



Higgins Waterfront Mixed Use – Hotel & Condos / Garage

Schematic Design Narrative – Acoustics DRAFT

IMEG # 26000379.00

TABLE OF CONTENTS

A. Acoustic Design Requirements 1

1. References 1

2. Criteria 1

3. Coordination Items – Architectural..... 5

4. Coordination Items – MEP 17

5. Mock-Ups 23



Schematic Design Narrative
for
Higgins Waterfront Mixed Use – Hotel
Missoula, Montana

IMEG # 26000379.00
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A. Acoustic Design Requirements

1. References (Condominium, Hotel)

- a. Acoustic criteria are based on the following:
 - 1) Marriott Global Design Standards dated May 2025.
 - 2) 2023 ASHRAE Handbook for HVAC Applications Chapter 49 Noise and Vibration Control will be followed for recommendations of mechanical noise and vibration control as minimum criteria.
 - 3) International Building Code (IBC) 2024.
 - 4) Montana Code Annotated 2025
 - 5) Missoula Municipal Code, Title 9 (updated 2/29/2024)
- b. We understand that sustainability certifications (e.g. LEED, WELL, etc.) are not currently being pursued.

2. Criteria (Condominium, Hotel)

- a. Exterior MEP Equipment Noise Control
 - 1) The State of Montana does not establish a statewide environmental noise code that establishes specific limits to criteria for stationary mechanical equipment (e.g., HVAC systems). State-level provisions are limited to broad public nuisance statutes and activity-specific requirements. Instead, noise regulation within Montana is generally addressed at the local jurisdictional level through municipal ordinances.
 - 2) The City of Missoula regulates environmental noise through its Municipal Code (Chapter 9.30 – Noise Control), which establishes quantitative limits applicable to all noise sources, including stationary mechanical equipment. Compliance is determined based on sound levels measured at or beyond 25' from the source or at the property line, with maximum permissible limits defined by the receiving land use. Requirements are summarized in the table below.

City of Missoula Sound Pressure Level Limits (Condominium, Hotel)			
Zone	Day (7:00 AM to 7:00 PM)	Evening (7:00 PM to 10:00 PM)	Night (10:00 PM to 7:00 AM)
Residential	60 dBA	55 dBA	50 dBA
Commercial	65 dBA	60 dBA	55 dBA
Light Industrial	70	65	60
Heavy Industrial	80	75	70

NOTE: In the hours between 7:00 AM and 7:00 PM, the noise levels permitted in the table above may be increased by 10 dBA for a period not to exceed 15-minutes in any 1-hour period.

- b. Environmental Sound (Condominium, Hotel)
 - 1) Interior Background Noise (Hotel)
 - a) Guestroom Areas: Limit noise intrusion levels to hourly equivalent levels (L_{eq}) of 45 dBA for day; 40 dBA at night. Day and night hours to be determined by the Operator brand.
 - (1) Short Term Noise: 50 dBA for short term (day / night) noise such as sirens and low-level helicopter flights
 - (2) Day – Night Level (L_{DN}) of 45 dBA for aircraft noise level intrusion.
 - b) Meeting Spaces: Limit noise intrusion levels to 40 dBA or as determined by consultant’s report and accepted by Operator brand.
 - 2) Interior Background Noise (Condominiums)
 - a) The maximum internal ambient noise levels include contributions from MEP systems, exterior road traffic, and internal noise sources. These maximum sound levels shall be:
 - (1) Limit road traffic noise intrusion to 45 $L_{Aeq, 1 \text{ hr}}$ for day, 40 $L_{Aeq, 1 \text{ hr}}$ at night.
 - (2) Short term day/night noise limits for sirens and aircraft is 50 L_{Amax}
 - (3) 45 L_{DNA} for aircraft noise intrusion
 - 3) A long-term environmental sound survey to benchmark existing conditions at the project site can be completed as an add alternate by the Owner’s request. The results will be used to inform building façade sound isolation requirements in alignment with the brand standards.
- c. Sound Isolation – Interior (Hotel, Condominium)
 - 1) Airborne sound isolation is commonly quantified by the Sound Transmission Class (STC) rating, a controlled laboratory test of an assembly. The on-site airborne sound isolation of an assembly is typically reduced due to flanking paths and is commonly quantified by the



Apparent Sound Transmission Class (ASTC) or Noise Isolation Class (NIC) rating.

- 2) Limits for impact noise transmission between vertically adjacent spaces are defined by Impact Insulation Class (IIC). Like airborne sound isolation, the on-site impact noise transmission of an assembly is typically reduced due to flanking paths and is commonly quantified by the Apparent Impact Insulation Class (AIIC) rating.
- 3) The following table provides criteria for condominium sound isolation of demising constructions by room adjacency.

