



Engineering Bulletin

IntelliPak™ 20-130 Ton Rooftops

Subject: Indoor Sound™

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Introduction

“SOUND” ADVICE FROM TRANE

For sound sensitive large rooftop installations

In order to achieve a quiet HVAC equipment installation the subject of “system sound attenuation” must be addressed. The “system” is made up of the air-conditioning equipment, the air distribution system (ductwork and air terminal devices) and the building structure.

- a) Recommended air distribution system design and installation practices
- b) Large packaged rooftop sound power data

This material, properly applied, will guide the designer toward producing an optimally quiet air conditioning system installation.

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APPLICATION CONSIDERATIONS

Rooftop Unit Location

The single most effective recommendation to prevent noise problems within a building is to locate the unit over non-critical areas such as copy rooms, restrooms, storage rooms...etc. and other similar non-occupied areas of the building. **Never locate a unit directly over or in close proximity to sound sensitive areas such as conference rooms, executive office spaces, and libraries, etc.**

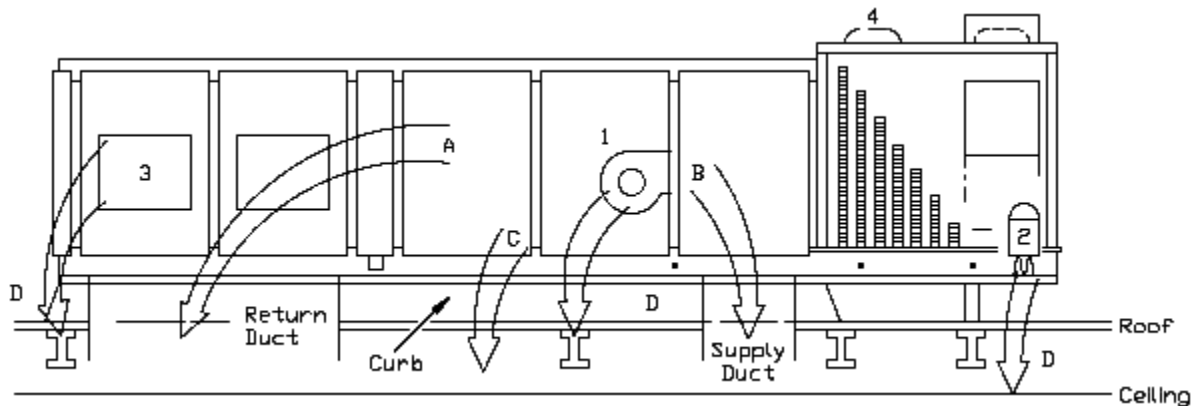
LOCATION – LOCATION – LOCATION

Sources of Unit Sound

There are six basic sources of noise associated with a rooftop installation. They are:

- I. Supply Fan (See Figure 2, Item 1)
- II. Compressors (See Figure 2, Item 2)
- III. Exhaust Fans (See Figure 2, Item 3)
- IV. Condenser Fans (See Figure 2, Item 4)
- V. Flow noise generated at duct fittings (See Figure 2, Items A and B). This noise is related to the design of the ductwork – not the rooftop unit itself.
- VI. Structural vibration generated by compressors and fan assemblies (Item 1,2,3 and 4 in Figure 2 – note that Item B can also cause structural vibration if the ductwork is rigidly connected to structural members).

Figure 2 – Sources of Unit Sound



“Noise Sources”

Legend

- 1. = Supply Fan(s)
- 2. = Compressors
- 3. = Exhaust Fans (Opt.)
- 4. = Condenser Fans

“Sound Transmission Paths”

Legend

- A = Return Duct
- B = Supply Duct
- C = Unit Base
- D = Building Structure

Not shown: Duct Fittings (i.e., “aerodynamic” noise source)

Paths of Sound Transmission

The sources of sound listed in section B, "Sources of Unit Sound," are transmitted to occupied space via four paths:

- I. Structural vibration of the building (See Figure 2, Items 1,2,3,4 and B)
- II. Sound transmitted through the roof structure directly (Path D in Figure 2).
- III. Source items are 1,4 and 2 (fan inlet) of Figure 2, and item 3 (fan inlet) with the compressors being a noise source using this path. With Trane's pedestal mounted rooftop unit, the compressor noise transmitted to the space is minimized since the noise is allowed to break out above the roofline (there is no direct path to the occupied space as with full perimeter curb support systems). Also, the pedestal support curb design eliminates a vibration problem—inherent in full perimeter curb designs—vibration of the condenser base pan (which can resonate like a drumhead). The base pan is not present in the condensing section of Trane large rooftop units.
- IV. Supply duct (Path B in Figure 2) - Source items 1 (fan discharge) and B.
- V. Return duct (Path A of Figure 2) - Source items 1 and 3 (fan inlet) and A.

The sources of noise and their transmission paths are generally the same for all types of HVAC systems whether packaged or built up. Since rooftop equipment is not enclosed by in an equipment room, the attenuation offered by walls, ceiling, and floor slabs is not present.

Supply Fan Noise

A major concern with forward curved (FC) fan noise is the low frequency sound generated by the fan, which is easily transmitted through the ductwork to the conditioned space. In a typical application, with ordinary ductwork, any noise problems that do occur usually occur within the first 20 feet of supply ductwork. This is where the fan noise breaks out of the ductwork. The dominant noise source in the general classification of fan noise is the supply fan discharge. In most cases, the supply fan discharge noise will be the dominant source for the entire rooftop.

To help attenuate the supply fan discharge sound, consider using some of the following options:

1. Use the extended length (model SXHF) casing in lieu of the SAHF casing. This will provide noise attenuation on the order of 3 to 6 dB in the critical 125 Hz octave band.
2. Route the supply duct horizontally above the roof 15 to 20 feet before penetrating the building envelope. **Use 2" internal duct lining** on this run to attenuate high frequency noise. This will provide very significant attenuation allowing the lower frequency fan noise to break out above the roofline.

Always **use an approved, fire-resistant flexible canvas connector** when making duct connections to the rooftop unit or curb to prevent transmission of vibration through the duct system. After penetrating the building envelope, and especially when dropping the duct through a vertical chase, **do not allow the duct to be in direct contact with chase walls or rigidly attached to structural members** of the building. Vibration may be transmitted through the duct system and into the building structure.

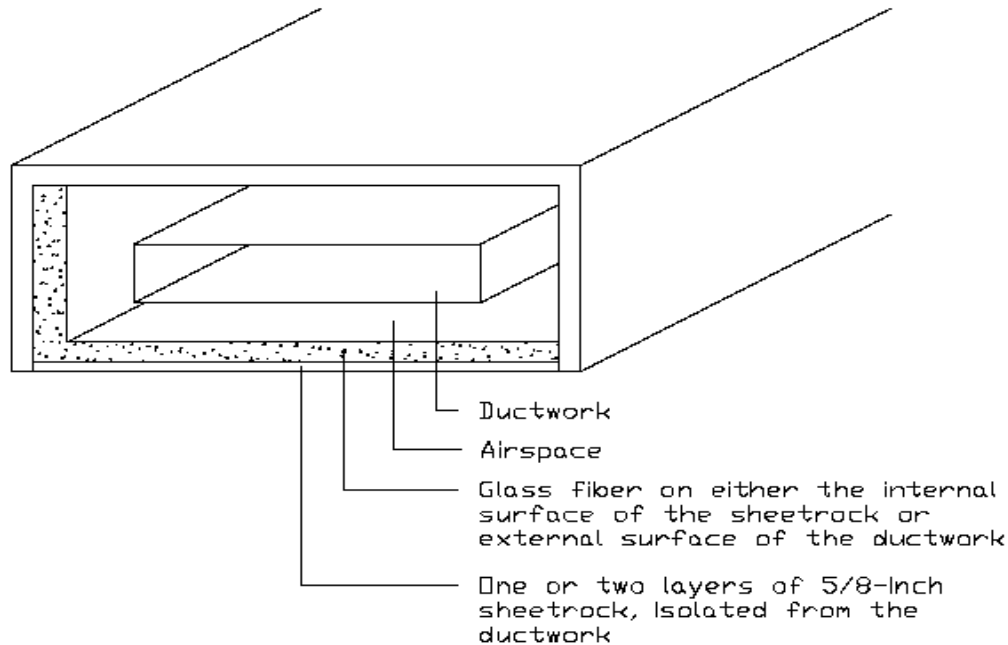
3. If horizontal ducting above the roof cannot be accomplished, **it is recommended that the rooftop be elevated or installed on a high curb to provide 7–8 feet of straight vertical drop.** This will provide development of smoother air flow and noise breakout above the roofline. Although not as effective as the horizontal ducting mentioned above, this method will provide significant sound attenuation.
4. If rectangular duct must be used, realize that this configuration of ductwork has very poor properties for resisting the breakout of fan noise. **The reader is advised to consult the "Noise and Vibration Control" handbook by Mark E. Schaffer** (see reference section at the end of this bulletin). When using rectangular ductwork the use of **heavy gauge sheet metal, #16 – 14 gauge is recommended** for the first 20 – 30 feet of duct. **Lagging is also recommended.** However, the effectiveness of the lagging depends upon 1) the material selected and 2) the method, skill level and experience of the installer.

Three types of lagging should be considered:

- a) Gypsum board isolated from the duct. Two layers of 5/ 8" gypsum board are supported on a frame separate from the ductwork. Glass fiber insulation can be added between the duct and the gypsum board, but this insulation must not bridge the gap (this would destroy the vibration isolation from the duct – refer to figure 3.

