BASIS OF DESIGN
ACOUSTICS AND SOUND CRITERIA

a) General Comments

In this section we have outlined the criteria for:

- Airborne Sound Isolation
- Impact Sound Isolation
- Sound Absorption/Reflection
- Exterior Noise Transmission to Interior
- HVAC System Noise and Vibration Control
- Plumbing System Noise and Vibration Control
- Electrical system Noise and Vibration Control

The drawings present a detailed design of these requirements. The drawings and the requirements presented here should be used in conjunction. When ever a design element is open to different interpretation between the drawings and the requirements outlined here the stricter of the two shall apply.

b) Airborne Sound Isolation

Sound Isolation is the “acoustical isolation” of one space from the other. Appropriate sound isolation assures “acoustical privacy” between spaces. Sound is typically isolated from one space to other by optimum design of the separation between the spaces including partitions, doors, windows, openings and penetrations. All separating elements must be taken into consideration in isolating one space from the other.

Sound isolation is measured in terms of Sound Transmission Loss or Sound Transmission Class (STC). The STC rating is a single number descriptor that is derived from the transmission loss. The STC rating has a very good correlation with reduction of speech. It has no (or limited) correlation with other sounds.

The sound isolation between various spaces in presented in Table 1, in terms of partition types P-2, P-3 and P-4 and P5. Description of the partitions is provided in Table 2.

	Corridor	Waiting/Reception	Storage	Cafeteria/Breakroom	General Private Office	Executive Private Office	Sherriff Office	Interview Rooms	Conference Room	Courtroom	Training Room	Multipurpose Room	Media Conf Room	Library	Men/Women
Corridor	-	-	-	P2	P2	P3	P4	P3	P3	P4	P3	P3	P4	P3	P2
Waiting/Reception	-	-	-	P2	P2	P3	P4	P3	P3	P4	P3	P3	P4	P3	P3
Storage	-	-	-	-	P2	P3	P4	P3	P3	P4	P3	P3	P4	P3	-
Cafeteria/Breakroom	P2	P2	-	P2	P3	P3	NR	P4	P4	NR	P4	P4	NR	P4	P3
General Private Office	P2	P2	P2	P3	P2	P3	P4	P3	P3	P4	P3	P4	P4	P3	P3
Executive Private Office	P3	P3	P3	P3	P3	P3	P4	P3	P3	P4	P4	P4	P4	P3	P3
Sherriff Office	P4	P4	P4	NR	P4	P4	-	NR	P4	NR	NR	NR	NR	P4	NR
Interview Rooms	P3	P3	P3	P4	P3	P3	NR	P4	P4	P4	P4	NR	NR	P4	P4
Conference Room	P3	P3	P3	P4	P3	P3	P4	P4	P4	P4	P4	P4	P4	P4	P4
Courtroom	P4	P4	P4	NR	P4	P4	NR	P4	P4	P5	P4	P5	P5	P4	NR
Training Room	P3	P3	P3	P4	P3	P4	NR	P4	P4	P4	P4	P4	P5	P4	P4
Multipurpose Room	P3	P3	P3	P4	P4	P4	NR	NR	P4	P5	P4	P5	P5	P5	P4
Media Conf Room	P4	P4	P4	NR	P4	P4	NR	NR	P4	P5	P5	P5	-	P5	NR
Library	P3	P3	P3	P4	P3	P3	P4	P4	P4	P4	P4	P5	P5	P3	P4
Men/Women	P2	P3	-	P3	P3	P3	NR	P4	P4	NR	P4	P4	NR	P4	P2