Condominium Sound Isolation Design Criteria			
Adjacency		Acoustic Criteria (Minimum)	
		STC	IIC
Condominiums	Demising walls	55	-
	Shaft and chase walls	55	-
	Elevator shaft walls (double stud)	60	-
	Corridor walls (with door)	50	-
	Vending / Ice machine alcoves	55	-
	Bathroom perimeter walls	54	-
	Exterior glazing	TBD*	-
	Floor / ceiling construction	50	55
Retail	Floor / Ceiling construction to condominiums	60	≥65
Private Offices	Demising walls	45	-
	Corridor walls (with doors)	42	-
	Elevator shafts, pantry cabinet walls (double stud)	55	-

***NOTE:** Acoustical performance of the exterior façade glazing system should be determined by the condo developer standards whether they prefer to meet minimum code requirements for exterior noise intrusion or if there is a desire to provide enhanced glazing for sound isolation from other exterior activities. For reference, typical 1-inch-thick glazing is approximately STC 30-35. Enhanced glazing with a performance of $\geq$ STC 40 typically requires very thick double laminated or double-glazed assemblies that typically increase cost compared to 'standard' assemblies (e.g. 1" insulated glazing unit). Additionally, the framing of the glass would need to be acoustically tested with the proposed enhanced glazing to confirm it will achieve the intended acoustical performance.

- 4) The following table provides a summary of Marriott Tribute hotel design standards for sound isolation of demising constructions by room adjacency.



Hotel (Marriott Tribute) Sound Isolation Design Criteria			
Adjacency		Acoustic Criteria (Minimum)	
		STC	IIC
Guestrooms	Guestroom demising walls	55	-
	Shaft and chase walls between guest baths	55	-
	Corridor walls (with door)	50	-
	Entry Door	32	-
	Connector Doors between guestrooms	32 (each door, back-to-back)	-
	Public, Meeting Spaces, Service Areas, Elevator, Equipment Rooms, Laundry, etc.	55+	-
	Floor / ceiling construction	55	57+
Meeting Spaces (e.g., Conference Rooms, Meeting Rooms, Pre-function)	Floor / Ceiling and partition envelope	55	57
	Operable Partitions	54 (NIC 46)	-
Restaurant, Specialty Bar*	Floor / Ceiling and partition envelope to guestrooms	60	60
Private Offices	Demising walls	50	-
Fitness	Floor / Ceiling and partition envelope to quiet areas	55	-

NOTE: *Limit noise intrusion levels to 40 dBA. Limit transmission of noise and vibration through walls, ceiling and floors.

d. MEP Background Sound Levels (Condominium, Hotel)

- 1) Background sound level design targets for condominiums are provided in the following table.

Condominium Background Sound Design Criteria		
Space	Background Sound Levels (NC), Recommended Criteria	
Condominiums	Off	NC 25 – 30
	Low	NC 30 – 35
	Med	NC 35 – 40
	High	NC 40 – 45
Residential Amenities	NC 30 – 35	
Private Offices	NC 35 – 40	
Common Areas, Public Corridors	NC 40 – 45	

- 2) The following table summarizes the background sound criteria provided in the Marriott Tribute design standards and the recommended criteria based on our project experience.



Hotel (Marriott Tribute) Background Sound Design Criteria		
Space	Maximum Background Sound Levels (NC), Marriott Standards	Background Sound Levels (NC), Recommended Criteria
Boardrooms (e.g., Conference Rooms)	NC 25	NC 25 – 30
Meeting Rooms and Event Spaces (e.g., Pre-Function, Meeting)	NC 35	NC 35 – 40
Guestrooms	NC 37	NC 30 (Low)* NC 35 (Med.)* NC 40 (High)*
Public Spaces (e.g., Restaurant, Bar / Seating, Lounge / Lobby)	NC 37	NC 35 – 40
Back of House Areas	NC 40	NC 40 – 45

NOTE: *HVAC background noise in guestrooms will be defined by the FCU or heat pump unit selection and may exceed the baseline criteria. These criteria are generic best practices pending Owner/Operator feedback. We have found that noise levels from NC 35 – 45 have been deemed acceptable by various owners. In addition to overall level, sound quality (e.g. tonal, rumbly, hissy, etc.) is an essential aspect of living unit HVAC noise.

e. Room Acoustics Criteria (Hotel)

- 1) The following table summarizes the room acoustics criteria provided in the Marriott Tribute design standards.

Hotel (Marriott Tribute) Room Acoustics Design Criteria	
Space	Maximum RT ₆₀ (500Hz – 4000Hz)
Ballrooms / Function Spaces (e.g., Conference Rooms)	1.2 seconds
Meeting Rooms / Breakout Rooms / Boardroom / VIP room	0.8 seconds
Pre-Function / Open Breakouts	1.5 seconds

3. Coordination Items – Architectural (Condominium, Hotel)

a. Interior Partitions

- 1) All partitions should extend to the structure above and be acoustically sealed. We prefer that all partitions be constructed with studs spaced at



24" o.c. as a substantial reduction in sound transmission loss occurs when narrower stud spacing is used.