- b) Use loaded vinyl barrier wraps. A flexible 1/8" thick, 1 lb. / sq. ft. loaded, vinyl coated Barrier over either acoustic foam or glass fiber blanket can increase the resistance to duct breakout. Reference individual manufacturer's literature for installation details.
- c) Gypsum board tight to duct. Two layers of 5/8" gypsum board over a 1" glass fiber blanket screwed tight to the duct provides an acoustic barrier and some vibration damping. No attempt is made to keep the gypsum board isolated from the duct vibration.

Figure 3 – Gypsum Board Lagging Around Ductwork



- 5. After installing the rooftop unit, and its associated air distribution system, it must be properly **air balanced by qualified air balancing technicians** using calibrated air measuring devices. The airside system should be balanced to achieve the desired airflow at all terminal outlets while maintaining the lowest possible fan rpm and system static pressure. It is quite common for system designers to over estimate the system static pressure capability that will be required to achieve design airflow. Consequently, larger than needed motor sizes and higher rpm drives than required to overcome the actual static pressure are specified and installed. "Over-aired" systems waste energy and are very noisy. The air terminal device balancing dampers are more restricted than necessary to compensate for over-airing. For minimum noise, operate the rooftop at the lowest possible pressure in the duct.
- 6. Sound Masking – the noise from some FC fans may sound like a low frequency rumble. This may be a **case of an unbalanced sound spectrum** rather than too high a noise level. A condition like this might occur when acoustical treatment on the ductwork and/or ceiling has attenuated most of the high frequency noise, but not much of the low frequency noise at a possible NC 20 level, making the low frequency noise annoying. The solution to this example may be to add the proper amount and type of additional noise to fill out the spectrum. The added sound fills in the missing portion of the noise and makes the combined sound spectrum more pleasing.

Testing has shown that rumble can and does occur in the lower 16, 32 and 63 Hz octave band center frequencies. Often, the lower 16 and 32 Hz octave bands have been ignored when evaluating and measuring a "rumbling" installation – this should not be the case.

- 7. **Use spiral seam round duct (internally lined) for the supply duct.** Spiral round duct has low frequency sound containment properties (particularly at the 16 and 32 Hz octave bands) far superior to rectangular duct. **However, to be successful, this design requires an immediate and properly designed transition** at the rooftop unit discharge to round. A two piece mitered round elbow with turning vanes may be used when space limitations are extreme. If space is limited, consider using smaller multiple round ducts in parallel. Again, the transition should be located at the

drop from the unit discharge. **It is very important that the proper rectangle-to-multiple round transition be made to prevent noise breakout at the transition into the building space.** The flat portions of the transition permit noise break out. The transition should be fabricated of heavy gauge sheet metal (#14 - #16 gauge). In addition, it is recommended that gypsum board lagging be placed around the transition and extended up to the roof decking (extended upstream and downstream of the transition piece). Since the high frequency noise will be contained within the round duct, and transferred down the duct, it is recommended that 2" internal lining be utilized over the first 20-30 feet of ductwork routed from the rooftop unit supply air opening. The lining will help attenuate the high frequency noise. **When applied, this type of ductwork system should be designed in conjunction with guidance from an acoustical consultant.** For additional information, involving a specific application where round duct may be applied, the reader is advised to contact the Applications Engineering Group at Trane LaCrosse, Wisconsin or the Large Commercial Unitary Systems Group at Trane, Clarksville, Tennessee.

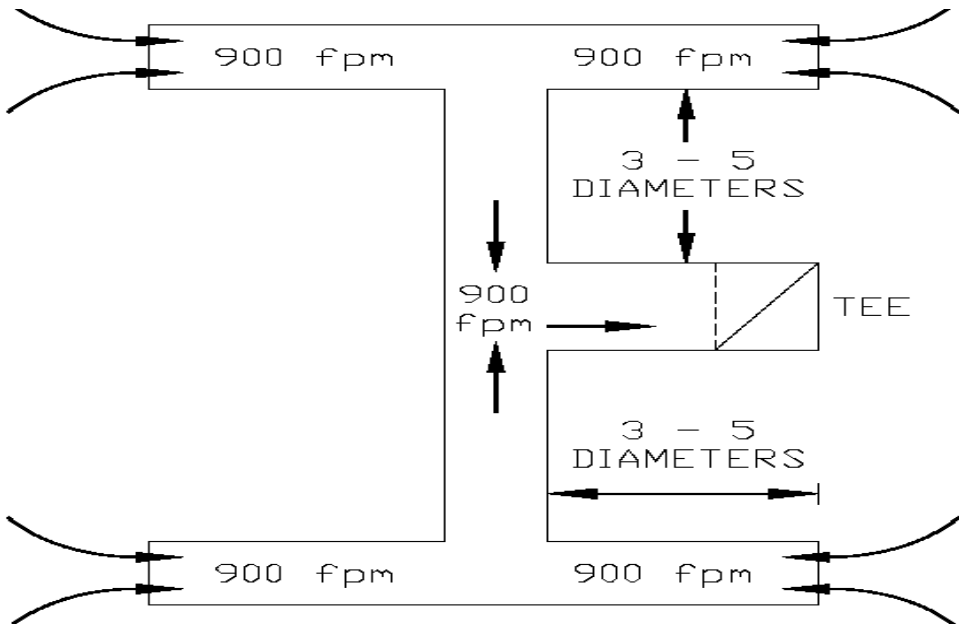
Exhaust Fan Noise

Noise may also be transmitted through the return air opening. The source of this noise is the supply fan inlet and the exhaust fan inlet (assuming an exhaust fan is supplied with the unit). To help attenuate noise being transmitted through the return air opening, consider the following:

1. On ducted returns use internally lined duct (2" minimum thickness is recommended).
2. For open plenum return systems, a heavy gauge internally lined boot or "T" section should be used (refer to Figure 4).
3. Size all return air ducts for 900 – 1000 feet per minute maximum air velocities.
4. Each leg should be sized to help get the duct end reflection loss per the recommendations of the ASHRAE Handbook, "HVAC Applications."

Each "leg" of the return ductwork should be 3 to 5 duct diameters long. Add a "T" on to a "T" if necessary to get a small enough final inlet cross section to achieve the end reflection loss (refer to Figure 4). More low frequency attenuation can be achieved through end reflection loss than by adding duct silencers.

Figure 4 – Recommended Return Air Side Ducting (Symmetrical Tees)



Aerodynamic Flow Noise Generated at Duct Fittings

Aerodynamic noise is generated at duct fittings such as elbows, dampers, and take-offs. The sound power levels generated at these fittings are dependent on airflow turbulence, fitting geometry, and airflow velocity.

Guidelines for minimizing the generation of aerodynamic noise are presented below. Procedures for estimating sound power as generated by various fittings are represented in the **ASHRAE Handbook "HVAC Applications"**.

1. Size rectangular ductwork for low velocities. Round duct can be sized for medium velocity airflow.
2. Allow smooth airflow to develop between fittings by allowing at least three duct diameters between any duct fittings.
3. Avoid abrupt changes in duct direction.
4. Choose the most efficient fittings – the greater the pressure drop, the greater the sound power generated.
5. Keep duct runs straight between fittings.

A special category of aerodynamic noise, referred to as duct rumble phenomena, deserves mention because it is commonly encountered with rooftops due to their roof-mounted installation.

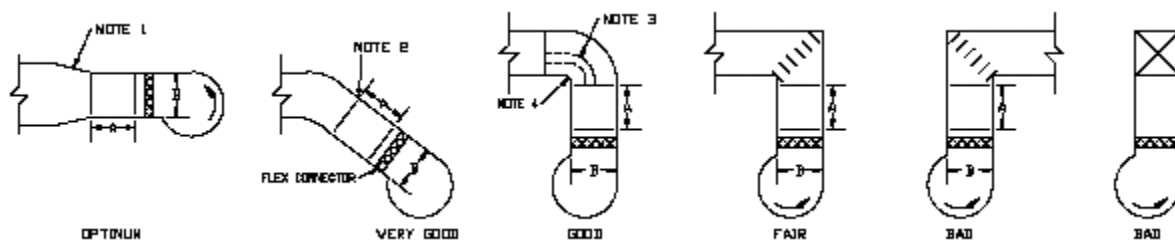
The **ASHRAE System Guide's** discussion of this subject is presented below.

Rumble results when excessive low frequency sound energy is generated in an air distribution system; most frequent cause is poor (turbulent) air flow conditions at the fan discharge or in the immediate downstream duct section. The troublesome frequency region is usually below 250 Hz, extending frequently down through 31.5 and 16 Hz octave bands. Once generated, sound energy in these low frequencies is not easily attenuated; it is transmitted readily both downstream and through the duct walls. Most add-on devices such as silencers or lagging are inefficient in low frequencies. Rectangular ductwork, because of flexibility, is more likely to cause trouble than circular ductwork. Good airflow design at or near the fan is the most effective method of avoiding possible rumble conditions.

Figure 5 shows various conditions and their classifications with regard to possible rumble development."

Noise and turbulent flow inside a duct also cause the walls to vibrate and radiate noise to the surrounding space. Rectangular ducts are more susceptible to this than are round ducts. The problem increases with increased duct sizes and air velocities. **To prevent excessive noise radiation from the duct walls, all fittings should be smooth and designed to avoid abrupt changes in direction or velocity.** Whenever possible, high velocity ducts and terminal units should be located in non-critical, unoccupied areas (e.g. above corridors).

Figure 5 – Various Outlet Conditions and Their Possible Rumble Developments



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Notes:

1. Converging or diverging slopes of 1 in 7 are preferred.
2. Slopes of 1 in 4 are permitted at air velocities below 2000 feet per minute (fpm) [10m/sec].
3. Dimension "A" shown in Figure 5 above should be a minimum of 1.5 "B" where "B" is the largest discharge duct dimension.
4. Rugged turning vanes should extend full radius of the elbow. If airfoil-turning vanes are used they should be only at 45 degrees. A converging 90-degree turn cannot use airfoil turning vanes properly.
5. Minimum of 6" [150 mm] radius.

