

NOISE & VIBRATION DESIGN GUIDANCE

HVAC

(Prepared by Noise Control Engineering, Billerica, MA)

INTRODUCTION

This note lists simple design rules in order to keep HVAC systems quiet. Analytical tools are available to predict HVAC noise, but following the rules below are a good first step toward a quiet system. HVAC noise in an accommodation compartment should be a minimum 3 dB below the any specified noise criteria¹. In general, noise from HVAC in machinery spaces is generally not a concern, because the ambient machinery noise levels are higher than those created by noisy HVAC equipment. Additional recommendations and detail design guidance are given in reference [1 & 2].

Noise generation in HVAC system occurs from four basic sources:

- Fans and Blowers
- Flow through Branches
- Flow through Turns
- Flow through Diffusers

Noise from these sources can be transmitted to compartments either down stream or up-stream of the air flow. For example in an exhaust air system noise from a fan can be transmitted against the air flow to a compartment. Noise is also transmitted into or out of a compartment by exposed ducts. This is called break-out and break-in noise. There are many general design rules that can minimize noise generated by HVAC systems.

A summary of the general rules are listed below:

1. Air flow velocities should be kept as low as possible. A target should be velocities no higher than 1,000 ft/min., and never exceed 3,000 ft/min.
2. Fan inlet air flow should be straight for at least 3 duct diameters. Turns closer than 3 diameters cause air flow turbulence which increases noise.
3. The fan discharge should be straight for a distance of at least three major duct widths to avoid turbulence. Noise will significantly increase due to turbulence from elbows too close to the discharge (or inlet).
4. Five to ten diameters of straight duct is required for turbulence to die out and flow to equalize. If the air flow does not become smooth before the next fitting or terminal device, the flow noise generated in the next element will increase.
5. Design the HVAC system so that fans operate near peak efficiency. Fans that do not operate near peak efficiency will have higher noise levels than fans operating at peak efficiency.
6. All ventilation fans should be resiliently mounted and all connections to the fan, including ducting and electrical cables, should be flexible and at least as effective as the vibration isolators.

¹ Limiting HVAC and machinery to levels 3 dB below the limit result in a noise level at the limit when combined together.

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7. If possible, fans should not be attached to bulkheads, decks and overheads that form the boundaries of noise sensitive spaces.
8. Square turns, mitered elbows and zero radius elbows should generally be avoided. Transforming sections should be symmetrical. Avoid using abrupt changes in cross-section or duct turns. Noise increases when expansion in a transition section exceeds a 7° angle from the straight ahead.
9. Where possible, use circular ducts instead of rectangular ducts. Circular ducts are more effective in preventing “breakout noise” from the duct walls than are rectangular ducts. In addition circular ducts attenuate noise moving down the duct better than rectangular ducts. Finally, low frequency rumble caused by turbulence, is less likely to occur in circular ducts than in square ducts because circular ducts are usually more rigid.
10. To avoid cross-talk between rooms served by the same duct system, provide offsets and 90° lined turns.
11. The use of vane turns is advised when the turn is within five duct diameters of a fan. If the bend is more than five diameters from the fan, regular elbows with ample radii should be used as they cause less pressure drop in the flow.
12. The area of the duct that engages a fan should be at least equal to , if not greater than the active area of the fan. Also, fan intakes should be kept symmetrical with respect to the fan.
13. Acoustically treated plenums should be used to reduce noise created by the flow, especially when outlet ports are rear fans or other noise sources. The plenums should be designed so that the inlet and outlet ports do not line-up. Also, the plenum should be made as large as possible.
14. The inside of the ducts should be as smooth as possible to avoid turbulent flow. Seams should be faired and protruding objects avoided. Improperly fitted gaskets and flax couplings should be avoided as well. Leading edges of dampers, splitters and deflectors should be rounded or folded back.
15. When using vaned or un-vaned elbows use the following straight length of duct preceding the fitting.

Turn Size (Degrees)	Diameters of Straight Duct
30	2
45	3
60	4
90	5

16. To eliminate sources of noise, adjustable splitters should be avoided. Orifices are preferred for balancing of systems. Splitters, if used, should be designed to be permanently and rigidly fixed in position after the systems are balanced.

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17. External lagging used as an acoustic treatment is not in general satisfactory. Fiberglass, held on with foil or canvas is much more effective.
18. Rat guards on flexible couplings should not bridge the flexible coupling. The guard should be rigidly attached to only one end of the ductwork.
19. Noise from HVAC systems should be designed to be at least 5 dB below the compartment noise specification so that when combined with other noise sources the noise specification is not exceeded.

REFERENCES

1. SNAME T&R Bulletin No. 3-37, "Design Guide for Shipboard Airborne Noise Control", 1983.
2. BBN Report "Practical Guide for Noise Analysis and Noise Control Design for Shipboard HVAC Systems", Report No. 7970, November 1994.

See also Noise-93, Vol. 3, How In-Duct Silencing Can Be Changed to Better Match the Acoustic and Aerodynamic Needs of HVAC Systems." Pages 217-222, C.R. Vanderburgh.