- 2) Gypsum wall and ceiling board should be type "X" with a minimum mass of 2.2 lbs/ft². and in lengths as long as practical to minimize the number of joints and in thicknesses indicated in the drawings.
- 3) Stagger seams in configurations with multiple layers of gypsum wall board.
- 4) Sound attenuation batting should be minimum 2-3 lbs/ft³
- 5) Resilient channels and resilient isolation clips should be avoided, as these components are prone to installation errors degrading the sound isolation performance of a partition.
- 6) The head and base of each partition should be sealed airtight with a non-hardening sealant.
- 7) Penetrations due to ductwork or pipe distribution at acoustic walls should be avoided, or otherwise perimeter sealed per acoustic detailing.
- 8) Where cable trays occur, we strongly recommend that they do not penetrate slab to slab acoustical partitions. Cable trays should stop either side of the partition and an acoustically sealed conduit sleeve should be used at partition penetrations. Cable trays/sleeves should be located above suspended ceilings in acoustically sensitive areas.
- 9) We recommend that furred partitions with two layers of drywall extending slab to slab are installed at demising concrete or CMU elevator shaft partitions shared with guestrooms or other sound sensitive spaces.
- 10) Where double stud partitions occur, we recommend that a 1" air gap be maintained between opposite rows of studs. There should be no ties between double or staggered rows or between the substrate and furred wall where structurally feasible. Such notes should be clearly indicated in the drawings. Double stud partitions are also recommended between storage rooms and occupied spaces.
- 11) Preliminary recommendations for partition types to achieve STC performances are provided in the table below:



STC-rated wood stud partitions (Condominium, Hotel)					
Stud Thickness	Minimum STC 40	Minimum STC 45	Minimum STC 50	Minimum STC 55	Minimum STC 60
2 x 4	2+3 GYP	2+2 ENG Gyp 1-layer of eng gyp on each side			
2 x 6	2+3 GYP	1+2 ENG Gyp 1-layer of eng gyp on each side	2+2 ENG Gyp 1-layer of eng gyp on each side		
- All wood stud partitions assume the following unless otherwise noted: - Full height walls extending from floor to deck - Studs spaced 16" on center 5/8" Type X gypsum board - Batt insulation with minimum 2 – 3 pcf density - Engineered acoustic drywall (eng gyp) such as National Gypsum's 5/8" SoundBreak XP or comparable should be specified where noted. - Isolation clip basis of design is Kinetics' IsoMax clip and Pliteq GenieClip with 7/8" (18mil) hat channel - Staggered stud partitions to be 2x4 studs staggered on 2x6 plates - Double stud partitions to be 2x4 studs on separate plates spaced 1" apart		Isolation Clips (2 x 4)	1+1 GYP	1+2 GYP	2+2 GYP
		Staggered Studs (2 x 4)	1+2 GYP	3+3 GYP	
		Double Studs (2 x 4)	1+1 GYP Minimum 1" airspace	1+2 GYP Minimum 1" airspace	2+2 GYP Minimum 1" airspace

b. Operable Partitions (Hotel)

- 1) It should be noted that operable partitions typically have a lower acoustic separation performance (i.e., STC) than the manufacturers' rating once installed in the field and that wear and tear on the acoustic seals will further degrade the acoustic performance over time.



- a) The field test performance of an STC 54 operable partition should be minimum NIC 46 per Marriott design standards.
- 2) The inclusion of pass-through doors in the operable partitions is not permitted by Marriott Tribute design standards because they are an acoustic weak point.
- 3) Acceptable operable partition system manufacturers include:
 - a) Advanced Equipment Co.
 - b) Modernfold by Dorma
 - c) Huppe by Dorma
- 4) For enhanced acoustic performance of operable partitions, we recommend the following strategies:
 - a) A vertical operable partition (e.g., Skyfold) be specified which helps reduce long term wear on acoustic seals and maintains a performance closer to the lab tested assembly.
 - b) Two horizontal operable partitions separated by a minimum of 3' are installed. This helps improve overall airborne sound isolation, particularly at low frequencies.
- 5) The wall above the operable partition should have an STC performance no less than the operable partition. Seal joints, around penetrations and wall perimeter.
- 6) Enclosures for operable partitions should have an STC performance no less than the operable partition.
- 7) It should be confirmed that the floor finish proposed does not compromise the acoustical performance of the operable wall: specifically, it is very important that the carpet is not ribbed or otherwise contoured in a manner that would permit sound to leak at the base of the operable wall.
- 8) If a storage room is provided for the operable partitions, we recommend extending the operable partitions into the storage space so that the operable partition will terminate against solid walls. We recommend that



operable partitions do not terminate against the storage room pocket door.

- 9) If the operable partition is motorized, we recommend that the motor is located such that it does not impact the operable partition's ability to fully deploy and seal or clash with the drywall header that extends and seals to the structure above.
- 10) Supply and return air ductwork should not pass above the head of the operable partitions since this will severely compromise the acoustic separation provided when the operable partitions are in use, even with the incorporation of duct attenuators within the ductwork. Supply and return air should be ducted directly to and from each sub-divided room to avoid the need for ductwork to pass above the head of the operable partitions.

c. Doors (Condominium, Hotel)

- 1) Door types and door hardware details will impact the overall airborne sound isolation performance of a partition. As a reasonable balance between cost and overall acoustic performance, a reduced sound isolation performance for doors is common practice. The table below outlines typical hardware strategies for sound-reducing doors (Type SR) by space type.
- 2) General Door Hardware Guidance:
 - a) Sound isolation door hardware options are provided below. These door treatments are intended to be a cost-effective approach to maintaining partition sound isolation performance and generally achieve the design criteria with proper equipment selection.