Supply Ductwork Noise Reduction

In order to investigate the treatment needed for supply ductwork to minimize sound transmission, Trane conducted several extensive acoustical test programs.

Initial testing was conducted involving different duct configurations. The noise reduction of each duct configuration was measured in reference to a plain rectangular duct with a 90-degree turn below the rooftop.

The duct configuration tests were conducted in Trane's Acoustic Laboratory using ANSI qualified reverberant rooms in that lab. All tests were run utilizing a 40-ton rooftop fan assembly at 20,000 cfm of airflow at 2" T.S.P. The 40-ton fan assembly consisted of two parallel, forward-curved, 20" diameter fan wheels.

The different combinations and the resulting noise reduction in the critical first three octave bands are shown in Table 11-1. Sketches of each duct configuration are included in the table following the test comparisons.

A second series of test were conducted at the Trane sound facilities utilizing a "real world" conference room mock up. These tests were run utilizing a 40-ton rooftop unit. Based upon the conference room mock up sound tests conducted by Trane, the following methods may be utilized to reduce or eliminate the supply ductwork noise component of the air distribution system:

1. First and foremost – do not locate the supply discharge trunk line ductwork directly above sound sensitive areas!
2. Utilizing 20 gauge duct, routed 14 feet horizontally off the downflow discharge (before penetrating the roof), an NC 40 indoor sound level was achieved. Use of a 2" internal is recommended to attenuate the higher frequency noise components. Based upon mock up results, **EXTERNAL HORIZONTAL DUCTING WILL PROVIDE A SIGNIFICANT REDUCTION IN THE INDOOR SOUND LEVEL.**
3. If horizontal ducting cannot be applied, **utilize a roof curb of greater height than a standard curb.** When elevating the rooftop unit, a minimum of 7 – 8 feet of straight vertical drop should be provided to allow smooth, laminar air flow to develop more completely. Also, the elevation allows the higher velocity, turbulent airflow noise from off the fan discharge to break out / dissipate before reaching occupied spaces. Although not as effective as ducting horizontally above the roof, this method of routing supply duct will provide significant attenuation.
4. When rectangular duct is used and routed within the building envelope one must be cognizant of the fact that this configuration of duct is very poor at resisting the break out of low frequency noise. Hence, for the routing of the first 20 –30 feet of rectangular duct, within the interior of a building, use heavy gauge (#16- #14) sheet metal to minimize noise break out. Gypsum board lagging is also recommended to provide additional protection against low frequency noise break out.

In addition to the information presented above, Trane offers a variety of additional aids for guidance in designing a "sound system". Available from the Customer Direct Service (C.D.S.) Network of Trane is the **Trane Acoustics Program (T.A.P.)**. This state-of-the-art program aids the mechanical designer in producing a quiet job. Also available is the Trane "**Acoustics in Air Conditioning**" applications engineering manual (literature order number FND-AM-5).

Table 11-1 Duct Breakout Insertion Loss – Potential Low Frequency Improvement over Bare Duct Elbow

Discharge Duct Configuration 12 ft of Horizontal Supply Duct	63	125	250	Side view	End view
Rectangular duct; no turning vanes (Reference)	0.0	0.0	0.0		
Rectangular duct: one dimensional Turning vanes.	0.0	0.5	0.5		
Rectangular duct: two dimensional Turning vanes.	0.0	0.5	1.0		
Rectangular duct: wrapped with foam And lead.	4.0	3.0	4.5	See end view	
Rectangular duct; wrapped with glass fiber, one layer of 5/8 in. gypsum board.	4.0	7.0	5.5	See end view	
Rectangular duct; wrapped with glass fiber, two layers of 5/8 in. gypsum board	7.5	8.5	9.0	See end view	
Rectangular plenum drop; three parallel rectangular supply ducts.	1.0	2.0	3.5		
Rectangular plenum drop; one round supply duct.	8.0	9.5	6.0		
Rectangular plenum drop: three parallel round supply ducts.	10.5	13.5	8.0		
Rectangular to multiple drop: round mitered with turning vanes, three parallel round supply ducts.	17.5	11.5	13.0		
Rectangular to multiple drop: round mitered elbows with turning vanes, three parallel round lined double wall, 22 in. OD supply ducts.	18.0	13.0	16.0		
Round drop: radius elbow, single, 37 in. diameter supply.	15.0	16.5	9.5		

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Structural Considerations

Proper vibration isolation to eliminate vibration transmission is only possible if the building structure is sufficiently rigid to serve as a base for the mechanical equipment. To help isolate the unit from the building consider the following:

1. **Use an inertia base or solid concrete pad as a base** for the rooftop unit. This mass properly supported will provide vibration dampening and prevent low frequency noise from breaking out through the roof directly below the unit.
2. **Isolate the unit on spring isolation rails** selected to match the characteristics of the roof structure.

CAUTION! Do not allow large rooftop equipment to be applied to buildings with a lightweight roof structure unless column supports are provided which are independent of the roof structure. Otherwise, the entire lightweight roof structure in the vicinity of the unit will vibrate, transmitting this vibratory motion throughout the entire building structure!

3. **Attach a flexible canvas connector** between the unit discharge and supply duct and between the unit return inlet and the return air duct to prevent transmission of vibration from the unit to the building via the duct system.
4. **Do not support ductwork rigidly to building structural members or chase walls.** Use hanger isolators and do not allow ductwork to be mounted in direct contact with the walls.
5. **Use a good duct sealant with vibration dampening characteristics** to prevent vibration transmission and air leaks in the duct system.
6. Attach electrical conduits, natural gas piping, hot water piping, steam piping...etc. with **flexible couplings.**
7. **Locate the unit over unoccupied areas** of the building such as a storage room, restroom, etc., over vertical supports. Do not locate the unit in the middle of a horizontal beam **avoid large column spans!** This will minimize the roof deflection and minimize vibratory transmission.

In addition, the reader is also encouraged to **read the ASHRAE paper NY-91-3-3**, also, an article from the ASHRAE Journal, May 2000, "Practical Guide – Controlling Noise From Large Rooftop Units" by Dave Guckelberger, and the other reference materials listed at the end of this publication. NY-91-3-3, "**Sound and Vibrations in Rooftop Installations**" (written by R.G. Harold, P.E. with the Trane Acoustics Laboratory), deals with the fact that proper sound control is a result of controlling the system (e.g. building structure, air distribution system and the rooftop equipment). Reprints of the foregoing paper are available from Trane upon request.

Large rooftop sound power levels

Sound power levels have been obtained for 20 – 130 ton IntelliPak™ rooftop units. The discharge and air return ducted components have been individually measured and presented in the data tables. All sound power levels were measured in strict compliance ARI Standard 260-2001 “Sound Rating of Ducted Air Moving and Conditioning Equipment”. In addition, the reverberant room was pure tone qualified in accordance with ANSI S12.32-2001 “**Precision Methods for the Determination of Sound Power Levels of Discrete Frequency and Narrow Band Noise Sources in Reverberant Rooms**”.

Supply Fan Total Static Pressure

For Trane rooftops, “Total Static Pressure” (T.S.P.) is used to enter the supply fan performance tables in the Trane large rooftop product catalogs. Total static pressure equals the sum total of rooftop component static pressure drops plus external static performance drops. “Blank” data lines in the catalog performance tables indicate static pressure / air flow conditions, which are outside the unit’s safe operating range.

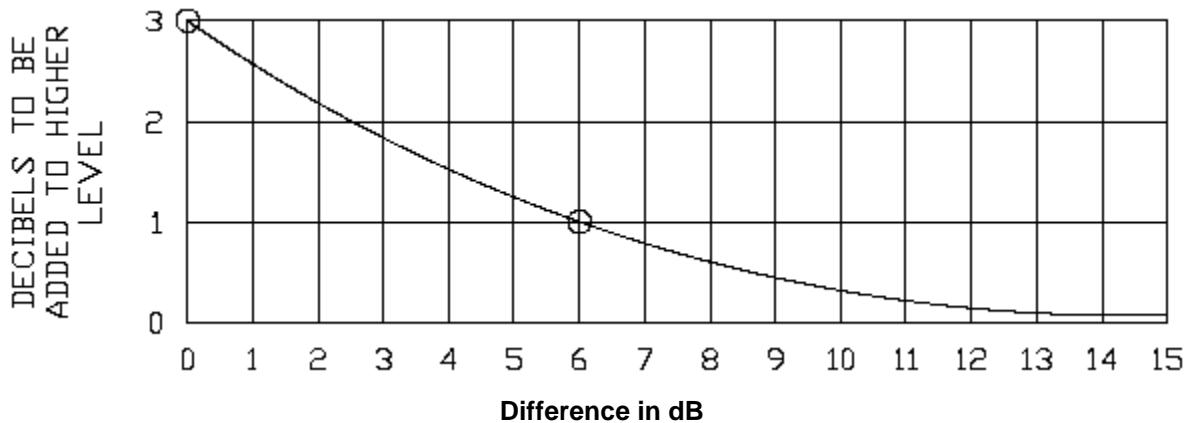
Including Exhaust Fan with Supply Fan Sound Power Levels

If an exhaust fan is an option, the exhaust fan sound power must be added to the supply fan sound power at the unit return air section to get an accurate octave band representation of the sound at the return air section of the unit. The mathematical method to add these two numbers is by the following equation (round off to nearest whole number):

$$Lw(total) = 10 \times \text{Log}_{10} \left(10^{\left(\frac{Lw(Supply)}{10} \right)} + 10^{\left(\frac{Lw(Exhaust)}{10} \right)} \right)$$

A simplified graphical method to add these two numbers is through the use of the following chart. (Figure 6)

Figure 6 – Adding Decibels



The addition of sound power data in decibels is a logarithmic add. The table simplifies this addition. For example, if a 90 ton rooftop supply fan was selected at 37,000 cfm and 4.0" T.S.P. (line 1) and the exhaust fan was selected at 35,100 cfm and .75" T.S.P. (line 2), the addition would look like this:

	Octave Band							
	63	125	250	500	1K	2K	4K	8K
Line 1: Supply Fan Sound Power Levels at the Unit's Return Air Section (from Table 23 – 1)	81	81	86	78	73	70	65	56
Line 2: Exhaust Fan Inlet Sound (from Table 31-1)	88	86	83	83	81	78	74	66
Line 3: Difference (Line 2 minus Line 1)	7	5	3	5	8	8	9	10
Line 4: Add to highest level (Line 2 in this case) (from Figure 6)	1	1	2	1	1	1	1	1
Total	89	87	88	84	82	79	75	67

In this scenario 1 to 2 dB was added to the higher sound power level for those dB differences of 10 or less (see Figure 6). On dB differences greater than 10, zero was added. Obviously, the controlling sound power level is the exhaust fan inlet level at the return section. The total line should be used in analyzing the return duct sound path.

