098000 ACOUSTICS

Cornell's Design and Construction Standards provide mandatory design constraints and acceptable or required products for all construction at Cornell University. These standards are provided to aid the design professional in the development of contract documents and are not intended to be used verbatim as a contract specification nor replace the work and best judgement of the design professional. Any deviation from the Design and Construction standards shall only be permitted with approval of the University Engineer.

PART 1: GENERAL

1.01 RELATED SECTIONS

A. Section 080000 – Doors and Windows

B. Section 230000 – Basic HVAC Requirements

C. Section 274000 – Audio-Video Communications

1.02 SCOPE AND PURPOSE

A. The goal of this section is to establish acoustical standards for renovation and new construction.

B. Excellence in acoustical design for classrooms, meeting spaces, offices, seminar and conference rooms is a critical outcome of renovation and new construction. Highly engaging and accessible learning environments that utilize audiovisual equipment--amplified microphones, speakers, conferencing systems, recording equipment, and assistive listening systems--are central to the mission of the University.

C. Room acoustics, sound absorption, sound isolation, and electronic/mechanical noise are to be analyzed and tested to confirm a successful outcome.

D. The intent is not to specify room materials and construction methods but rather to establish standards to be adhered to during the design phases and verified through measurement during construction and the final commissioning phase.

E. Proper acoustical design and proper sound system design will result in high levels of speech intelligibility in large teaching spaces, the appropriate projection of sound to seats, and sound isolation for privacy in office and conference room settings, and impact isolation for residence halls.

1.03 CODES AND STANDARDS

A. IEC 60268-16:2011, "Sound System Equipment - Part 16: Objective Rating of Speech Intelligibility by Speech Transmission Index"

B. ANSI/ASA S12.60 PART 1, "American National Standard Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools, Part 1: Permanent Schools"

C. ANSI/ASA S12.2-2008, "Criteria for Evaluating Room Noise"

D. AHRI Standard 885, "Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets."

E. ANSI S1.4, "Specification for Sound Level Meters"

F. ISO 3382-2:2008, "Acoustics-Measurement of room acoustic parameters - Part 2: Reverberation Time in Ordinary Rooms"

G. AVIXA A102.01:2017, "Audio Coverage Uniformity in Listener Areas"

H. ASHRAE Applications Handbook, 2015 Chapter 48 Noise and Vibration Control

I. International WELL Building Institute Standard, Concept: Comfort, Features 74, 75, 78, 79, 80, 81

J. Government Services Administration – Facilities Standard for Public Buildings (P-100)

1.04 DEFINITIONS

A. Decibel – A unit that measures sound or the power level of an electrical signal by comparing it with a reference level on a logarithmic scale.

B. Sound Pressure Level (SPL) – A measurement of sound amplitude in decibels referenced against threshold of hearing as 0 dB or ~20 micropascals.

C. Ceiling Attenuation Class (CAC) -- CAC is a measure for rating the performance of a ceiling system as a barrier to airborne sound transmission through a common plenum between adjacent closed spaces.

D. A-weighted Sound Level (dBA) – A measurement of loudness in decibels that applies a conventional frequency weighting that simulates human hearing (equal loudness contour) to the levels of sound pressure.

E. Maximum dBA – Decibel denoting the maximum allowable overall sound pressure level in a space.

F. Noise Criteria (NC) – NC curves: Classifies continuous ambient background noise levels in a space by evaluating sound pressure level across eight octave band frequencies in the 63-8000 Hz range. This includes background noise created by mechanical (HVAC) systems, AV/IT equipment, as well as noise from the outside environment. Refer to ANSI/ASA S12.2-2008 standard for measurement method. This is also generically known as noise floor.

G. Room Criteria (RC) Mark II Rating - A single number rating of airborne sound transfer of a system at frequencies of 16-8000 Hz similar to NC, as well as sound balance.

H. Sound Transmission Class (STC) - A single number rating of an assembly's ability to resist airborne sound transfer at frequencies 125-4000 Hz.

I. Apparent Sound Transmission Class (ASTC) - ASTC is STC as measured in the built environment and is typically within 0 - 5 decibels of the laboratory STC rating for a well-constructed assembly.

J. Noise Isolation Class (NIC) – Single number rating of the noise isolation between two enclosed spaces that are acoustically connected by one or more paths, abbreviation NIC. The rating is derived from the difference in sound levels between two spaces. A higher NIC rating provides more noise isolation between the two spaces.

