NOISE MINIMISATION BY CORRECT FAN SELECTION

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1.0 Introduction.

1.1 The commercial environment of the 1990's demands that optimum utilisation of capital plant is made, Fans are no exception to this rule being one of the most common complete machines supplied to industry. The basis of fan selection is a combination of many user defined factors. A typical cross section of these requirements are Prime cost, Fan efficiency and energy costs, Noise, Space limitations, Availability, Serviceability and Fan type.

1.2 There is no fixed or constant parameter for fan specification and manufacturers as well as users realise that no one fan type will be ideal for all applications. For example in the case of property development a speculative developer may be looking for minimum cost at a reasonable specification, while a user developer still requiring cost effectiveness, may be driven by high specification, long life and quality to a greater extent.

1.3 This paper examines briefly the types of fan available and identifies the generalised noise characteristics. The importance of the reference test standards and fan installation codes is identified. The correct use of catalogue information is detailed in relation to installation and guidance is made indicating the potential shortfalls of information identified and its use.

2.0 Fan types and performance characteristics.

2.1 There are a number of well defined fan types used in air movement, these are restated in Fig 1 the generalised noise characteristics are evaluated below. All fan noise levels will vary with operating speed.

2.2 Axial Flow Fans.
Noise output is dependent upon installation code and blade angle. For higher stalling pitch angles fans exhibit a flat overall noise characteristic from zero pressure towards the stall region with minimum noise at the peak efficiency point. Fans are not generally offered in the unstable stall region which exhibits an increase in overall noise levels. The frequency distribution generally shows a peak at blade passage frequency falling between 3-6 dB per octave above and below the peak. Performance at non stalling angles shows a greater change from zero to peak pressure with a flatter spectrum distribution.

2.3 Radial/Centrifugal Fans.
Noise output will be dependent upon the installation code. Noise output tends to be minimum at the peak efficiency point. On both forward and Backward curve fans the frequency spectrum will peak at low frequencies showing a falling spectrum distribution between 3-6 dB per octave from the peak. Care must be taken to select fans on the stable part of the operating characteristic to avoid rotating stall which results in high levels of low frequency noise.

2.4 Mixed Flow Fans.
Noise output will be dependent upon installation code. Noise will be minimum at the peak efficiency point. The frequency distribution is very flat with low levels of low frequency noise these fans tend to be stable over the complete characteristic.

3. Fan selection.

3.1 When selecting fans a number of physical limitations and project specifications will influence the type of fan unit selected in addition to any limitation imposed by the basic duty requirements. Factors such as those listed are common,

- Quality requirements such as BS 5750:Pt1(ISO 9000) capability.
- Type of fan, Axial, Centrifugal for example.
- Size of fan, for limitations in space.
- Noise level and characteristic shape.
- Availability of system noise attenuation and treatment.
- Speed control requirements.
- Operating efficiency.
- Reliability and serviceability.
- Delivery time and Prime cost.

3.2 Figure (2) shows a comparison of fan duties at a common power input (the mixed flow fan is not included) showing the degree of overlap that is available to the fan selector clearly indicating the range of potential choices available.

4. Fan installation Codes and Test specifications.

4.1 During the past 20 years there has been a growing international realisation of the need to obtain test data for fans installed in a number of different mounting arrangements, normally called 'Installation Code's. The codes are described below and shown in Fig 3. Most existing test standards allowed testing to the different installation codes but did not make a point of the need to test to all possible for a given product. Many manufacturers such as Woods have always tested the products to the most relevant test standards available.

Code A. Performance of a fan only arrangement with no attached ductwork.
Code B. Performance of a fan ducted on the discharge side only with an open inlet.
Code C. Performance of a fan ducted to the inlet side only with no discharge ducting.
Code D. Performance of a fan ducted to both inlet and outlet.

5. Use of Catalogue Information.

5.1 When considering the 4 basic installation types it is correct to assume that a number of different base noise levels will apply to any one fan assembly. One of the installation codes will be a "best fit" to the users requirements. The additional installation codes has led to a vast increase in amount of information acquired during product qualification.

In many cases information will be provided on a single page that enables the calculation of performance for all installation codes, this degree of data needs careful examination and selection by the user. In critical installations confirmation of selection is advisable with the fan manufacturer.