Indoor sound power levels for the supply, and return, side of the IntelliPak™ rooftop are given on the following pages. A table defining the abbreviations/acronyms used with the sound power data tables used also follows immediately below.

Table 14-1 ABBREVIATIONS USED IN SOUND POWER DATA TABLES

Abbreviation	Defining Description
CFM	cubic feet per minute (air flow)
dB	decibel (numerical expression denoting the relative loudness of a sound)
K	multiplier of 1000
Lw	Sound Power Level (watts)
Rpm	revolutions per minute
TSP	Total Static Pressure*
* For rooftop component pressure drops refer to Table PD-44 in catalog RT-PRC010-EN	

“F” Development Sequence 20 – 75 Ton Supply Fan Data

Table 15-1

SAHF 20, 25 Ton COMMERCIAL PACKAGED ROOFTOP																		
SAHF 20, 25 Ton Supply Fan--- Sound Power Levels											With &without inlet guide vanes							
			Discharge Lw, dB								Return Lw, dB							
CFM	TSP	RPM	63	125	250	500	1K	2K	4K	8K	63	125	250	500	1K	2K	4K	8K
5000	1.5	872	84	84	77	77	74	73	67	61	75	77	68	68	67	65	55	51
5000	2.0	1000	87	87	80	79	77	75	70	65	78	80	71	70	69	67	57	54
5000	2.5	1109	89	90	83	82	79	77	73	67	80	82	73	71	71	69	59	56
5000	3.0	1206	91	92	85	83	81	79	74	69	82	84	74	73	72	70	60	58
5000	3.5	1293	93	94	87	85	82	80	76	71	84	85	76	74	74	72	62	59
5000	4.0	1374	94	95	88	86	83	82	77	72	85	86	77	75	75	73	63	60
5000	4.5	1449	95	96	89	87	85	83	78	73	86	88	78	76	76	74	64	62
5000	5.0	1519	96	97	90	88	86	84	79	74	87	89	79	77	77	75	65	63
5000	5.5	1585	97	98	91	89	87	85	80	75	88	89	80	77	78	75	65	64
5000	6.0	1648	98	99	92	90	87	86	81	76	89	90	80	78	78	76	66	64
7000	1.5	892	85	85	79	79	77	74	70	63	75	78	70	71	69	67	57	52
7000	2.0	1018	88	88	81	81	80	77	72	67	78	80	72	73	71	70	59	55
7000	2.5	1131	90	90	84	83	82	79	74	69	80	83	74	75	73	71	61	57
7000	3.0	1233	92	92	86	85	83	81	76	70	82	84	76	76	74	73	62	59
7000	3.5	1327	93	94	87	86	84	82	77	72	84	86	77	77	76	74	63	60
7000	4.0	1413	95	95	89	87	85	83	78	73	85	87	78	77	77	75	64	62
7000	4.5	1493	96	97	90	88	86	84	79	74	87	88	79	78	78	76	65	63
7000	5.0	1567	97	98	91	89	87	85	80	75	88	89	80	79	78	76	66	64
7000	5.5	1638	98	99	92	90	88	86	81	76	89	90	81	80	79	77	67	64
9000	1.5	928	86	86	81	81	80	78	73	67	75	78	70	72	70	68	57	53
9000	2.0	1038	88	88	83	83	82	79	75	69	78	81	73	75	73	71	60	56
9000	2.5	1151	90	91	85	84	84	81	76	71	80	83	75	77	75	73	62	58
9000	3.0	1252	92	92	86	86	85	82	77	72	82	85	77	78	76	74	64	60
9000	3.5	1344	94	94	88	87	86	83	79	73	84	86	78	79	77	76	65	61
9000	4.0	1431	95	95	89	88	87	84	80	74	85	88	79	80	78	77	66	62
9000	4.5	1514	96	97	90	89	88	85	81	75	87	89	80	81	79	77	67	63
9000	5.0	1591	97	98	91	90	88	86	81	76	88	90	81	81	80	78	68	64
11000	2.0	1088	89	90	85	85	84	82	77	72	79	82	73	75	73	71	60	56
11000	2.5	1181	91	91	86	86	85	83	78	73	81	84	76	78	75	74	63	59
11000	3.0	1271	92	93	87	87	87	84	79	73	82	85	77	80	77	76	65	60
11000	3.5	1364	94	94	88	88	88	85	80	74	84	87	79	81	78	77	66	62
11000	4.0	1452	95	96	90	89	88	86	81	75	85	88	80	82	79	78	67	63
11000	4.5	1533	97	97	91	90	89	87	82	76	87	89	81	82	80	79	68	64
11000	5.0	1609	98	98	92	91	90	88	83	77	88	90	82	83	81	80	69	65

Table 16-1

SAHF 30 Ton COMMERCIAL PACKAGED ROOFTOP																		
SAHF 30 Ton Supply Fan ---- Sound Power Levels											With &without inlet guide vanes							
Discharge Lw, dB											Return Lw, dB							
CFM	TSP	RPM	63	125	250	500	1K	2K	4K	8K	63	125	250	500	1K	2K	4K	8K
8000	1.5	744	85	86	79	79	75	74	68	62	76	79	70	69	67	66	56	52
8000	2.0	857	89	89	82	81	79	76	72	66	80	82	72	71	70	68	58	55
8000	2.5	955	91	92	85	83	81	79	74	69	82	84	74	72	72	70	60	58
8000	3.0	1041	94	94	87	85	83	81	76	71	84	86	76	74	74	71	62	59
8000	3.5	1117	95	96	89	87	85	83	78	73	86	87	77	75	75	73	63	61
8000	4.0	1186	96	97	91	88	86	84	79	74	87	88	78	76	76	74	64	62
8000	4.5	1251	98	99	92	89	87	85	80	76	89	90	80	76	77	75	65	63
8000	5.0	1311	99	100	93	90	88	86	81	77	90	91	80	77	78	75	66	64
8000	5.5	1368	100	101	94	91	89	87	82	78	91	92	81	78	79	76	67	65
12000	1.5	760	87	87	82	82	79	77	73	65	76	80	72	73	70	69	58	53
12000	2.0	866	90	90	84	84	81	79	75	68	79	83	74	76	74	72	61	57
12000	2.5	964	92	92	86	85	84	81	77	71	82	85	76	77	75	74	63	59
12000	3.0	1053	94	94	88	87	86	83	79	73	84	86	78	78	77	75	64	61
12000	3.5	1136	96	96	90	89	87	85	80	75	86	88	79	79	78	76	66	62
12000	4.0	1213	97	98	91	90	88	86	81	76	87	89	80	79	79	77	66	63
12000	4.5	1286	98	99	92	91	89	87	82	77	89	91	81	80	80	77	67	64
12000	5.0	1354	99	100	93	92	90	88	83	78	90	92	82	81	80	78	68	65
13500	1.5	779	89	88	83	84	80	79	75	67	77	80	72	73	71	69	59	54
13500	2.0	875	90	90	84	85	83	81	76	69	80	83	75	77	74	73	62	57
13500	2.5	969	92	92	86	86	85	83	78	72	82	85	77	78	76	75	64	60
13500	3.0	1057	94	94	88	88	87	84	79	74	84	87	78	79	78	76	65	61
13500	3.5	1138	96	96	90	89	88	86	81	75	86	88	80	80	79	77	66	63
13500	4.0	1215	97	98	91	90	89	87	82	76	87	90	81	81	80	78	67	64
13500	4.5	1288	98	99	92	91	90	87	83	77	89	91	82	81	80	79	68	65
13500	5.0	1357	100	100	94	92	90	88	83	78	90	92	83	82	81	79	69	66