Sound Reducing Door Assemblies (Condominium, Hotel)			
Door Type	Acoustic Requirement	Door Hardware	Recommended Spaces
SR-1	• Solid core, flush panel, wood construction 1-3/4in thick (min) • Hollow metal steel (16 gauge) frame, fully welded joints	• Continuous head and jamb bulb-type seals (Pemko S88 or equivalent) • Mortised automatic threshold drop seal (Pemko 411PKL or equivalent) • Flat, smooth threshold with continuous caulking/adhesive underneath	Guestrooms Condominiums Mechanical Electrical ITC
SR-2	• Solid core, flush panel, wood construction 1-3/4in thick (min) • 18-gauge hollow steel, fiberglass filled leaf 1-3/4in thick (min) • Door lites ½in laminated glass (where applicable) • Steel frame (16-gauge, grout or fiberglass filled) • Door leaf must be sealed airtight	• Continuous head and jamb bulb-type seals (Pemko S88 or equivalent); • Astragal at double-door meeting stile (Pemko 379R or equivalent) • Surface-mount, mortised, or semi-mortised automatic threshold drop seal (Pemko 411PKL, 4131SL or equivalent). • Rabbeted threshold with continuous caulking/adhesive underneath (Pemko 2006 or equivalent)	Meeting Spaces Private Offices
SR-3	• Specialty manufactured acoustic door set • Door, frame and latching hardware supplied together, assembled • Designed to meet STC 50 • Additional non-standard hardware may be required	• Full perimeter seals per manufacturer's details • Floor track per manufacturer's details	High noise equipment rooms near noise sensitive areas

d. Floor / Ceiling Construction (Condominium, Hotel)



- 1) We understand that each floor / ceiling structure is proposed to be as follows:
 - a) Level 1: concrete PT slab (thickness varies)
 - b) Level 2: 12" thick concrete PT slab
 - c) Levels 3 & 4: 11-7/8" wood TJI spaced at 16" o.c. with 1-1/2" gypcrete topping
- 2) Where resilient underlayment is recommended, an intermediate neoprene filler is required at the perimeter of the floor areas. It should be confirmed that the underlayment used satisfies all project and Code requirements and should be reviewed with the floor supplier and/or installer.
- 3) In order to achieve the Marriott Tribute STC and IIC requirements for the proposed floor / ceiling structures, we recommend the following floor / ceiling assemblies per the table below. Please note that exact assemblies will be confirmed as design progresses. Increased performance floor / ceiling assemblies are provided later in this report for fitness center to restaurant / bar adjacencies.

STC & IIC Rated Floor / Ceiling Assemblies (Condominium, Hotel)				
Floor / Ceiling Structure	Finished Floor	Ceiling Below	Min. STC	Min. IIC
12" normal weight concrete PT slab	Carpet with pad	None	65	65+
	- LVT or Tile 1" gypcrete with 1/4" resilient underlayment	None	65	60
	LVT or Tile with 1/8" resilient underlayment	12" wire suspended ceiling 3.5" batt 1-layer 5/8" Type X gyp.	70	61
11-7/8" wood TJI spaced at 16" o.c.	- Carpet with pad 1.5" gypcrete, 3/4" OSB	- Resilient channels spaced 16" o.c., 6.25" batt 2-layers 5/8" Type X gyp.	58	65+
	- LVT or Tile, 1.5" gypcrete with 3/4" resilient underlayment 3/4" OSB	- Resilient channels spaced 16" o.c., 6.25" batt 2-layers 5/8" Type X gyp	58	57



	• LVT or Tile with 1/16" resilient underlayment • 1.5" gypcrete with 1" resilient underlayment • 3/4" OSB	• Neoprene clips on furring channels spaced 24" o.c. • 6.25" batt • 2-layers 5/8" Type X gyp	60	62
Notes: • Resilient underlayment basis of design is Maxxon Acousti-Mat and Pliteq GenieMat • Isolation clip basis of design is Kinetics' IsoMax clip and Pliteq GenieClip with 7/8" (18mil) hat channel				

e. Penetrations from Ductwork, Piping and Conduit (Condominium, Hotel)

- 1) Penetration sealing details are applicable even where partitions are not subject to a fire-rating requirement. In fire-rated partitions, the fire-sealing detail is comparable to acoustic sealing methods and should be reviewed to ensure proper acoustic seal is achieved.
- 2) All penetrations, such as for duct, pipe and conduit, should have a 1/8" gap minimum between the penetrating service line and the partition and be acoustically sealed with a resilient caulking.

f. Partition-Façade Intersections (Condominium, Hotel)

