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FURNACE SOUND POWER LEVEL

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Measurement of the sound power levels of furnaces is fraught with difficulty. There is a number of noise sounds to consider, depending upon the type of furnace.

Burners generate broad band noise, generally in the mid to high frequency range, as a result of air flow into the furnace and combustion noise radiating out through the burner air inlets. This results in turbulence generated in the registers. Burners also transmit combustion noise from the inside of the furnace. Some types of burner atomise their fuel by means of rotary devices which can result in periodic oscillations.

Fuel flow to burners can radiate significant flow noise from piping and control valves. The type of fuel burned can have a marked effect on the noise radiated. This is noticeable in dual fuel furnaces.

Burner emitted noise can be reduced by fitting plenum chambers with silencers at their inlets. In this way the sound power radiated from the air inlet can easily be made negligible by comparison with that from the remainder of the furnace. To achieve the ultimate performance from a plenum chamber it should not be structurally connected to the burner. An alternative technique for suppression of burner noise is to install a forced draught system. This can be designed to improve the economy of operation of the furnace as well as providing noise control. Such a ducted system does, however, introduce three more noise sources whose sound power must be considered. These are the duct wall radiated noise, fan casing radiated noise and fan inlet noise. Burner generated flow noise and combustion noise as well as fan noise is radiated from each of these items. A fan inlet silencer, fan casing lagging and ducting lagging are normally required.

Furnace walls can emit substantial amounts of sound power, despite the fact that they are relatively massive and the sound pressure level close to the wall is often not particularly high (in the mid 70 to mid 80 dB(A) range). The size of the wall accounts for the relatively large sound power emission. Wall radiated noise can contain substantial low frequency components, particularly in the case of box furnaces. Furnace walls typically consist of 6mm thick steel plates attached to frame members. The plates are sometimes press formed into a shallow dished shape to increase stiffness. Inside the steel walls are one or more layers of thermal insulation, which, it would appear could have an effect on radiated sound power. Some older furnaces have insulating bricks backed by fibrous insulation, which would appear to provide a substantial amount of damping to the walls. In other furnaces the insulating bricks are replaced with a castable insulation, with apparently less inherent damping. A recent development has been the fitting of insulation layers consisting only of high temperature fibrous insulation. Whilst this might be expected to increase the acoustic absorption inside the furnace and reduce the mid to high frequency reverberant sound pressure level, it might also be expected to give a lower transmission loss wall system with reduced damping and hence higher external noise levels for a given internal source strength. Simple calculations suggest that these changes may only result in an alteration in the spectrum of wall radiated noise without a radical change in A weighted sound power level. So far there have been insufficient opportunities to make comparable measurements with the two types of insulation to be able to confirm this view.

Low frequency noise can be emitted from the exit ducting or stacks of furnaces. There are considerable practical problems associated with measurement of stack radiated noise because of the difficulty of access to the top of the stack coupled with the considerable directivity of noise emission from a stack which often makes ground level measurements of little value. It can be estimated that induced draught fans should produce significant amounts of stack radiated sound power levels unless in line silencers are fitted. These must be designed with considerable care because of the hostile environment in which they operate.

How Should Furnace Sound Power be Measured?

The 'traditional' method of estimation of furnace sound power level is to make sound pressure level measurements around the furnace, subdividing the noise radiating surface of the furnace into sub areas from which or through which similar sound power levels propagate. The sound power level is then

$$\sum (\text{SPL} + 10 \log A) \text{ terms}$$

where A = measurement area in m^2

The sub areas chosen would typically be the furnace walls, overhead flue ducting, edges of underfurnace space (for bottom fired furnaces), and mouths of inlet ducts of plenum chamber equipped furnaces. In addition the sound power level of discrete sources, for instance, sidewall burners and forced draught fan inlets would be treated as point sources. Noise levels would normally be measured at 1 metre from the surface or noise source concerned. This method has many difficulties. The noise from individual sources can often not be determined properly because of the interfering noise from other sources, and the noise reflecting off the furnace surfaces. In many cases furnaces produce low frequency environmental noise problems. These cannot be properly assessed from close in noise measurements because the microphone is in the near field of the sources. Unless the furnace is the only significant emitter of low frequency noise measurements made at greater distances can give little more help.

Concawe has published (ref 1) a method for measurement of sound power level, based on sound pressure level measurements, and furnace wall vibration measurements where appropriate. It is intended that this method should provide a standard means of comparing noise emitted by different furnaces and a standard means of testing to verify conformity with guarantees.

This method again uses the principle of integrating sound pressure level over selected measurement surface areas and applies a correction of -3dB to the partial power levels of each sub area to correct for geometric near field effect.

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Detailed instructions for selecting the measurement scheme appropriate to differen furnace burner arrangements are given. When attempting to assess furnace wall radiation by vibration measurements it is recommended that, where possible, a cross check is done by means of noise measurements. There appears to be a need for more measured data to confirm the validity of the vibration measurement methods.

Potentially better methods of measurement of furnace sound power level are now becoming available. These are in the form of intensity meters (ref 2) which measure the acoustic intensity flowing past a point, using a pair of microphones. For low frequency furnace noise measurements greater microphone spacing than normal is necessary, but because furnaces radiate a very wide range of frequencie: two sets of microphone spacings may be necessary. Using the intensity meter measurements may be made close to the furnace surface, or assuming background noise is not too high, at greater distances from the surface. Use of the intensity meter should make it unnecessary to apply corrections for near field error and give a more accurate assessment of sound power level. At the time of writing the method has not been exhaustively proved in the field.

1. K.J. MARSH et al, Test Method for the Measurement of noise emitted by furnaces for use in the petroleum and petrochemical industries, CONCAWE Report No 3/77 Den Haag May 1977.

2. F.J. FAHY Noise Control Engineering vol.9 No.3, November/December 1977. A technique for measuring sound intensity with a sound level meter.