5.2 Recent work (5) has indicated that control of manufacturing processes and product quality have important influence in the control of noise from a product range particularly the similarity between catalogue performances and that of the standard manufactured product. Capability to show compliance with the requirements of BS 5750:Pt1 will provide additional confidence to the user.

6. Potential Problems

6.1 The fan test codes of all types BS, DIN, AMCA for example all use controlled test conditions as the basis for determination of fan performance. The users of fans are often subjected to far less favourable installed conditions. In this environment the selection of the right fan type becomes ever more critical. Many conferences in recent years have centred attention on the effect of installation on fan performance recognising the need to inform fan users of the variation, in all aspects, of performance that can occur. The most common influencing factors being;

Rapid area changes up and downstream of fans
Obstructions in airways
Bends on inlet and outlet
Fan/duct mis-alignment.

These are just a few of the considerations, also illustrated in Fig 4, which are more extensively covered in the HEVAC (3) and ASHRAE (4) publications that act as a positive guide to fan users.

7. Conclusion

7.1 The correct selection of fans to suit an application is a detailed and difficult process. To achieve good selection a number of conflicting parameters will decide the type of fan to be used. For extreme duties there may be no choice in the type of fan to be used, however there will be a choice between manufacturers. Users should always employ reputable manufacturers capable of evaluating the products made, to the requirements of the international test codes.

7.2 The recognition by the fan industry of the 4 types of installation has resulted in catalogue information that allows the experienced user to select the most appropriate fan for his requirements, more information is available on product ranges than ever before allowing a correctly engineered solution to fan selection.

7.3 The growth in quality control amongst fan manufacturers, such as Woods which manufacture Axial, Radial and Mixed flow fans, has resulted in tighter control of product manufacture and close adherence to tested catalogue performances required under the control measures of BS5750:Pt1 and AQAP 1. In addition to this certified performance schemes have been instigated such as the BSI assessed, `CAME scheme´ to ensure that catalogue information is certified independently before publication, this gives users greater confidence in the data published.

7.4 The greatest barrier to low noise levels from fans is often the limitations imposed by poor installation which can often eliminate gains available by careful fan selection. The guidelines set out in the industry texts will enable optimum installed noise levels, but careful consideration of the design of any fan system using the identified `good practise´, ref. (1), (2),(3) & (4), criteria will ensure the lowest possible noise levels will be achieved .

7.5 For difficult installations users should always make use of the technical support activities offered by the reputable fan manufacturers when fan selections are critical or installation factors are not clearly understood.

References

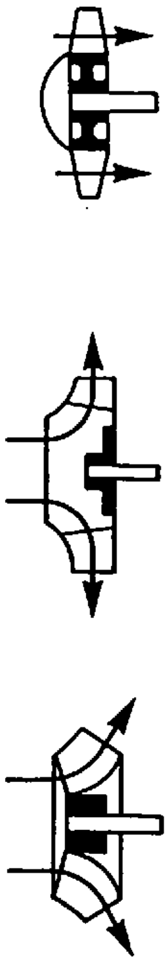
(1) Woods Practical Guide to Noise Control, Woods of Colchester Ltd
(2) Woods Practical Guide to Fan Engineering, Woods of Colchester Ltd
(3) Guide to Fan Noise and Vibration, HEVAC 1984.
(4) A Practical Guide to Noise & Vibration Control, Mark E Schaffer, ASHRAE
(5) Control of tonal noise generation in Axial flow fans by optimisation of fixed and rotating components, P J Hunnaball, International Fan noise conference, Senlis, France, 1992.

7.5.1 Axial flow. In a pure axial fan the effective progress of the air is straight through the impeller at a constant distance from the axis. The primary component of blade force on the air is directed axially from inlet to outlet, and thus provides the pressure rise by a process that may be called direct *blade action*. The blade force necessarily has an additional component in the tangential direction, providing the reaction to the driving torque: this sets the air spinning about the axis independently of its forward motion.

7.5.2 Radial flow. In a pure centrifugal fan the air enters the impeller axially, turns through 90°, and progresses radially outwards through the blading. The blade force is mainly tangential, causing the air to spin with the blades. The *centrifugal force* resulting from the spin is now in line with the outward progress of the air and is the main cause of the rise of pressure. There may or may not be an outward blade force component adding pressure by blade action.