K. Impact Insulation Class (IIC) – Single number rating for the attenuation, measured in an acoustical testing laboratory of structure borne sound through floor or floor-ceiling assemblies from floor impacts into the space below. A higher IIC rating provides more impact sound attenuation into the space below.

L. Acoustical Privacy - Pertains to the acoustical attenuation between spaces that is needed to prevent conversation in one space from being understood in an adjacent space.

M. Speech Privacy Potential (SPP) – SPP is a measurement of acoustical privacy. SPP = STC + NC.

N. Reverberation Time (RT60) – RT60 is the time (in seconds) it takes for sound to decay 60 dB below its initial sound level. Reverberation of sound in a space is a major factor in determining speech intelligibility, affecting both natural sound sources and electronically amplified sound. RT60 can be calculated during the design phases of a project using the Sabine formula, which takes into account room volume and the sound absorption characteristics of the room's floor, ceiling, and wall materials, as well as fixtures in the space. RT60 can be measured in existing spaces during initial site surveys, and after construction to verify conditions. Refer to ISO 3382-2:2008 standard for measurement method.

O. Speech Transmission Index (STI) – STI is a measurement of speech intelligibility in a space.

P. Speech Transmission Index for Public Address Systems (STIPA) – STIPA is a methodology for measuring and assessing STI in a room. The STIPA method of measurement can be used in spaces that do not contain sound amplification systems, as well as measuring speech intelligibility from a sound amplification system. Refer to IEC 60268-16:2011standard for measurement method.

1.05 ACOUSTICAL DESIGN REQUIREMENTS

A. The design team shall meet the minimum standards governing acoustical performance by categories of space usage as indicated in Table 1. Higher or lower values might be appropriate and should be based on an analysis of space size, use, adjacencies, and user needs. An experienced acoustical consultant should be retained for guidance on spaces where acoustical criteria are integral to the use of the space. Verify sound criteria with local codes.

B. The following are minimum acoustical performance requirements for all projects on campus:

1. Acoustical design shall consider the multiple pathways of sound transmission and use the industry standard measurement of NIC (Noise Isolation Class) as referenced in Tables 1 and 2.
2. Partitions and ceilings enclosing spaces shall achieve the NIC listed in Table 1.
3. Background noise from HVAC and installed electronics shall meet a defined NC per Table 1.
4. Exterior equipment shall not exceed 50 dBA as measured at façade of adjacent building.
5. As applicable to project acoustical criteria, determine if sound masking technology is appropriate to generate a continuous minimum noise level. See WELL Standard Design Guidelines for office spaces for sound masking. 45-50 dBA.
6. Provide adequate speech privacy in open office designs and refer to GSA P-100 and WELL Standard Design Documents.
7. Consider using noise masking for a variety of settings including offices and learning spaces that fluidly change from presentation mode to group collaboration mode.

C. The Consultant shall identify and document the acoustical design requirements in each phase of the project as follows:

1. Pre-Schematic Design Phase: Identify acoustic requirements by indicating any key program spaces that may have acoustic and/or vibration, such as teleconference rooms, rooms with sensitive laboratory equipment, open work areas, large public areas, etc.

2. Schematic Design Phase:
   a. Establish and document user expectations.
   b. Develop performance criteria and Adjacency Matrix.
   c. Based on discussions with the client and user group, develop a basis of design sound criteria matrix and narrative for each discreet space type requested in the program. The matrix as a minimum shall include, as applicable:
      - NIC ratings between space adjacencies
      - NC rating
      - RT60 rating
      - STIPA rating
   d. Identify locations where sound masking should be incorporated into the design.
   e. Existing acoustical conditions should be measured and documented by an acoustical consultant as befits the project acoustical criteria and as is programmatically appropriate for the space.

3. Design Development Phase
   a. Continuation of acoustical design, noting any changes made from the previous phase.
   b. Update basis of design sound criteria matrix and narrative.
   c. Develop a color-coded plan indicating NIC ratings between space adjacencies, NC ratings and STC partition types to support the overall NC and NIC ratings in Tables 1 and 2.
   d. Begin development of partition types and detailing. Partition and ceiling schedules shall denote STC ratings and CAC ratings where appropriate as designated by partition/ceiling type.
   e. Determine the types of acoustical interventions to incorporate into the design.
   f. Where applicable, use RT60 Sabine calculations based on the proposed wall, ceiling, and floor materials, in relation to room size for all spaces with reverberation time criteria in Table 1.

g. Provide preliminary layout of sound masking systems including equipment list, conduit and power requirements, and expected heat loads.

h. Provide a Draft Acoustical Testing Plan for review by the project team.