- 1) At Façade/Interior wall intersections where demising partitions meet the façade, specific detailing is required to avoid sound flanking transmission and maintain the achievable sound isolation performance of the wall partition.
- 2) Interior partition/façade intersection details will be coordinated as the design develops

g. Perimeter Beam Conditions (Condominium, Hotel)

- 1) The void between the perimeter structural beam and the exterior building wall should be blocked with gypsum board and thoroughly sealed both sides where slab to slab partitions occur.

h. Mounting of Video Displays and Loudspeakers (Condominium, Hotel)

- 1) We would discourage the recessing of wall mounted televisions/video displays or loudspeakers within acoustical wall assemblies. If this is proposed, please let us know in order that we can coordinate architectural/acoustical detailing to attempt to minimize any associated



sound isolation downgrade of the wall assembly. Acoustically, we prefer that double stud or furred partitions are specified where recesses are proposed and that the layers of drywall equivalent to the partition type on the recessed side of the partition enclose the backing of the recessed equipment.

i. Fitness Room (Hotel)

- 1) The following are acoustic considerations from fitness room activities to guestrooms above and any sensitive areas horizontally adjacent:
 - a) Airborne sound transfer through building structures to areas above and horizontally adjacent (e.g., amplified music).
 - b) Impact sound transfer through building structures to areas above and horizontally adjacent (e.g., aerobic classes, weight drops, rhythmic impacts of treadmills).
- 2) Airborne Sound Recommendations
 - a) Use of amplified music and heavy impact activities (e.g., aerobics classes) should be limited to daytime hours only, typically 8AM to 10PM.
 - b) We recommend that a spring hung drywall ceiling (e.g., Kinetics' ICC) with two (2) layers of gypsum board and batt insulation in the cavity be installed to improve the sound isolation performance to guestrooms above and provide increased flexibility for the fitness room.
 - c) Penetrations through acoustic ceiling barriers should be avoided. If required, minimize penetrations and seal with a non-hardening acoustic sealant. Any penetrations should be resilient in nature, so the isolated ceiling is not 'short circuited'.
- 3) Impact Sound Recommendations
 - a) For control of impact sound and structural resonance from activity the base building construction under gym areas must be designed for minimum 9 Hz natural frequency. This is necessary for isolated floor systems above to provide designed performance, and to limit propagation of vibration through structure to the rest of the building.



- b) For attenuation of structureborne sound propagation from fitness room activity, we have provided three design strategies below for consideration:

Impact Sound Isolation Strategies (Hotel)				
Design Option	Buildup Dimension	System Description	Delta IIC	Basis of Design
"Good"	~3"	Direct application of a high-performance fitness underlayment on the slab.	+10 – 15	Pliteq GenieMat FIT 70
"Better"	~4"-5"	Isolator 'pucks' and insulation blanket on the floor slab with a wood subfloor and finish floor placed on top. Perimeter venting 'gap' partially filled with resilient material (rubber, neoprene, foam) to prevent rigid connection to the wall.	+20 – 25	Pliteq FF70 or Kinetics MetaWRX
"Best"	~6"-8"	Structurally isolated "floating" floor on spring or neoprene isolators with subfloor and finish floor on concrete floating floor. Perimeter venting 'gap' partially filled with resilient material (rubber, neoprene, foam) to prevent rigid connection to the wall.	+25 – 45	Kinetics LSM Spring Lift Slab Floor Mount

j. Restaurant & Bar (Hotel)

- 1) The following are acoustic considerations from restaurant and bar and activities to guestrooms above, below and any sensitive areas horizontally adjacent:
 - a) Airborne sound transfer through building structures to areas above, below and horizontally adjacent (e.g., amplified music, occupant activity sound).
 - b) Impact sound transfer through building structures to areas above, below and horizontally adjacent (e.g., footfall impact sound, rolling carts).
- 2) Airborne Sound Recommendations
 - a) Use of amplified music should be limited to daytime hours only, typically 8AM to 10PM.



- b) We recommend that a spring hung drywall ceiling (e.g., Kinetics' ICC) with two (2) layers of gypsum board and batt insulation in the cavity be installed for the ground floor restaurant to improve the sound isolation performance to guestrooms above and provide increased flexibility for the restaurant.
 - c) Similar spring hung drywall ceilings should be installed in the guestrooms directly below the rooftop bar and terraces to improve sound isolation performance.
 - d) Penetrations through acoustic ceiling barriers should be avoided. If required, minimize penetrations and seal with a non-hardening acoustic sealant. Any penetrations should be resilient in nature, so the isolated ceiling is not 'short circuited'.
- 3) Impact Sound Recommendations
- a) A resilient floor system should be installed throughout the upper floor restaurant and bar areas to reduce low frequency impact noise to areas below and horizontally adjacent.
 - b) An isolated concrete floating floor system typically provides the highest level of impact sound attenuation. However, it can be challenging to incorporate into the structural design and increase project cost.
 - c) As an alternative, a lighter weight resilient underlayment with built up concrete panels or multiple plywood layers could be installed beneath the proposed finished floor.
 - d) Although such systems will reduce impact sound to adjacent areas, such assemblies will not reduce impact sound completely.
- k. Trash & Laundry Chute Recommendations (Condominium, Hotel)
- 1) Laundry and trash chutes should be located remotely from condominiums, guestrooms or occupied spaces.
 - 2) The chutes should be supported on resilient mounts to reduce impact energy from being transmitted into the building structure.
 - 3) The chutes should not include bends, especially at the bottom.