Table 17-1

SAHF 40, 50, 55 Ton COMMERCIAL PACKAGED ROOFTOP																		
SAHF 40, 50, 55 Ton Supply Fan --- Sound Power Levels With & without inlet guide vanes																		
CFM	TSP	RPM	Discharge Lw, dB								Return Lw, dB							
			63	125	250	500	1K	2K	4K	8K	63	125	250	500	1K	2K	4K	8K
12000	2.0	787	90	90	84	83	80	78	73	67	81	83	74	73	72	70	60	56
12000	2.5	876	93	93	86	85	82	80	76	70	83	85	76	75	74	72	62	59
12000	3.0	956	95	95	88	87	84	82	78	72	86	87	77	76	76	73	63	61
12000	3.5	1030	97	97	90	88	86	84	80	75	87	89	79	76	77	74	65	62
12000	4.0	1098	98	99	92	90	88	86	81	76	89	90	80	77	78	75	66	63
12000	4.5	1160	99	100	93	91	89	87	82	77	90	91	81	78	79	76	66	64
16000	1.5	725	90	90	85	85	82	80	75	69	78	82	73	71	69	68	58	53
16000	2.0	812	92	92	86	86	83	81	77	70	81	84	75	75	73	71	61	57
16000	2.5	893	94	94	88	87	85	83	78	72	84	86	77	77	76	74	64	60
16000	3.0	969	96	95	89	89	87	85	80	74	85	88	79	78	77	75	65	62
16000	3.5	1042	97	97	91	90	89	86	81	76	87	89	80	79	79	77	66	63
16000	4.0	1110	99	99	93	91	90	87	83	77	89	91	81	80	80	78	67	64
18000	1.5	752	92	92	87	87	83	82	78	71	79	82	73	70	69	67	58	53
18000	2.0	832	93	93	87	87	85	83	79	72	82	84	75	75	73	71	61	57
18000	2.5	909	95	94	89	88	87	84	80	74	84	86	77	77	76	74	64	60
18000	3.0	981	96	96	90	90	88	86	81	75	86	88	79	79	78	76	66	62
18000	3.5	1051	98	98	92	91	90	87	82	77	87	89	81	80	79	77	67	64
18000	4.0	1117	99	99	93	92	91	88	83	78	89	91	82	81	80	78	68	65
20000	2.0	857	95	94	89	89	87	85	80	74	82	85	75	74	74	71	61	58
20000	2.5	929	96	95	90	90	88	86	81	75	84	87	78	77	76	74	64	60
20000	3.0	998	97	97	91	91	90	87	82	77	86	88	79	79	78	76	66	62
20000	3.5	1064	98	98	92	92	91	88	83	78	87	90	81	81	80	78	68	64
20000	4.0	1128	99	99	93	92	92	89	84	79	89	91	82	82	81	79	69	65
24000	2.0	926	97	97	93	92	91	89	84	79	84	86	75	72	73	69	61	57
24000	2.5	983	98	97	93	92	91	89	84	79	85	87	78	76	76	73	64	60
24000	3.0	1043	98	98	93	92	92	89	85	80	87	89	80	79	78	76	66	62
24000	3.5	1102	99	99	94	93	93	90	85	80	88	90	81	81	80	78	68	64
24000	4.0	1161	100	100	95	94	93	91	86	81	89	92	83	83	81	79	69	65

Table 18-1

SAHF 60, 70, 75 Ton COMMERCIAL PACKAGED ROOFTOP																		
SAHF 60, 70, 75 Ton Supply Fan---- Sound Power Levels With & without inlet guide vanes																		
			Discharge Lw, dB								Return Lw, dB							
CFM	TSP	RPM	63	125	250	500	1K	2K	4K	8K	63	125	250	500	1K	2K	4K	8K
18000	1.5	633	93	88	84	84	81	79	74	68	78	82	74	74	71	70	59	54
18000	2.0	718	95	90	86	85	81	80	76	70	81	85	76	76	74	72	62	57
18000	2.5	7911	97	92	87	86	83	82	77	71	84	87	78	78	76	75	64	60
18000	3.0	855	98	94	89	88	85	83	79	73	85	88	80	80	78	77	66	62
18000	3.5	913	100	95	90	89	87	85	80	75	87	90	81	81	80	78	68	64
18000	4.0	966	101	96	91	90	88	86	81	76	88	91	82	83	81	80	69	66
18000	4.5	1016	102	97	92	91	88	87	82	77	90	92	83	84	83	81	70	67
18000	5.0	1063	103	98	93	92	89	87	83	78	91	93	84	85	83	82	71	68
18000	5.5	1107	104	99	94	93	90	88	84	79	92	94	85	86	84	83	72	69
24000	1.5	659	94	91	87	87	83	82	78	70	79	83	74	75	72	71	60	55
24000	2.0	746	96	92	88	88	85	83	79	72	82	85	77	77	75	74	63	58
24000	2.5	821	97	93	89	89	86	84	80	73	84	87	79	80	78	76	66	61
24000	3.0	889	98	94	90	90	88	86	81	75	86	89	81	81	80	78	67	63
24000	3.5	951	100	96	91	91	89	87	82	76	88	90	82	83	81	79	69	65
24000	4.0	1008	101	97	92	92	90	88	83	77	89	92	83	84	82	81	70	66
24000	4.5	1060	103	98	93	93	90	88	84	78	90	93	84	85	83	82	71	67
24000	5.0	1109	104	99	94	94	91	89	85	79	91	94	85	86	84	83	72	68
28000	2.0	763	96	93	89	90	86	85	81	73	82	86	77	78	75	74	64	58
28000	2.5	839	97	94	90	90	87	86	81	74	85	88	79	80	78	77	66	61
28000	3.0	907	98	95	91	91	89	87	82	75	86	89	81	82	80	79	68	64
28000	3.5	969	100	96	92	92	90	88	83	77	88	91	82	84	82	80	69	65
28000	4.0	1028	101	98	93	93	91	89	84	78	89	92	84	85	83	81	71	67
28000	4.5	1082	103	99	94	94	92	90	85	79	90	93	85	86	84	82	72	68
32000	2.0	802	97	95	91	92	88	87	83	76	83	86	77	77	75	73	63	59
32000	2.5	858	97	95	91	92	88	87	83	76	85	88	80	81	79	77	66	62
32000	3.0	924	98	96	92	92	89	88	83	76	87	90	81	83	81	79	68	64
32000	3.5	988	100	97	93	93	91	89	84	78	88	91	83	84	82	80	70	65
32000	4.0	1046	101	98	94	94	92	90	85	79	90	93	84	85	83	82	71	67
32000	4.5	1100	103	99	95	95	93	91	86	79	91	94	85	86	85	83	72	68

Table 19-1

S_HF 20, 25 Ton COMMERCIAL PACKAGED ROOFTOP

SX, SF, SE, SL, SS 20, 25 Ton Supply Fan ---Sound Power Levels

With & without inlet guide vanes

Discharge Lw, dB											Return Lw, dB							
CFM	TSP	RPM	63	125	250	500	1K	2K	4K	8K	63	125	250	500	1K	2K	4K	8K
5000	1.5	872	83	79	73	73	71	68	63	59	73	73	67	64	61	59	52	48
5000	2.0	1000	85	82	76	75	74	70	66	63	76	76	70	66	64	62	55	52
5000	2.5	1109	87	84	78	77	76	72	68	65	77	78	71	68	67	65	58	55
5000	3.0	1206	88	85	80	77	77	73	70	67	79	79	73	69	68	66	60	57
5000	3.5	1293	90	87	81	79	78	74	71	68	81	81	75	70	70	68	61	59
5000	4.0	1374	91	88	83	80	79	75	72	69	82	82	76	71	71	69	63	60
5000	4.5	1449	93	89	84	81	80	76	73	70	83	83	77	73	72	70	64	62
5000	5.0	1519	94	90	84	81	81	77	74	71	85	84	78	73	73	71	65	63
5000	5.5	1585	94	91	85	82	82	77	75	72	86	85	79	74	74	72	66	64
5000	6.0	1648	95	92	86	83	82	78	75	73	86	86	80	75	74	73	67	65
7000	1.5	892	83	80	74	74	73	69	65	60	73	73	68	65	63	61	52	48
7000	2.0	1018	85	83	77	76	75	72	68	64	75	76	70	67	66	64	55	52
7000	2.5	1131	87	85	79	77	77	73	70	66	77	78	72	69	68	66	58	55
7000	3.0	1233	89	87	81	79	79	74	72	68	79	80	74	70	70	68	60	57
7000	3.5	1327	90	88	82	80	80	76	73	69	81	81	75	72	71	69	62	59
7000	4.0	1413	92	89	84	81	81	77	74	71	82	83	77	73	72	70	63	60
7000	4.5	1493	93	90	85	82	82	78	75	72	84	84	78	74	73	71	64	61
7000	5.0	1567	94	91	86	83	83	79	76	73	85	85	79	75	74	72	65	63
7000	5.5	1638	95	92	87	84	84	80	77	74	86	86	80	76	75	73	66	64
9000	1.5	928	84	81	76	76	74	71	68	62	74	74	69	66	64	62	53	49
9000	2.0	1038	85	83	78	77	77	73	70	65	75	76	71	68	67	64	56	52
9000	2.5	1151	87	86	80	79	79	74	72	67	77	78	72	70	69	67	58	55
9000	3.0	1252	89	87	82	80	80	76	73	69	79	80	74	71	71	68	60	57
9000	3.5	1344	91	89	83	81	81	77	74	70	81	82	76	73	72	70	62	58
9000	4.0	1431	92	90	84	82	82	78	75	71	82	83	77	74	73	71	63	60
9000	4.5	1514	93	91	85	84	83	79	76	72	83	84	78	75	74	72	64	61
9000	5.0	1591	94	92	86	84	84	80	77	73	85	85	79	76	75	73	66	62
11000	2.0	1088	86	85	80	79	78	74	72	66	76	77	71	69	68	66	57	53
11000	2.5	1181	88	87	81	80	80	76	73	68	77	79	73	71	70	67	59	55
11000	3.0	1271	89	88	82	81	81	77	74	69	79	81	75	72	71	69	60	57
11000	3.5	1364	91	89	84	82	82	78	75	71	81	82	76	73	73	70	62	58
11000	4.0	1452	92	91	85	83	83	79	76	72	82	83	77	74	74	72	63	60
11000	4.5	1533	93	92	86	84	84	80	77	73	83	85	79	76	75	73	65	61
11000	5.0	1609	95	93	87	85	85	81	78	74	84	86	80	76	76	74	66	62