4. Construction Document Phase

a. Continuation of acoustical design, noting any changes made from the previous phase.

b. Update basis of design sound criteria matrix and narrative.

c. Update color-coded plan indicating NIC ratings between space adjacencies, NC ratings and STC partition types to support the overall NC and NIC ratings in Tables 1 and 2.

d. Finalize partition types and detailing. Partition and ceiling schedules shall denote STC and CAC (for shared plenum ceilings) ratings designated by partition/ceiling type.

e. On projects where the owner hires a third-party acoustical testing agency to review and finalize sound partition details, acoustical consultant to participate in review meetings and integrate acoustical design details as necessary.

f. Finalize sound masking drawings complete with specifications for competitive bidding.

g. Complete Acoustical Testing Plan.

1.06 RECOMMENDED ACOUSTICAL DESIGN STRATEGIES

To meet the design criteria, consider the following common approaches:

A. Partitions & Ceilings

1. Extend walls and gypsum board to the structural deck. Fill flutes between top track and metal deck with appropriate materials to block sound transmission through this path.

2. Doors, sidelites, storefront systems, clerestories, exterior windows, electrical outlets and air transfer represent the weakest point where sound will travel. Flanking paths such as continuous roof structures and exterior curtain walls represent another weak point where sound will travel. Review of these weak points during design can mitigate issues that arise during construction. The specification/construction of a high STC wall may not address the NIC requirement in Table 2.

3. Consider heavy solid core wood doors or metal doors filled with fibrous material, gasketed around perimeter to increase transmission loss.

4. Avoid louvered or undercut doors to attempt increased airflow within a space.

5. All corner/ceiling/floor connections and penetrations shall be sealed with acoustical caulk.
6. Electrical boxes in adjacent spaces shall be spaced apart with a stud separating them. Electrical boxes shall require acoustical putty pads, caulking, and insulation behind them.
7. To improve the transmission loss of an assembly, consider the following:
   (a) Adding mass to the assembly.
   (b) Increasing or adding air space in a wall or window assembly.
   (c) Adding absorptive material in the partition.
   (d) Staggering studs or using dual studs.
   (e) Specifying 25 gauge metal studs.
   (f) Increasing stud spacing.
8. Specify acoustical ceiling tiles for a 0.75 NRC (minimum of 35 CAC).
9. Consider insulated glazing units (IGUs) in glass walls at conference rooms, glass sidelites and glass doors.

B. Adjacencies: Do not locate mechanical equipment rooms or toilet rooms next to offices, conference rooms, classrooms, performing arts spaces, or other sound critical spaces. See Table 2.

C. HVAC

1. Design air distribution systems to minimize resistance and turbulence.
2. If possible, variable air volume units and fan coil units shall be placed outside noise sensitive areas; ideally in corridors, toilet rooms, or storage, utility, and mechanical rooms.
3. Select fans to operate near to rated peak efficiency. Select the fan size that best balances aerodynamic efficiency with low sound generation. Consider a larger fan at lower rotational speed provides lower sound levels.
4. Design duct connections to fans for uniform and straight airflow.
5. When duct silencers are used, select with a maximum static pressure drop of 0.25-inches water column including system effects.
6. Separate elbows or duct branch takeoffs at least 5 - 10 duct diameters from each other.
7. Keep airflow velocity in the duct at 1500 feet per minute and below. For duct transitions, do not exceed an included expansion angle of greater than 15.
8. Place registers, grilles and diffusers 5-10 duct diameters away from volume dampers, elbows and branch takeoffs.

9. Use turning vanes in rectangular elbows.
10. Isolate all reciprocating and rotating equipment connected to the structure.
11. Vibration isolate ducts and pipes for the first 50 feet from connected equipment.
12. Use appropriately sized plenum fans, plenum should be acoustically treated with sound absorptive material; locate the plenum discharge away from the fan's air blast.
13. Supply and return air systems shall be detailed to prevent transmission of sounds between spaces.
14. Use of duct lining is discouraged as a primary means of sound attenuation.
15. Avoid plenum return systems using transfer ducts. If possible, duct all return air systems.
16. When used, fan coil units in occupied spaces shall be selected to provide full cooling/heating capacity when running at a maximum of medium (50%) speed.