- 4) A damping compound should be applied to the exterior walls of the chutes to damp ringing noise caused by vibrating or shock excited metal surfaces.
- 5) Durability, sanitary requirements and application of this treatment should be reviewed with the manufacturer.

I. Room Acoustics (Condominium, Hotel)

- 1) Room acoustics are influenced by the room geometry, volume, finishes, and internal elements such as occupants, furniture, etc. and are mostly analyzed in terms of reverberation time and/or average sound absorption coefficients. It is important to control the reverberation time for occupants to:
 - a) Understand natural (unamplified) speech.
 - b) Understand reinforced speech through the installed sound reinforcement equipment.
 - c) Limit the magnification of mechanical and equipment noise due to excessive reverberation.
- 2) The reduction of room reverberance is mostly achieved using sound absorbing materials. Strategic architectural integration of acoustic finishes will be designed to provide acoustic control. Detailed recommendations for location and performance will be further developed in the next design phase. Sound absorbing finishes should typically have a minimum performance of NRC 0.70 unless noted otherwise.
- 3) The following table outlines recommendations for acoustic finish coverages for walls and ceilings within various space types by room type. Maximum reverberation time (RT60) performances are provided in the Marriott design standards. Further design of acoustic finishes will be provided as design progresses to achieve such standards.
 - a) Wall treatment will be most acoustically effective installed in 4' minimum tall bands centered at seated ear height (typically between 3' and 7' above the finished floor). Sound absorbing treatment should be placed on walls opposite any wall mounted loudspeakers. If necessary, include sound absorbing shades or drapes in front of glazed walls or exterior facades.



Sound Absorbing Treatment Recommendations (Condominium, Hotel)			
Space	Ceiling Acoustic Design Criteria (NRC)	Wall Acoustic Design Criteria (NRC)	Area of Coverage
Conference Rooms	≥0.90	≥0.90	≥90% ceiling + walls ¹
Meeting Rooms	≥0.90	≥0.90	≥90% ceiling + wall ²
Private Offices	≥0.75	-	≥90% ceiling
Lounge / Lobbies, Reception, Pre-Function	≥0.75	-	≥80% ceiling
Restaurants, Bars	≥0.70	-	≥65% ceiling
Fitness Rooms	≥0.70	-	≥60% ceiling
Kitchen, Housekeeping, Laundry, BOH Corridors, Residential Amenities	≥0.70	-	≥60% ceiling

NOTES:

1. Sound absorbing wall treatments should be applied to minimum two perpendicular walls.
2. Sound absorbing wall treatments should be applied to minimum one wall.

4. Coordination Items – MEP (Condominium, Hotel)

- a. General guidance and best practice approaches to typical MEP systems are provided below for consideration by the MEP engineer. Additional recommendations will be given as the design progresses and equipment selections are made.
- b. Duct Velocities (Condominium, Hotel)
 - 1) Ductwork will be reviewed as the design progresses. Preliminary ductwork and shaft sizes should be determined based on the following maximum duct velocities. Slightly higher velocities may be acceptable if smooth transitions/airflow can be achieved.
 - 2) The values provided in the table below are guidelines only and assume good airflow conditions. Presence of elbows, fittings, or abrupt duct transitions may require air to run at lower velocities. Also, please note that multiple guidelines may apply to a given section of ductwork (e.g., main branch ductwork within 10' of a supply terminal). In such cases, we recommend that ductwork is sized according to the most stringent applicable guideline. In spaces with "-" we recommend that the



indicated ductwork condition does not occur in spaces of the indicated acoustical sensitivity.

- 3) We recommend the following to reduce airflow-induced noise:
 - a) Provide smooth duct turns, transition fittings, and simple duct layouts
 - b) Wherever possible, avoid installing elbows, tees, take-offs, and other fittings adjacent to each other.
 - c) Provide a minimum of 3-duct diameters of straight duct between fittings.
 - d) For flexible ductwork, provide at final connections to diffusers with smooth connection and no kinks.
 - e) Select the system to perform at the lowest applicable fan speed with dampers open.
 - f) In general, we recommend that duct dimension ratios should not exceed 3:1.

