound Transmission Class (STC)
Single performance rating of transmission loss. It is a standard ASTM ISO rating.

Speech intelligibility
It is the ability to understand spoken words in a particular environment.

Speech Transmission Index (STI)
Analytical measure of the intelligibility of speech in an environment. On a scale of 0 to 1, an STI of 0 is completely unintelligible. An STI of 1 would be perfectly intelligible. STI can be measured in the field or can be calculated using computer models of architectural spaces.

Teaching Space
Any school space designed for and used in part or in whole for the purpose of teaching.
It is a space where a teacher is required to communicate and a student to listen. It also includes spaces used for studying and reading. A teaching space can include but is not limited to the following: classrooms (all types, all levels), computer rooms, art rooms, music rooms, industrial arts rooms, media centers, multi-purpose rooms and gymnasiums.

Transmission Loss (TL)
A standard ASTM test similar to Noise Reduction but removes influences of the test sample size and amount of sound absorption of test room. TL is reported in decibels for individual octave or 1/3 octave frequency bands.

END OF GLOSSARY