a. Make sure there is no solid connection between the machine and the structure (hold-down bolts, brackets, pipes, ducts and conduit connections).
b. Make sure the flexible mounts are free and have not failed.
c. Make sure there is an acoustical pad or grommet between spring mounts and the base, and that the material has not hardened or become brittle.
d. Make sure the mounts provide horizontal as well as vertical flexibility.
e. Make sure that pipes and ducts are isolated from the structure.
f. Make sure drives are properly aligned and shafts are not bent.
g. Make sure there are no loose and rattling parts (gage lines, covers, bearings).
h. If possible, change the speed by about ± 10 percent. If resonance is involved, such a small change can make a big difference.

5. Sometimes fans are found to be poorly matched for the system. If a belt-driven fan delivers air at a higher static pressure that is needed to move the design air quantity through the system, the fan speed should be reduced by changing sheaves. If the fan does not deliver enough air, an increase in fan speed should be considered only after checking the duct system for avoidable losses. Turbulence in the air approach to the fan inlet will not only increase the fan sound generation, but also decrease its air capacity. Other parts that may cause excessive turbulence are duct bends, sudden enlargements or contractions of the duct, and dampers.

When investigating fan noise, assistance can usually be obtained from the supplier or manufacturer of the fan.

6. If the conclusion is reached that additional acoustical treatment is to be installed in the ductwork, a frequency breakdown must be obtained so that the design procedure described in Step 4 can be carried out. This involves the use of an octave band analyzer and should generally be left to a trained acoustician.

## Use and Care of Sound Measuring Instruments

For practical reasons, instrumentation that can be carried on a field trip has to be limited to the bare essentials, usually a sound level meter, or a sound survey meter. To get the most out of this limited equipment, its capabilities must be understood.[24] A sound level meter[25] gives only a single number reading, which cannot fully describe a sound. However, when used with the A-weighting network, which simulates ear response, this single number reading can be very useful.[26]

The B-network of the sound level meter is normally not used in air-conditioning work. The flat response C-network is used only when making an analysis by frequency.

Instruments for measuring and analyzing sound are rather complex as compared to other instruments commonly used in air-conditioning work. Errors in the instruments and in their use are, therefore, more likely and harder to detect.[27] The instructions coming with the instruments should be followed carefully and readings should be repeated as a doublecheck. The calibration of the instrument should be checked at least once a day. For this purpose, an acoustical calibrator is preferred, because it will also check out the microphone. This is important, because most microphones are very easily damaged without giving any external indication of such damage. In particular, temperatures above 110 F will ruin the more common types of microphones. The 110 F limit can easily be exceeded when the instrument is left in a car on a hot summer day. The basic sound measuring system, therefore, should consist of a sound level or sound survey meter, together with an acoustical calibrator. The latter consists of a pocket size oscillator and a small loudspeaker fitting over the microphone.

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(*Continued on p. 222*)



Date ____________
Name ____________

### ASHRAE SOUND CONTROL WORK SHEET

(Based on ASHRAE Guide And Data Book, 1965; Chapter 14)

Line
1 Project: ____________ Architect: ____________
2 Address: ____________ Mechanical Engineer: ____________
3 Supply/Return System No. ______ Floor No. ______ Room No. ______
4 FAN (Make, Size, Type): ____________ RPM: ______
5 SP: 1.5 in., CFM: 6000, BHP: 2, Stat. Eff. = 1.57 × CFM/10,000 × SP/BHP × 100 = 70
6 ROOM TERMINALS (Diffusers, Grilles, Induction Units, etc.) (Make, Size, Type): ____________ No. ______
7 CFM, Each Terminal 300, Terminal cfm/Fan cfm × 100 = 5 %

10 STEP #1: DETERMINE DESIGN GOAL
11 Type of Area (See Table 4): CONFERENCE ROOM
12 Acceptable NC-Level (from Architect or Table 4): 30