Table 20-1

S_HF 30 Ton COMMERCIAL PACKAGED ROOFTOP																		
SX, SF, SE, SL, SS 30 Ton Supply Fan ---Sound Power Levels											With & without inlet guide vanes							
Discharge Lw, dB											Return Lw, dB							
CFM	TSP	RPM	63	125	250	500	1K	2K	4K	8K	63	125	250	500	1K	2K	4K	8K
8000	1.5	744	85	81	75	75	73	71	66	61	76	75	70	67	63	61	54	50
8000	2.0	857	88	84	78	78	75	73	69	64	79	78	73	69	66	64	57	53
8000	2.5	955	90	86	81	79	78	75	71	67	81	80	74	71	69	67	60	56
8000	3.0	1041	91	88	83	80	79	76	73	69	82	82	76	72	71	69	62	59
8000	3.5	1117	93	90	84	82	81	77	74	71	84	83	77	73	72	70	64	61
8000	4.0	1186	94	91	85	83	82	78	75	72	85	84	78	74	73	71	65	62
8000	4.5	1251	95	92	86	84	83	79	76	73	86	86	79	75	74	72	66	64
8000	5.0	1311	96	93	87	85	84	80	77	74	87	87	80	76	75	73	67	65
8000	5.5	1368	97	94	88	85	85	81	78	75	88	88	81	77	76	74	68	66
12000	1.5	760	86	82	76	76	75	72	68	62	76	76	71	68	65	63	54	49
12000	2.0	866	88	85	79	79	77	74	70	65	78	78	73	70	68	65	57	53
12000	2.5	964	90	87	81	80	79	75	73	68	80	81	75	72	70	68	60	56
12000	3.0	1053	91	89	83	82	81	77	74	70	82	82	76	73	72	70	62	58
12000	3.5	1136	93	91	85	83	83	79	76	72	83	84	78	74	74	71	64	60
12000	4.0	1213	94	92	86	85	84	80	77	73	85	85	79	75	75	73	65	62
12000	4.5	1286	95	93	88	86	85	81	78	75	86	86	80	77	76	74	67	63
12000	5.0	1354	97	94	89	87	86	82	79	76	87	87	81	78	77	75	68	65
13500	1.5	779	86	83	77	78	75	73	69	63	76	76	71	69	66	63	54	50
13500	2.0	875	88	85	79	79	77	75	71	66	78	79	73	71	68	66	57	53
13500	2.5	969	90	87	82	80	79	76	73	68	80	81	75	72	70	68	60	56
13500	3.0	1057	91	89	84	82	81	78	75	70	81	82	76	73	72	70	62	58
13500	3.5	1138	93	91	85	84	83	79	76	72	83	84	78	75	74	72	64	60
13500	4.0	1215	94	92	87	85	85	80	78	74	84	85	79	76	75	73	65	62
13500	4.5	1288	95	93	88	86	86	81	79	75	86	86	80	77	76	74	67	63
13500	5.0	1357	97	94	89	87	87	82	80	76	87	88	81	78	77	75	68	64

Table 21-1

S_HF 40, 50, 55 Ton COMMERCIAL PACKAGED ROOFTOP																		
SX, SF, SE, SL, SS 40, 50, 55 Ton Supply Fan Sound Power Levels											With & without inlet guide vanes							
Discharge Lw, dB											Return Lw, dB							
CFM	TSP	RPM	63	125	250	500	1K	2K	4K	8K	63	125	250	500	1K	2K	4K	8K
12000	2.0	787	89	85	79	79	76	74	69	65	81	80	74	70	66	64	59	55
12000	2.5	876	91	88	82	81	78	75	72	68	83	82	76	72	69	67	61	58
12000	3.0	956	92	89	84	82	80	77	73	70	84	84	77	73	71	69	64	60
12000	3.5	1030	94	91	86	83	82	78	75	72	85	85	78	74	72	70	65	62
12000	4.0	1098	95	92	87	85	82	79	76	73	87	86	79	75	73	72	67	64
12000	4.5	1160	96	93	88	86	83	80	77	74	88	87	81	77	74	73	68	65
18000	1.5	725	88	85	79	79	76	74	69	64	79	78	72	70	65	63	57	52
18000	2.0	812	90	87	81	81	78	75	71	67	81	80	74	72	68	66	59	55
18000	2.5	893	91	88	83	82	79	77	73	69	82	82	76	73	70	68	62	58
18000	3.0	969	92	90	85	83	81	78	75	71	84	84	77	74	72	69	64	60
18000	3.5	1042	94	92	86	84	82	79	76	72	85	85	79	75	73	71	65	62
18000	4.0	1110	95	93	87	86	83	80	77	74	86	87	80	76	74	72	67	64
20000	2.0	857	91	89	83	83	79	78	74	69	82	82	75	73	69	67	61	56
20000	2.5	929	92	90	84	84	81	78	75	70	83	83	77	74	71	69	63	58
20000	3.0	998	93	91	86	85	82	79	77	72	84	85	78	75	73	70	64	60
20000	3.5	1064	94	93	87	86	84	80	78	73	85	86	79	76	74	72	66	62
20000	4.0	1128	95	94	88	87	85	81	79	75	86	87	80	77	75	73	67	64
24000	2.0	926	92	91	86	86	82	80	77	72	84	83	76	75	71	68	63	58
24000	2.5	983	93	92	87	86	83	81	78	73	84	84	78	75	73	70	64	60
24000	3.0	1043	94	93	88	87	84	81	79	74	85	85	79	76	74	72	65	61
24000	3.5	1102	95	94	88	88	85	82	79	75	86	87	80	77	75	73	66	63
24000	4.0	1161	96	95	89	88	86	83	80	76	87	88	81	78	76	74	68	64

Table 22-1

S_HF 60, 70, 75 Ton COMMERCIAL PACKAGED ROOFTOP																		
SX, SF, SE, SL, SS 60, 70, 75 Ton Supply Fan ---Sound Power Levels											With & without inlet guide vanes							
Discharge Lw, dB											Return Lw, dB							
CFM	TSP	RPM	63	125	250	500	1K	2K	4K	8K	63	125	250	500	1K	2K	4K	8K
18000	1.5	633	87	84	78	77	74	72	68	63	79	78	72	69	64	62	57	53
18000	2.0	718	90	86	80	79	75	73	70	65	82	81	75	71	66	64	60	56
18000	2.5	791	91	88	82	81	77	75	72	67	83	83	76	73	68	67	62	58
18000	3.0	855	93	89	84	82	78	76	73	69	84	84	78	74	70	68	64	61
18000	3.5	913	94	91	85	83	80	77	74	71	86	86	79	75	71	70	66	63
18000	4.0	966	95	92	86	84	81	78	75	72	86	87	80	76	73	71	67	64
18000	4.5	1016	95	93	87	84	82	78	76	73	87	88	81	77	74	72	68	66
18000	5.0	1063	96	94	88	85	83	79	77	74	88	89	82	78	75	73	69	67
18000	5.5	1107	97	94	89	86	83	80	78	75	89	90	83	78	75	74	70	68
24000	1.5	659	88	85	79	80	75	73	70	64	80	79	73	70	65	63	58	53
24000	2.0	746	90	88	82	81	76	75	72	67	82	82	75	73	68	66	60	56
24000	2.5	821	92	89	84	82	79	77	74	69	84	84	77	74	70	68	63	59
24000	3.0	889	93	91	85	84	81	78	75	71	85	85	78	75	71	70	65	61
24000	3.5	951	94	92	87	85	82	79	77	73	86	86	80	76	73	71	66	63
24000	4.0	1008	95	93	88	86	83	80	78	74	87	88	81	77	74	72	68	65
24000	4.5	1060	96	94	89	87	84	81	78	75	88	89	82	78	75	73	69	66
24000	5.0	1109	97	95	90	88	85	81	79	76	89	90	83	79	76	74	70	67
28000	2.0	763	91	88	83	82	78	77	73	68	82	82	76	73	68	66	61	56
28000	2.5	839	92	90	85	84	80	77	75	70	84	84	78	75	71	68	63	59
28000	3.0	907	93	92	86	85	81	79	76	72	85	86	79	76	72	70	65	61
28000	3.5	969	95	93	88	86	83	80	78	73	86	87	80	77	74	72	67	63
28000	4.0	1028	96	94	89	87	84	81	79	75	87	88	81	78	75	73	68	65
28000	4.5	1082	97	95	90	88	85	82	80	76	88	89	82	79	76	74	69	66
32000	2.0	802	92	90	85	84	80	78	75	70	84	83	77	75	70	67	62	57
32000	2.5	858	93	91	85	85	81	79	76	71	84	85	78	76	71	69	64	59
32000	3.0	924	94	93	87	86	82	80	78	73	85	86	79	77	73	71	65	62
32000	3.5	988	95	94	88	87	84	81	79	74	86	87	80	78	74	72	67	63
32000	4.0	1046	96	95	89	88	85	82	80	75	88	89	81	79	76	73	68	65
32000	4.5	1100	97	96	90	89	86	83	81	76	89	90	83	80	77	75	70	66