Table 1: Sound Isolation Between Various Spaces

Partition Designation	Condition Below Ceiling	Condition Above Ceiling
P2 (Single Stud)	1 layer of gypboard on each side of stud	• Side 1: Gypboard stops 6 inches above ceiling • Side 2: gypboard to structure above
P3 (Single Stud)	1 layer of gypboard on one side and 2 layers on the other side	• Side 1: One layer of gypboard stops 6 inches above ceiling the other layer continues to structure above. • Side 2: gypboard to structure above
P4 (Single Stud)	2 layer of gypboard on each side of stud	• Side 1: One layer of gypboard stops 6 inches above ceiling the other layer continues to structure above. • Side 2: One layer of gypboard stops 6 inches above ceiling the other layer continues to structure above.
P5 (Double Stud)	2 layer of gypboard on each side of stud	• Side 1: One layer of gypboard stops 6 inches above ceiling the other layer continues to structure above. • Side 2: One layer of gypboard stops 6 inches above ceiling the other layer continues to structure above.
Gypboard is 5/8 inch thick	Stud gauge is 22 or lighter	Batt insulation in cavity

Table 2: Partition Description

In order to avoid "deterioration" of partition acoustical performance the following must be considered:

- Partitions will be sealed at floors, ceilings, mullions and adjacent partitions.
- Outlet boxes in partitions will not be placed back to back. These will be stagger on opposite sides of partitions at least one stud space. Back of boxes will be sealed with a "putty" type pad.
- Pipe penetrations through the partitions will be sealed airtight using a non-hardening sealant.
- Doors within Partitions: Provide airtight perimeter and floor seals on doors within partition types P2 and P3 as shown on drawings. Doors are not recommended in Partition types P4 and P5. If doors must be used in Partition Types P4 and P5 then these must be acoustical doors with manufacturer guaranteed performance. The doors shall be minimum STC-45 for partition type P4 and STC=50 for partition type P5.
- Windows within Partitions: Where ever glass is a project requirement provide ½ inch thick vision glass in partition type P2, ½ inch laminated glass in Partition type P3. Glass is not recommended in Partition types P4 and P5. If glass must be used in Partition Types P4 and P5 then it shall be a widow with a manufacturer guaranteed performance. The window shall be minimum STC-45 for partition type P4 and STC=50 for partition type P5.
- Sound Isolation of Amplified Sound: Wherever amplified sound will occur at high levels there is a potential for airborne and structure borne noise transfer. Loudspeakers shall not be directly mounted to any single stud partition where there is an occupied space on the opposite side of the wall. One option is to provide a double stud or staggered stud partition where wall mounted loudspeakers are required. Similarly, loudspeakers should not be recessed in the wall where there is an occupied space on the opposite side of the wall.

c) Impact Sound Isolation

Impact isolation is a measure of impact generated sound transmission to the space below. Impact noise is generated as a result of impact between two hard bodies, example, heel of person walking striking the hard floor. The impact produces structural vibrations, which radiate noise. The obvious solution to the problem is to either isolate the impact generator (walking person) from the structure or the radiation surface (ceiling below) from the structure. Below are requirements for floor surface above occupied spaces:

- Surface above is Carpeted: In the carpeted areas the impact will be partially isolated by the carpet. If carpet is used floors will meet the requirements for impact isolation.
- Surface above is Hard: In the hard floor areas "isolation" is required. Isolation of the hard finished floor from the main floor can be achieved by using a resilient material between the walking surface and the floor surface. In the hard floor areas provide a floor/ceiling assembly with a minimum IIC=50 rating.
- Rooftop Spaces: Impact isolation is also required at hard surface rooftop terraces/balconies that are used for activities.

d) Sound Absorption

The incorporation of acoustically absorbing material serves two purposes:

- Reduces Reverberation: In large volume spaces with hard surfaces the sound generated persist for a long time due to a mechanism called reverberation. Sound reverberation reduces speech intelligibility and can also be annoying, as it's perceived as "high" background noise. The addition of acoustically absorbing materials reduces the reverberation. The reduction in reverberation for a given space is a function of the "total" absorption (total square foot) within a space. The amount of acoustically absorbing material required for optimum reverberation is dependent on the room volume, absorbing properties of the material and the nature of the activities taking place.
- Reduces Echoes: Parallel hard surfaces can produce flutter echoes, reflection of sound back and forward. Again, echoes reduce speech intelligibility and can also be annoying, as it's perceived as "high" background noise.