20 STEP #2: CALCULATE PERMISSIBLE SOUND POWER LEVEL AND SELECT ROOM TERMINALS
21 Terminals: Number 4; Installed Height: 10 ft; Min. Distance from Listener (Fig. 4), $r = \sqrt{9 + 36} = 6.7$ ft.
22 Room Dimensions: ___ ft × ___ ft = 1000 sq ft Floor Area, 10 ft Ceiling Height
23 Room Construction; Heavy/Medium/Light Panels. Room Surfaces: Hard/Average/Soft (Table 7)

| Line | Item | Reference | Octave Band Center, cps 106 125 | 212 250 | 425 500 | 850 1000 | 1700 2000 | 3400 4000 | 6900 8000 |
|---|---|---|---|---|---|---|---|---|---|
| 24 | Room Effect, $L_W - L_p$, db (Based on Floor Area (Line 22) or Distance (Line 21), whichever gives lower value). | Figure 6 | 10 | 11 | 11 | 11 | 12 | 12 | 13 |
| 25 | Sound Pressure Level for NC 30 | Figure 2 | 51 | 43 | 37 | 32 | 30 | 28 | 27 |
| 26 | Total Permissible Sound Power Level | Line 24 + Line 25 | 61 | 54 | 48 | 43 | 42 | 40 | 40 |
| 27 | Allowance for 4 Terminals | Table 8 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| 28 | Permissible Sound Power Level per Terminal | Line 26 − Line 27 | 55 | 48 | 42 | 37 | 36 | 34 | 34 |
| 29 | Ratings of Terminal(s) selected | Manufacturer | | | | | | | |

NOTE: This shortcut method assumes equal and evenly distributed terminals and gives values of permissible sound power level which are generally on the safe side. In critical cases, the actual sound pressure level at any point due to each source can be found by using Figs. 5 and 8 and totalled by using Table 2.

30 STEP #3: CALCULATE DUCT ATTENUATION REQUIRED TO REDUCE FAN AND FITTING NOISE

| Line | Item | Reference | Octave Band Center, cps 106 125 | 212 250 | 425 500 | 850 1000 | 1700 2000 | 3400 4000 | 6900 8000 |
|---|---|---|---|---|---|---|---|---|---|
| 31 | Sound Power Output of: Fan | From Ex. 3 | 89 | 89 | 79 | 74 | 69 | 64 | 59 |
| 32 | Power Divisions to Terminal, 5 % Area | Table 11 or 12 | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| 33 | Natural Attenuation, 24 × 36 in. Duct, 20 ft long | Table 13 × Length | 4 | 2 | 1 | 1 | 1 | 1 | 1 |
| 34 | Attenuation of 36 in. Elbow, with/~~without~~ Vanes | Tables 14 and 15 | 2 | 4 | 4 | 3 | 3 | 3 | 3 |
| 35 | Elbow Attenuation of 18 in. Take-Off, with/~~without~~ Vanes | Tables 14 and 15 | 0 | 2 | 5 | 3 | 3 | 3 | 3 |
| 36 | Natural Attenuation, 12 × 18 in. Duct, 20 ft long | Table 13 × Length | 4 | 3 | 2 | 2 | 2 | 2 | 2 |
| 37 | Attenuation of __ in. Elbow with/without Vanes | | | | | | | | |
| 38 | Attenuation of: | Table 13 × Length | | | | | | | |
| 39 | End Reflection for Size 12 × 18 in. Q-4 | Figure 13 | 5 | 1 | 0 | 0 | 0 | 0 | 0 |
| 40 | Total Natural Attenuation in Branch | Sum of Lines 32 to 39 | 28 | 25 | 25 | 22 | 22 | 22 | 22 |
| 41 | Sound Power Level per Terminal without Sound Treatment | Line 31 Minus Line 40 | 61 | 64 | 54 | 52 | 47 | 42 | 37 |
| 42 | Permissible Sound Power Level per Terminal, Allowing 3 db for Return Duct | Line 28 of Step 2, Minus 3 db | 52 | 45 | 39 | 34 | 33 | 31 | 31 |
| 43 | Min. Attenuation of Sound Treatment to be designed for 12 × 18 in. Duct | Line 41 Minus Line 42 | 9 | 19 | 15 | 18 | 14 | 11 | 6 |

* NOTE: Calculated attenuation required (Line 43) for each significant sound source (Fan, fittings, etc.) separately, and add up per Table 2.