“G” Development Sequence 90 – 130 Ton Supply Fan Data

Table 23-1

S_HG 90 Ton COMMERCIAL PACKAGED ROOFTOP																		
SX, SF, SE, SL, SS 90 Ton Supply Fan ---Sound Power Levels											With inlet guide vanes							
Discharge Lw, dB											Return Lw, dB							
CFM	TSP	RPM	63	125	250	500	1K	2K	4K	8K	63	125	250	500	1K	2K	4K	8K
27000	2.5	1024	85	85	85	83	79	74	66	59	79	79	78	71	66	64	63	53
27000	3.0	1084	86	85	87	84	81	74	68	60	79	79	80	73	67	65	63	53
27000	3.5	1143	87	85	89	85	82	76	69	62	80	80	81	74	69	66	64	54
27000	4.0	1201	88	86	90	86	83	77	70	63	81	80	83	75	70	67	64	55
27000	4.5	1259	89	87	91	88	83	78	71	64	81	81	84	76	71	68	64	56
27000	5.0	1317	90	88	92	89	85	79	73	66	82	82	85	77	72	69	65	56
27000	5.5	1374	92	88	94	90	86	79	74	67	83	83	86	78	72	70	65	57
27000	6.0	1430	93	89	95	91	87	80	75	68	84	84	87	78	73	70	66	58
27000	6.5	1484	95	90	97	92	88	81	76	69	85	85	88	79	74	71	66	59
37000	2.5	1201	86	86	91	89	84	78	71	64	79	80	83	76	71	68	64	54
37000	3.0	1249	87	87	92	89	85	79	72	65	80	80	84	77	71	68	64	54
37000	3.5	1296	88	87	93	90	86	79	73	66	80	81	85	78	72	69	65	55
37000	4.0	1342	88	87	93	91	86	79	74	67	81	81	86	78	73	70	65	56
37000	4.5	1386	89	88	94	91	87	80	74	67	82	82	86	79	73	70	65	56
37000	5.0	1430	89	88	95	92	88	80	75	68	82	82	87	79	74	71	66	57
37000	5.5	1474	89	88	97	92	89	81	76	69	83	83	88	80	74	71	66	57
37000	6.0	1517	90	89	98	93	89	82	77	70	84	84	89	80	75	71	66	58
37000	6.5	1560	91	89	99	94	90	82	77	70	85	84	90	81	75	72	67	58
45000	2.5	1359	88	88	95	93	89	81	76	68	81	81	86	80	74	71	65	55
45000	3.0	1402	88	88	96	93	89	81	76	69	81	82	87	80	74	71	66	56
45000	3.5	1444	89	89	97	94	90	82	77	69	82	82	88	81	75	72	66	56
45000	4.0	1485	89	89	98	94	90	82	78	70	83	83	89	81	75	72	66	57
45000	4.5	1524	89	89	99	95	91	83	78	71	83	83	89	82	76	72	67	58
45000	5.0	1563	89	90	100	95	91	83	79	71	84	84	90	82	76	73	67	58
45000	5.5	1601	89	90	101	96	92	84	79	72	85	84	91	83	77	73	67	59
45000	6.0	1638	90	90	103	96	92	84	80	72	85	85	92	83	77	73	68	59

Table 24-1

S_HG 90 Ton COMMERCIAL PACKAGED ROOFTOP																		
SX, SF, SE, SL, SS 90 Ton Supply Fan ---Sound Power Levels											Without inlet guide vanes							
Discharge Lw, dB											Return Lw, dB							
CFM	TSP	RPM	63	125	250	500	1K	2K	4K	8K	63	125	250	500	1K	2K	4K	8K
27000	2.5	992	87	83	83	81	78	72	66	59	79	78	77	70	64	63	63	52
27000	3.0	1053	88	83	85	83	78	73	68	61	79	79	79	71	65	64	64	53
27000	3.5	1111	89	84	86	83	79	73	69	62	80	79	80	72	66	65	64	54
27000	4.0	1167	89	85	88	84	81	74	70	63	80	80	82	73	68	66	65	55
27000	4.5	1223	90	86	89	85	82	75	71	65	81	81	83	74	69	67	65	55
27000	5.0	1277	91	87	90	86	83	76	72	66	82	82	84	75	70	68	66	56
27000	5.5	1330	93	88	91	87	83	77	73	67	83	83	86	77	71	69	66	57
27000	6.0	1382	94	89	93	88	84	78	74	68	84	84	87	78	72	69	67	58
27000	6.5	1434	95	90	94	89	85	79	75	69	84	85	88	79	73	70	67	59
37000	2.5	1156	89	86	89	86	82	74	70	63	80	80	82	73	68	65	64	54
37000	3.0	1204	89	86	90	87	83	75	71	64	80	81	83	74	69	66	65	54
37000	3.5	1253	90	86	91	88	83	76	72	65	81	81	84	75	69	67	65	55
37000	4.0	1300	90	87	92	88	84	77	73	66	81	82	85	76	70	68	65	56
37000	4.5	1343	91	87	92	89	85	78	73	67	82	82	86	76	71	68	66	56
37000	5.0	1386	92	88	93	89	85	78	74	68	82	83	87	77	72	69	66	57
37000	5.5	1431	92	88	94	90	86	79	75	69	83	83	87	78	73	69	66	58
37000	6.0	1475	93	89	95	91	87	79	76	70	83	84	88	79	73	70	66	59
37000	6.5	1517	94	90	96	91	88	80	76	71	84	84	89	79	74	70	67	59
45000	2.5	1302	90	88	93	90	86	78	73	67	81	82	85	76	71	68	65	56
45000	3.0	1348	91	88	94	91	87	79	74	68	82	82	86	77	72	68	66	56
45000	3.5	1390	91	89	95	91	87	79	75	69	82	83	87	78	72	69	66	57
45000	4.0	1430	92	89	95	92	88	79	75	69	82	83	88	78	73	69	66	58
45000	4.5	1470	92	89	96	92	88	80	76	70	83	84	88	79	73	70	66	58
45000	5.0	1509	93	90	97	93	89	80	76	71	83	84	89	79	74	70	66	59
45000	5.5	1549	93	90	98	93	90	81	77	72	84	85	90	80	75	70	66	59
45000	6.0	1587	94	90	99	94	90	81	78	72	84	85	91	80	75	71	67	60

Table 25-1

S_HG 105, 115, 130 Ton COMMERCIAL PACKAGED ROOFTOP																		
SX, SF, SE, SL, SS 105, 115, 130 Ton Supply Fan ---Sound Power Levels											With inlet guide vanes							
Discharge Lw, dB											Return Lw, dB							
CFM	TSP	RPM	63	125	250	500	1K	2K	4K	8K	63	125	250	500	1K	2K	4K	8K
31000	2.5	1091	86	85	88	85	81	76	68	61	79	79	80	73	68	65	63	53
31000	3.0	1145	87	86	89	86	83	77	69	62	79	79	82	74	69	66	63	54
31000	3.5	1197	87	86	90	87	84	77	70	63	80	80	83	75	70	67	64	54
31000	4.0	1249	88	86	91	88	85	78	71	64	80	80	84	76	71	68	64	55
31000	4.5	1300	89	87	92	89	85	79	72	65	81	81	85	77	72	69	65	56
31000	5.0	1352	90	87	93	90	86	80	73	66	82	82	86	78	72	69	65	56
31000	5.5	1402	91	88	94	90	86	80	74	67	83	82	87	78	73	70	65	57
31000	6.0	1453	91	89	96	91	87	81	75	68	84	83	88	79	74	71	66	58
31000	6.5	1503	92	89	97	92	88	81	76	69	85	84	89	80	74	71	66	58
39000	2.5	1239	87	87	92	90	85	79	72	65	80	80	84	77	71	69	64	54
39000	3.0	1286	87	87	93	90	86	80	73	66	80	80	85	78	72	69	65	55
39000	3.5	1332	88	87	94	91	87	80	74	67	81	81	86	78	73	70	65	55
39000	4.0	1376	88	88	94	91	87	81	75	67	81	81	86	79	73	70	65	56
39000	4.5	1419	89	88	95	92	88	81	75	68	82	82	87	79	74	71	66	56
39000	5.0	1461	90	88	96	93	89	81	76	69	83	83	88	80	74	71	66	57
39000	5.5	1503	90	89	98	93	89	82	77	70	83	83	89	80	75	72	66	58
39000	6.0	1544	91	89	99	94	90	82	77	70	84	84	90	81	75	72	67	58
39000	6.5	1585	91	90	100	95	91	83	78	71	85	85	91	81	76	72	67	59
46000	3.0	1422	89	89	96	94	90	82	77	69	82	82	87	81	75	71	66	56
46000	3.5	1463	89	89	97	94	90	82	78	70	82	82	88	81	75	72	66	57
46000	4.0	1504	89	89	98	95	91	83	78	70	83	83	89	82	76	72	67	57
46000	4.5	1543	90	89	100	95	91	83	79	71	84	84	90	82	76	73	67	58
46000	5.0	1581	90	90	101	96	92	84	79	72	84	84	91	83	77	73	67	58
46000	5.5	1618	90	90	102	96	92	84	80	72	85	85	92	83	77	73	68	59
46000	6.0	1655	91	91	103	97	93	84	80	73	86	85	93	83	77	73	68	59