Maximum allowable duct velocities						
Noise Criterion		NC 45	NC 40	NC 35	NC 30	NC 25
Main branch above suspended ceiling		2000	1800	1500	1300	-
Main branch in exposed configuration		1600	1500	1200	1100	-
Duct within 10 to 20' of supply diffuser/return grille	Supply	900	850	800	700	550
	Return	1000	950	900	800	650
Duct within 0 to 10' of supply diffuser/return grille	Supply	700	650	600	500	450
	Return	800	750	700	600	500
Supply diffuser – 'free velocity'		550	500	450	400	300
Return grille – 'free velocity'		650	600	550	500	400
Open return duct above ceiling		850	750	650	-	-
Open return duct exposed		800	700	600	-	-

c. Terminal Units (Condominium, Hotel)

- 1) Locate volume control boxes away from noise-sensitive rooms (e.g., more stringent than NC 35) to prevent radiated noise breakout to the room. As the basis of design manufacturer is finalized, volume control box selections are being actively coordinated internally to ensure design target NC levels are not exceeded.
- 2) Where continuous finished ceilings occur, we recommend that volume control boxes are selected with radiated and discharge noise ratings of at least 10-NC points below the background noise criterion of the space above which the units are located and the space served. Where exposed



ceilings or non-continuous ceiling finishes occur, radiated noise ratings should be at least 15-NC points below the background noise criterion of the space above which the units are located.

d. Diffusers & Grilles (Condominium, Hotel)

- 1) Diffusers should be selected such that they are 10-NC points less than the space serviced (e.g., public spaces should incorporate diffusers selected for a maximum of NC-30).

e. Internal Duct Lining (Condominium, Hotel)

- 1) Acoustic duct liner should be composed of fiberglass or cotton fiber of 3-5 pcf density and a minimum rating of NRC 0.80.
- 2) Supply, return and exhaust air ductwork from air handler units will be lined with 1" thick internal duct liner for the first 25' from the units.
- 3) Incorporate a minimum of 10' of duct liner after any discharge side of VAV boxes. Additional duct liner may be required for spaces rated $\leq$ NC 30.
- 4) The feasibility of incorporating internal duct lining and/or sound attenuators shall be reviewed with the owner and mechanical engineer. If fiberglass lining is not allowed, custom units which achieve lower supply, return, and/or casing radiated noise levels should be considered for costing purposes.

f. Balancing Dampers (Condominium, Hotel)

- 1) Noise is generated as airflow passes through balancing dampers, typically perceived as a whistle or hiss.
- 2) To mitigate this noise, we recommend that a minimum of 5' of acoustical flex duct or internally lined sheet metal duct with a minimum lining thickness of 1" is included between diffusers and balancing dampers. It is very important that dampers are not incorporated into grilles. The use of diffuser blades for "balancing" the air system should be avoided.

g. Acoustic Flexible Ductwork (Condominium, Hotel)



- 1) Acoustic flexible ductwork should be installed per manufacturer specifications. If flex duct is kinked in any way, which results in turbulent airflow, it should be replaced or reconfigured. The length should not exceed 5' to limit sagging and damage. We recommend that an acoustic flex duct like Flexmaster 6M be used.

h. Return Air Transfers (Condominium, Hotel)

- 1) In locations where full height partitions are scheduled and returns are not fully ducted, transfers for air will be required to meet return air requirements set by the mechanical engineer. In general, transfers should occur through 1" internally lined U or Z-shaped transfer ducts sized for a maximum 500 fpm. As previously mentioned, the mechanical engineer shall confirm whether internal duct lining is allowable. If not, alternate sound attenuation measures at return air transfers shall be coordinated.
- 2) The height dimension of the duct after the 90° bends should be equivalent to minimum 2 width dimensions of the duct.
- 3) The return transfer should occur at the vertical face above the entry door and not in demising walls of enclosed rooms. As the mechanical design is developed, it should be kept in mind that there should be no transfers that occur between noise sensitive rooms

i. Duct Layout and Crosstalk (Condominium, Hotel)

- 1) Duct runs in areas with slab-to-slab partitions should be configured to maximize separation between takeoffs to individual rooms to reduce duct borne room-to-room crosstalk. Duct takeoffs to terminal grilles should be staggered to maximize the available acoustical separation provided.
- 2) Ductwork should be routed to avoid clashing with slab-to-slab partitions. Where this condition cannot be avoided, partitions should be jogged around the ductwork such that the ductwork remains on the less acoustically sensitive side of the partition.

j. Electrical Junction Boxes (Condominium, Hotel)

- 1) Outlets should not be installed back-to-back, but instead in separate stud cavities with a minimum separation of 24". For devices recessed into



demising walls, we also recommend that the junction boxes be wrapped in putty pads like Hilti Type CP-617.

k. Rooftop Air Handling Units (Condominium, Hotel)