1.07 CONSTRUCTION

A. Construction Administration Phase

1. The Acoustical Consultant and in some cases a third party acoustical consultant will be engaged through construction. The Contractor will ensure the timing of submittals, substitution requests, and mockups of acoustical details are coordinated with the design team's scheduled site visits to observe the implementation of the acoustical design scope.
2. Owner may include third party testing for a specific project component to measure the performance of the component. Define scope of work for third party testing and observe testing to confirm test procedures and completeness.

1.08 POST OCCUPANCY TESTING AND VERIFICATION

A. Post occupancy acoustical testing. The owner shall retain an acoustic testing consultant to commission systems during construction. The commissioning shall include observing, documenting, and validating the acoustic design requirements during construction to ensure that it is in full accordance with the basis of design and contract documents. Testing shall include confirming the final NC, STIPA, and RT60 as shown in Tables 1 and 2. RC Mark II Ratings shall be measured, documented, and submitted with Record Documents. Both background sound measurements with the Audiovisual and mechanical equipment turned off; as well as with the AV/HVAC turned on will be taken. Consider building utilization for increased activities may warrant testing during peak hours.

Table 1: Rooms: Acoustic Design Guidelines & Post Occupancy Testing				
Space Type Code	**Space Type**	**Noise Criteria (NC)**	**RT60 (sec)**	**STI/STIPA**
20	Circulation Area – corridor	40		
20	Circulation Area – atrium	35-40	1.5	
24	Lobby	40-45	1.2	
110/680	Classroom/Meeting Room – volume < 10,000 ft^3	30	0.6	0.75 – 0.85
110/680	Classroom/Meeting Room – volume > 10,000 ft^3 and < 20,000 ft^3	30	0.7	0.75
110/680	Classroom/Meeting Room – volume > 20,000 ft^3	*	*	*
115/215/217/ 355/685	Classroom, Laboratory, Conference Room, Meeting Room Service – control room, observation room, translation services	35		
210	Class Laboratory, Dry – band rooms, choral rooms, (group) music practice rooms, language laboratories	*	*	*
210	Class Laboratory, Dry – Shop/Garage	40-45	0.7	
210	Class Laboratory, Dry – Other	35	0.6	
212	Class Laboratory, Wet	40-45	0.7	
230	Individual Study Laboratory – music practice rooms, sound booths used in language learning	*	*	*
230	Individual Study Laboratory – other	35-45	0.5	
250	Non-Class Laboratory (Research)	35-45	0.7	
310	Office, Private	30	0.4 - 0.7	
314	Office, Shared	35	0.5	
320	Office, Open Plan	40		
315	Office Service	45		
350	Office Conference Room	25 - 30	0.5	0.75
420	Library	35-40	0.7	
520	Athletic-Physical Education	35-40	1.5	
530/535	Audio-Visual/Radio/TV	*	*	*
610	Assembly	*	*	*
630	Food Facility	40	0.6 - 1.5	
650	Lounge	35-40		
810/855	Health Care (student & animal)	30	0.6	
910/920/ 940/943/	Sleep/Study	25	0.5	

* To be determined by project's stakeholders in consultation with acoustical consultant.

Table 2: Room Adjacencies: Acoustic Design Guidelines & Post Occupancy Testing

Space Type Code I	Space Type Code II	Space Type I	Space Type II	Noise Isolation Class NIC	Impact Insulation Class IIC
110	020	Classroom	Corridor	45	
110	110	Classroom	Classroom	50 - 52	50
110	030	Classroom	Mechanical	52**	
110	031	Classroom	Toilet	52	
350	020	Office Conference Room	Corridor	45	
350	350	Office Conference Room	Office Conference Room	50 - 52	50
310/314	310/314	Office, Private and Shared	Office, Private and Shared	45	
310/314	020/320	Office, Private and Shared	Corridor / Open Office	30	
910/919/920/ 940/943/950/ 952/953	910/919/920/ 940/943/950/ 952/953	Residence	Residence	45	50
910/919/920/ 940/943/950/ 952/953	020/954	Residence	Corridor	30	

** Better performance may be needed to meet NC requirements for classrooms.