Table 26-1

S_HG 105, 115, 130 Ton COMMERCIAL PACKAGED ROOFTOP																		
SX, SF, SE, SL, SS 105, 115, 130 Ton Supply Fan ---Sound Power Levels											Without inlet guide vanes							
Discharge Lw, dB											Return Lw, dB							
CFM	TSP	RPM	63	125	250	500	1K	2K	4K	8K	63	125	250	500	1K	2K	4K	8K
31000	2.5	1054	87	84	86	84	80	74	68	61	79	79	79	71	66	64	64	53
31000	3.0	1109	88	85	87	85	81	75	69	62	80	79	80	72	67	65	64	53
31000	3.5	1160	89	85	88	85	81	75	70	63	80	80	82	73	67	66	65	54
31000	4.0	1213	90	85	89	86	82	76	71	65	81	81	83	74	68	67	65	55
31000	4.5	1265	91	86	90	87	83	77	72	66	81	81	84	75	69	67	65	56
31000	5.0	1314	91	87	91	87	84	77	73	67	82	82	85	76	70	68	66	56
31000	5.5	1362	92	88	92	88	85	77	73	68	82	83	86	77	71	69	66	57
31000	6.0	1410	93	89	93	89	85	78	74	69	83	83	87	78	72	69	67	58
31000	6.5	1457	94	89	94	90	86	79	75	70	84	84	88	78	73	70	67	59
39000	2.5	1192	90	87	90	87	84	76	71	64	80	81	83	74	69	66	65	54
39000	3.0	1239	90	87	91	88	84	77	72	65	81	81	84	75	69	67	65	55
39000	3.5	1284	91	87	92	89	85	77	72	66	81	81	85	76	70	67	65	55
39000	4.0	1330	91	87	92	89	85	78	73	67	81	82	85	76	71	68	66	56
39000	4.5	1374	91	88	93	90	86	78	74	68	82	82	86	77	72	69	66	57
39000	5.0	1416	92	88	94	90	86	79	75	69	82	83	87	78	72	69	66	57
39000	5.5	1456	92	89	95	91	87	80	75	70	83	83	88	78	73	70	66	58
39000	6.0	1499	93	89	96	91	88	80	76	71	83	84	89	79	74	70	66	59
39000	6.5	1541	94	90	97	92	88	81	77	71	84	85	90	80	74	71	67	60
46000	3.0	1366	91	89	94	91	87	79	74	68	82	82	86	77	72	68	66	57
46000	3.5	1408	92	89	95	92	88	80	75	69	82	83	87	78	72	69	66	57
46000	4.0	1448	92	89	96	92	88	81	76	70	83	83	88	79	73	69	66	58
46000	4.5	1487	93	89	97	93	89	81	76	70	83	84	89	79	74	70	66	58
46000	5.0	1525	93	90	98	93	89	81	77	71	84	84	90	80	74	70	66	59
46000	5.5	1564	94	90	99	94	90	81	77	72	84	85	91	80	75	71	66	60
46000	6.0	1602	94	91	100	94	90	82	78	73	85	85	91	81	76	71	67	60

Exhaust Fan Sound Data

Table 27-1

S_HF 20 & 25 Ton										
COMMERCIAL PACKAGED ROOFTOP										
All 20 & 25 Ton Exhaust Fan --- Sound Power Levels with & without inlet guide vanes										
CFM	TSP	RPM	63	125	250	500	1000	2000	4000	8000
4000	0.50	538	71	68	65	60	57	50	47	43
4000	1.00	730	74	72	70	66	63	59	56	51
4000	1.50	882	76	75	73	69	67	65	62	56
6000	0.50	570	71	69	67	63	59	53	49	45
6000	1.00	765	74	73	72	68	66	61	58	53
6000	1.50	912	76	76	75	71	69	67	64	58
8000	0.50	619	72	70	69	65	62	56	53	48
8000	1.00	797	74	74	73	70	67	63	61	55
8000	1.50	947	77	77	76	74	71	68	66	60
10000	0.50	712	73	73	72	69	66	61	58	53
10000	1.00	837	75	75	74	72	69	65	63	57
10000	1.25	911	76	77	76	73	71	68	65	60

Table 28-1

S_HF 30 Ton										
COMMERCIAL PACKAGED ROOFTOP										
30 Ton Exhaust Fan --- Sound Power Levels with & without inlet guide vanes										
CFM	TSP	RPM	63	125	250	500	1000	2000	4000	8000
6000	0.50	570	71	69	67	63	59	53	49	45
6000	1.00	765	74	73	72	68	66	61	58	53
6000	1.75	975	78	78	76	73	71	69	66	60
8000	0.50	619	72	70	69	65	62	56	53	48
8000	1.00	797	74	74	73	70	67	63	61	55
8000	1.75	1013	78	79	78	75	73	70	68	62
10000	0.50	712	73	73	72	69	66	61	58	53
10000	1.00	837	75	75	74	72	69	65	63	57
10000	1.75	1045	79	79	79	77	75	72	69	63
12000	0.50	806	74	75	74	72	69	66	63	58
12000	1.00	905	75	77	76	74	71	69	66	60
12000	1.25	956	76	78	77	75	73	70	67	62

Table 29-1

S_HF 40, 50, 55 Ton										
COMMERCIAL PACKAGED ROOFTOP										
All 40, 50, 55 Ton Exhaust Fan --- Sound Power Levels with & without inlet guide vanes										
CFM	TSP	RPM	63	125	250	500	1000	2000	4000	8000
9000	0.50	499	76	72	69	67	63	56	52	48
9000	1.00	618	78	75	73	71	68	62	58	54
9000	1.75	812	80	80	78	76	73	70	67	62
12000	0.50	496	75	72	70	68	64	56	53	49
12000	1.00	628	78	76	74	72	69	63	60	55
12000	1.75	817	80	80	79	77	74	71	68	63
15000	0.50	567	76	75	73	71	68	61	58	54
15000	1.00	667	78	77	76	74	71	65	62	58
15000	1.75	824	80	80	79	78	75	71	69	63
18000	0.50	642	78	77	75	74	71	66	63	58
18000	1.00	724	79	79	77	76	73	68	66	61
18000	1.75	856	80	81	80	79	77	73	70	65

Table 30-1

S_HF 60, 70, 75 Ton										
COMMERCIAL PACKAGED ROOFTOP										
All 60, 70, 75 Ton Exhaust Fan --- Sound Power Levels with & without inlet guide vanes										
CFM	TSP	RPM	63	125	250	500	1000	2000	4000	8000
12000	0.50	423	73	71	66	63	59	57	54	48
12000	1.00	572	79	78	73	71	67	65	62	56
12000	1.75	740	84	83	79	77	74	71	68	62
18000	0.50	516	78	77	72	70	66	64	62	56
18000	1.00	607	81	80	75	73	69	67	64	58
18000	1.75	766	85	85	80	78	75	72	69	63
21000	0.50	578	81	80	75	73	70	68	65	60
21000	1.00	647	82	82	77	75	71	69	66	60
21000	1.75	781	86	85	81	78	75	73	70	64
27000	0.50	711	86	86	81	79	76	74	72	67
27000	1.00	761	86	86	81	79	76	74	71	66
27000	1.75	844	88	88	83	80	77	75	72	67

Table 31-1

S_HG 90 Ton

COMMERCIAL PACKAGED ROOFTOP										
SX, SF, SE, SL, SS 90 Ton Exhaust Fan --- Sound Power Levels										
With & without inlet guide vanes										
CFM	SP	RPM	63	125	250	500	1000	2000	4000	8000
27,900	0.25	520	83	81	78	76	74	76	73	66
	0.75	580	84	81	78	77	75	74	70	64
	1.50	690	87	84	81	80	78	75	70	64
	2.50	800	91	87	83	82	81	78	73	67
35,100	0.25	630	88	86	83	83	81	80	776	68
	0.75	690	88	86	83	83	81	78	74	66
	1.50	770	91	87	84	84	83	79	74	67
	2.50	880	94	90	86	86	85	81	76	69
41,400	0.25	745	93	90	88	88	86	85	81	72
	0.75	780	92	89	87	87	85	82	78	70
	1.50	860	94	90	88	88	87	83	78	71
	2.50	950	96	92	89	90	88	83	77	70

Table 32-1

S_HG 105, 115, & 130 Ton

COMMERCIAL PACKAGED ROOFTOP										
SX, SF, SE, SL, SS 105, 115, & 130 Ton Exhaust Fan --- Sound Power Levels										
With & without inlet guide vanes										
CFM	SP	RPM	63	125	250	500	1000	2000	4000	8000
24,300	0.25	460	80	78	74	72	70	73	71	65
	0.75	540	82	79	76	74	72	72	69	63
	1.50	650	85	82	78	77	75	73	69	63
	2.50	800	90	86	82	81	80	78	73	67
33,300	0.25	610	87	85	82	81	79	79	76	68
	0.75	660	87	85	82	81	79	77	72	65
	1.50	750	90	86	83	83	81	78	73	66
	2.50	865	93	89	86	85	84	81	76	69
40,500	0.25	730	92	89	87	88	86	84	80	72
	0.75	770	92	89	86	87	85	82	77	70
	1.50	845	94	90	87	87	86	83	78	70
	2.50	940	96	91	89	89	88	83	77	70

Exhaust fan sound power levels at exhaust fan inlet (dB).

Supply fan not operating.

Exhaust fan airflow equals 90% of rated supply fan airflow.

SP is the static pressure that the exhaust fan works against (I.e. return duct static pressure).

Suggested Reference Materials

1. ASHRAE. 1991. Schaffer, Mark E. “**A Practical Guide to Noise Vibration Control for HVAC Systems**”. Atlanta, GA: American Society of Air-Conditioning Engineers, Inc. (Revised every four years)
2. ASHRAE. 1999. “**ASHRAE Handbook-1999 HVAC Applications**”, chapter 46. Atlanta, GA: American Society of Air-Conditioning Engineers, Inc.
3. ASHRAE. 2001. “**ASHRAE Handbook-2001 Fundamentals**”, chapter 7. Atlanta, GA: American Society of Air-Conditioning Engineers, Inc.
4. ASHRAE. Paper **NY 91-3-3** or **ASHRAE Transactions**, 1991, Vol. 97, Part 1, “**Sound and Vibration Considerations in Rooftop Installations**”, R.G. Harold, P.E. (Copies available)
5. From Trane Commercial Unitary Systems Product, Planning and Support Group, Clarksville, TN.
6. Harris, Cyril M. 1979. “**Handbook of Noise Control**”, New York, NY: McGraw-Hill Book Co.
7. Jones, Robert S. 1984. “**Noise and Vibration Control in Buildings**”, New York, NY: McGraw Hill Book Company
8. Trane 1986 “Acoustics in Air Conditioning. Application Manual FND-AM-5. La Crosse, WI



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