- 1) Locate units above/adjacent to non-critical spaces such as equipment rooms, storage rooms, bathrooms, and stairwells. Avoid placing these units above noise-sensitive spaces.
 - a) Where this is unavoidable, provide a massive and stiff roof structure to allow for proper functioning of vibration isolators and to reduce airborne sound transmission with a minimum mass of 75 lb/ft²; typically, at least 6" thick normal weight concrete or composite metal deck is appropriate.
- 2) If a concrete slab on the roof is not feasible, a lower-performing option is to incorporate multiple layers of roof coverboard or concrete structural panels depending on the sensitivity of the spaces below. These panels should be installed within the roof curb and extend at least 10' from all sides of each rooftop unit.
- 3) Rooftop units should be located as close to structural columns as possible.
- 4) Provide horizontal inlets and discharge to reduce ductborne and breakout noise to the spaces below. Ductwork from rooftop units should be routed outdoors for at least 10' providing enough space for a 5' duct silencer equivalent to Price model RM, before penetrating the roof into a shaft. This outdoor ductwork should consist of light-gauge rectangular duct with 1" or 2" internal fiberglass duct liner.
 - a) If the RTU must have a bottom discharge and inlet, incorporate a noise control curb solution that has integral discharge and inlet silencers and noise control curb barrier, equivalent to Vibro-Acoustics model NCC-VCR.
- 5) Rooftop units should be mounted on vibration-isolating roof curbs. As a basis of design, consider the Vibro-Acoustics model VCR with a static deflection of 1" to 2", depending on the rotational speed of the fans, the location of the equipment, and the structure below.
- 6) The roof should not be removed within the curb volume except where duct penetrations occur. Internal spring isolators should be bolted down



in the locked position or switched to elastomeric (e.g. neoprene, rubber, or engineered foam) mounts.

- 7) If the rooftop unit has a condensing section, specify the manufacturers' option for low-sound condenser fans.

I. Vibration Isolation – Mechanical Equipment (Condominium, Hotel)

- 1) All major mechanical equipment will require vibration isolation per the guidelines set out in ASHRAE 2019 HVAC Handbook: Chapter 49 "Sound and Vibration Control". In some cases, isolation methods may be employed which exceed ASHRAE guidance to achieve lower noise or vibration levels. Special attention should be given to rooftop equipment to attenuate vibration transmission. Further recommendations will be issued in later design stages after the building structural and mechanical strategies have been confirmed.
- 2) For costing and design purposes, all operating mechanical and electrical equipment and attached pipe shall be vibration isolated in accordance with the guidelines in the 2019 ASHRAE Handbook – HVAC Applications, Chapter 49 - Noise & Vibration Control, Table 47.
- 3) In some cases, isolation methods may be employed which exceed ASHRAE guidelines to achieve noise or vibration levels that meet the design targets.
- 4) All large equipment should be located on stiff and massive slabs or rooftop dunnage steel (if any). No equipment should be mounted to lightweight structure.
- 5) Pipework should be supported on isolation hangers throughout the equipment rooms or roof, and for at least 50' from the connected equipment. In some cases, additional isolation may be warranted.
- 6) All electrical, pipe and duct connections to equipment should be via flexible connections.
- 7) Large diameter chilled water pipes should not be supported from structure common to the acoustically critical areas. These large, noisy pipes should run only in spaces that are inherently noisy (major equipment rooms, loading dock, etc.). Vibration isolators alone do not provide adequate protection against the high vibration energy from such pipes.



m. Plumbing Pipe Installations (Condominium, Hotel)

- 1) Noise and vibration control measures should be implemented into the design, including resilient support for plumbing lines, flexible pipe work at connections to vibration isolated equipment, selection of moderate plumbing fluid velocities and vibration isolation for the pumps.
- 2) Plumbing pipes located in double stud partitions should be mounted on the service side studs only and should not have any rigid connection to the opposite row of studs.

n. Electrical Systems (Condominium, Hotel)

- 1) The electrical system contains various components that create noise. Unlike noise from the HVAC system, which is typically broadband in nature, electrical components tend to generate highly tonal noise. Such noise can be annoying or distracting even at moderate noise levels. As such, noise and vibration control measures should be incorporated into the design of the electrical system. Typically, these would include the use of proprietary vibration isolators for sub-stations, transformers and some distribution panels. Detailed recommendations and specifications will be developed as the project progresses.
- 2) Further review of noise impact to the environment and to the interior of the building from the proposed emergency generator (if included on the project) will be assessed as the project progresses.

5. Mock-Ups (Condominium, Hotel)

- a. Much can be gained from evaluation of a condominium and guestroom mock-up to provide assurance of the acoustic performance of various issues that lead to complaints.
- b. If the Owner has interest in acoustic testing of mock-up spaces, we recommend that they be planned to allow for the following testing:
 - 1) Demising partition performance, including doors and mullion detail. This will confirm that standard workmanship and all detailing addressed in the construction documents will be sufficient to provide repeatable acoustic performance.
 - 2) Condominium and guestroom HVAC options to confirm sound level and quality of various units. If FCUs operating over NC 37 are intended, we recommend conducting a listening mock-up including additional units.



Such a test may allow for less-expensive units to be evaluated and accepted by Ownership.

- 3) Flooring underlayment options. There are many options, and some of the least expensive options can greatly vary in acoustic performance. Mock-up(s) only need to install a section of 4'x4' finished floor.

c. Additional mock-up(s) for testing may include:

- 1) Operable partition to assess detailing and acoustic seal performance.
- 2) Slab-edge at façade detail to assess the horizontal and vertical flanking paths.
- 3) Guestroom connecting doors (if applicable) to assess detailing and acoustic seal performance.

d. Mock-ups shall be constructed on-site whenever possible.

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