In designing for sound absorption the first step is to calculate the total absorption required and then determine the placement of absorption. In general random distribution of the absorbing material is more effective then concentration at one location.

The total absorption within a space is product of the area covered (square footage) and the absorption coefficient (NRC) of the material. Highly absorptive material (high NRC value) will require less coverage. Requirements for sound absorption in various spaces are outlined in Table 3.

Space	Ceiling	Walls/Floor
Waiting/Reception	Acoustical	See Drawings
Cafeteria/Breakroom	Acoustical	10% of wall area
General Private Office	Acoustical	Carpet Preferred
Executive Private Office	Acoustical	Carpet Preferred
Sherriff Office	Acoustical	Carpet Preferred
Interview Rooms	Acoustical	Carpet Preferred + 10% of Wall Area
Conference Room	Acoustical	Carpet Preferred + 156% of Wall Area
Courtroom	Acoustical	Carpet Preferred + Absorption on side and front wall starting at seated shoulder level and extending to 8 feet elevation.
Training Room	Acoustical	Carpet Preferred + Absorption on 2 adjacent walls starting at seated shoulder level and extending to 7 feet elevation
Multipurpose Room	Acoustical	Carpet Preferred + Absorption on 2 adjacent walls starting at seated shoulder level and extending to 7 feet elevation
Media Conf Room	Acoustical	Carpet Preferred + Absorption on 2 adjacent walls starting at seated shoulder level and extending to 7 feet elevation
Library	Acoustical	Carpet Preferred
Where acoustical surface is indicated provide materials with NRC greater than 0.7.		

Table 3: Sound Absorbing Materials in Various Spaces

e) HVAC System Noise and Vibration Control

– Noise Criteria: The design goals for maximum room noise levels for the building HVAC systems are stated in terms of noise criteria (NC) levels. The background noise level from continuous noise with all systems in operation shall not exceed NC-35, except as noted below. In the event the equipment produces pure tone components, an NC Criterion, which is 5 decibels lower, will be used.

Room Type	**Noise Criterion**
Corridor	45
Men/Women	45
Waiting/Reception	40
Cafeteria/Breakroom	40
Executive Private Office	30
Sherriff Office	30
Conference Room	30
Courtroom	30
Media Conf Room	30

– Vibration Criteria: Vibration levels from the HVAC systems shall not exceed 8,000 micro-inches/second in any one-third octave in the frequency range 8 to 100 Hz, averaged over 10 seconds.

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– Noise Control General:

1. Equipment will be selected to have noise output characteristics consistent with the noise criteria. Equipment transmission path characteristics between the source and receiver (the closest occupied space in both the horizontal and vertical direction) will be taken into consideration.
2. For equipment, such as fans, air handling units and fan-coil units' inlet, outlet and casing radiated sound power levels will be considered in evaluating the equipment for compliance with the noise criteria. Acoustical analysis on the basis of inlet, outlet and casing radiated sound power levels will be performed to determine sound trap, duct lining, casing lining, enclosure, partition/block wall and acoustical absorption requirements.
3. It should be noted that noisier equipment selections will require increased structure around them as well as enhanced sound attenuation measures, sound traps, duct/plenum lining etc to satisfy the noise criteria.
4. The methods for controlling fan air volume will not increase noise output as volume is reduced - such as variable frequency drives. Inlet guide vanes and other methods which increase noise with decreased air volume will be considered in evaluation for meeting noise criteria.
5. Sound attenuating devices, including sound traps, acoustical louvers, duct, plenum and equipment room lining, acoustical flexible ducting etc., will be used to meet the required noise criteria. Sound traps will be selected and sized not only for adequate

insertion loss, but also for appropriate low pressure drop, taking any non-ideal conditions (proximity to bends, fans, take-off etc and open inlet or discharge) into account.