7.5.3 Mixed flow. In a mixed flow fan the air enters axially, and turns outwards through an angle which may range from 30° to 90°. An essential feature is that the impeller blading extends over the curved part of the flow path. In this region the blade force has a component in the direction of the arrow on the diagram as well as a tangential component and the pressure rise is developed partly by blade action and partly by centrifugal action.

FIG 1 - FAN TYPES, ref(2)



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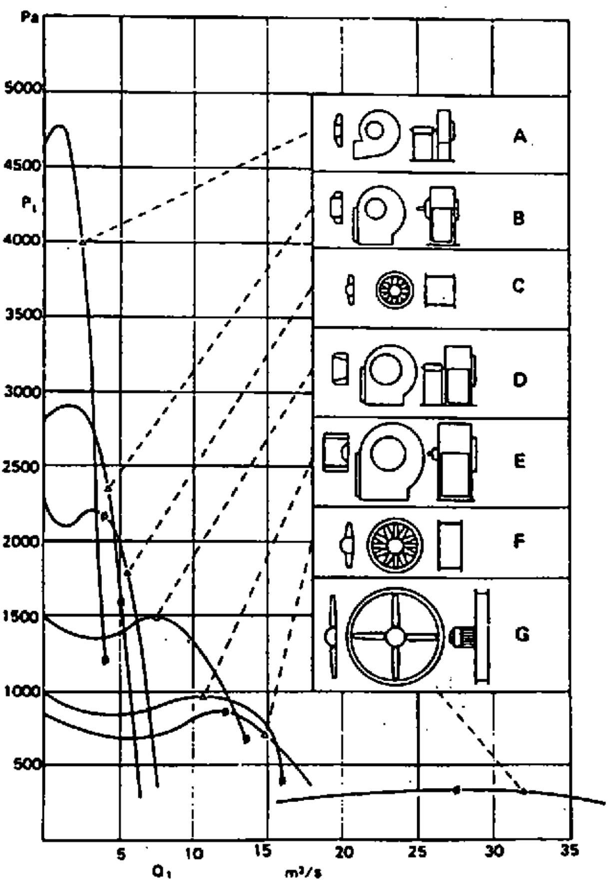
COMPARISON OF TYPES OF FAN

FIG 2 - COMPARISON OF FAN TYPES

Below are performance curves for various types of fans, all at similar power requirements. Note that the fan sketches indicate relevant physical sizes of fans.



Each fan, operating at top speed and best efficiency point Δ is chosen for an output $Q \cdot P_t = 10$ kW.

Peak input power is taken at Ø

Drawings are to a uniform scale of 1 : 120

A Backward-curved Half-width 630mm 42 rev/s 13.5 kW at 17 kW at Ø

B Backward-curved Full-width 630mm 36 rev/s 12 kW at 14 kW at Ø

C Axial 50% hub 630mm 48 rev/s 13.5 kW at 15 kW at Ø

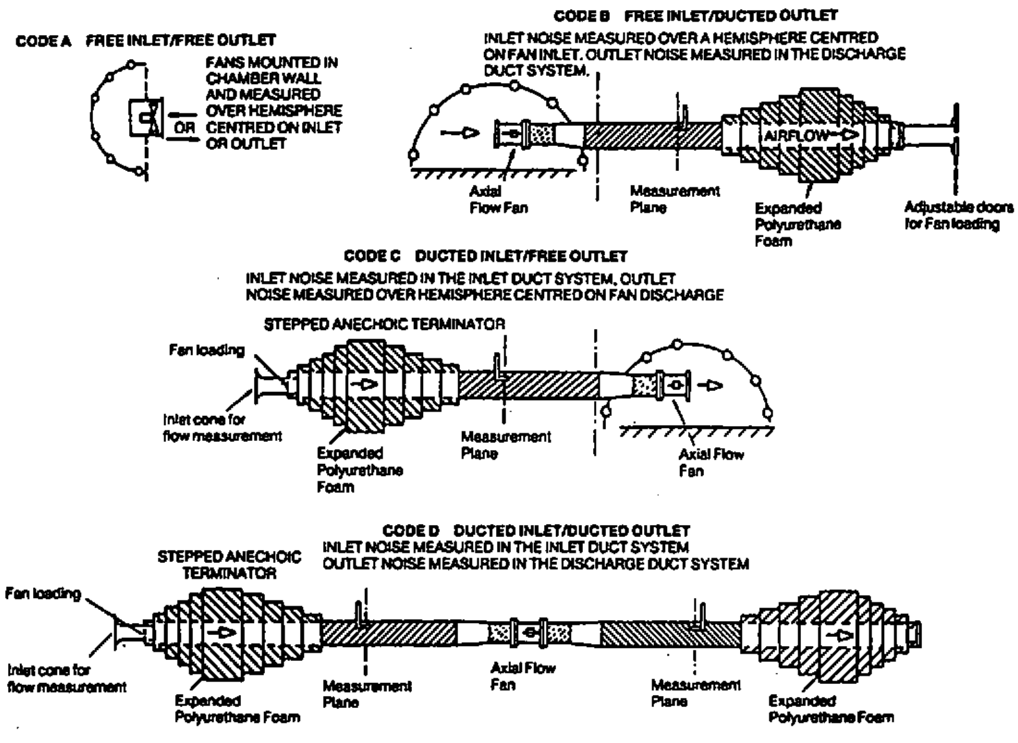
D Forward-curved centrifugal 700mm 18 rev/s 15 kW at 30 kW at Ø