- Equipment Noise Control: Provide for review and approval calculations based on equipment noise data showing the following equipment will meet project noise criteria. The calculations shall outline the procedure used and will should the attenuation and noise generation assumed for each design element.
  1. Chillers
  2. Cooling Towers
  3. Pumps
  4. Air Handling Units
  5. Exhaust/Supply Fans

- Duct Sizing and Routing: Turbulence generated noise can produce noise levels higher then the equipment. Turbulence-generated noise is function of velocity and is generally generated at elbows and transitions. We recommend that ductwork be sized for 1500 FPM. If velocity exceeds 1500 FPM then radius elbows and takeoffs will be required. The following criteria will be used in evaluating turbulence-generated noise:
  1. Velocity less than 1500 FPM – No sound attenuation will be used.
  2. Velocity between 1500 FPM and 1700 FPM – Radius elbow and radius takeoff will be used. No elbow or take off will be located over noise sensitive space.
  3. Velocity over 1700 FPM is not recommended. If it cannot be avoided, then provide for review and approval calculations or design solutions that will attenuate the noise.

- Vibration Isolation: HVAC equipment/piping, shall be vibration isolated. As a minimum the equipment will be vibration isolated to meet the requirements of Table 42 in Chapter 35 of the ASHRAE Applications Handbook, Sound and Vibration Control. Equipment vibration isolation must be designed to meet the noise/vibration criteria outlined in Table 3.

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- Grilles and Diffusers/VAV Boxes: Grilles and diffusers and VAV boxes shall be selected to meet the NC criteria outlined in Table 3. Provide for review and approval calculations based on equipment noise data showing the following these will meet project noise criteria. The calculations shall outline the procedure used and will outline the attenuation and noise generation assumed for each design element. Provide a sample of 10 calculations.

f) Plumbing System

The plumbing system shall be designed such that the noise from equipment and piping does not exceed the NC criteria outlined below

Room Type	**Noise Criterion**
Corridor	45
Men/Women	45
Waiting/Reception	40
Cafeteria/Breakroom	40
Executive Private Office	30
Sherriff Office	30
Conference Room	30
Courtroom	30
Media Conf Room	30
. Occupied spaces not indicated above shall be NC-35 . Noise from piping, flushing, and use of faucets shall be 5 dB below the levels above.	

The major causes of noise in plumbing systems are turbulence generated at the water valves, noise from water draining where the waste lines occur in the ceiling space below, and noise in pumped lines. Each of these noise sources can be minimized with proper equipment selection and design. Plumbing noise is accentuated when the plumbing piping contact studs and drywall, since the wall surface acts as a sounding board. In order to minimize sound transmission, where necessary, the piping will be vibration isolated.

g) Electrical System Noise Criteria

The electrical system shall be designed such that the noise from equipment does not exceed the NC criteria outlined below

Room Type	**Noise Criterion**
Corridor	45
Men/Women	45
Waiting/Reception	40
Cafeteria/Breakroom	40
Executive Private Office	30
Sherriff Office	30
Conference Room	30
Courtroom	30
Media Conf Room	30

The noise and vibration design shall be such that the design criteria specified NC levels can be achieved. As a minimum the design will provide:

- Transformer Vibration Isolation
  1. On grade neoprene pads - 0.06" static deflection
  2. Above grade - less than 100KVA - neoprene mounts - 0.20 in. static deflection (supported) or neoprene hangers
  3. Above grade - 100KVA or greater - steel springs - 1.0" static deflection (supported) or spring hangers
  4. Wall mounted transformers not permitted
  5. Seismic restraints as required
- Flexible Connection shall be provided at transformer, motors, etc. Length based upon distance required for 360 degree loop.
- Emergency Generator – Provide for review and approval calculations based on equipment noise data showing generator will meet project noise criteria. The calculations shall outline the procedure used and will should indicate the attenuation and noise generation assumed for each design element.