E Multi-vane centrifugal 850mm 9 rev/s 15 kW at 30 kW at Ø

F Axial 35% hub 1000mm 24 rev/s 13 kW at 30 kW at Ø

G Axial 25% hub 2000mm 12 rev/s 12.5 kW at 14 kW at Ø

510



Arrangement of Test Ducting for Measurement of In-duct and Free Field Sound Power Levels

FIG 3 - INSTALLATION CODES

FIG 4 - NOISE MECHANISMS, ref (2)

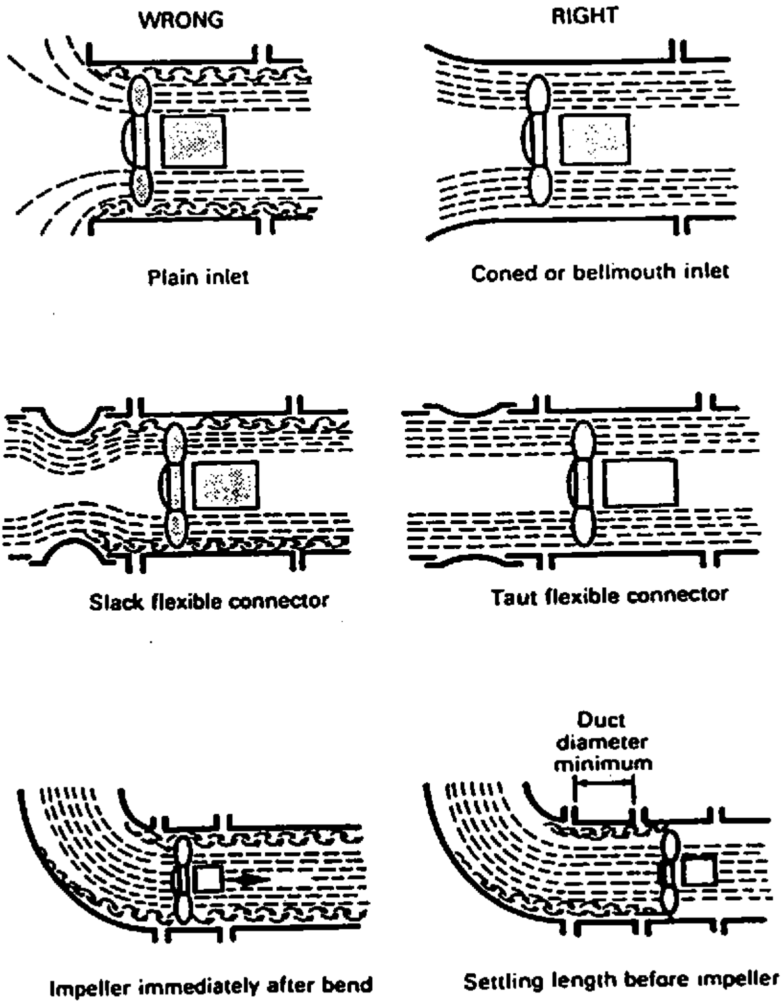


Fig. 10.2 Examples of noise generating installations.