NOISE ABATEMENT OF PROCESS HEATER BURNERS

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ABSTRACT

Although the installation of high intensity forced draft burners, with or without preheated air, is on the increase, the greater majority of burners in process heaters are of the natural draft type or "natural draft" type in plenums with low pressure preheated air and with an emergency natural draft backup air source. This situation is not likely to be altered to any great extent in up-coming years because of the simplicity, reliability and flexibility of the "natural draft" type operation.

Since the combustion air inlets of natural draft burners provide a short direct path for noise emission, noise levels in the immediate vicinity of the units can be objectionable.

This paper will discuss the nature and causes of this noise and describes typical approaches to reducing the level of the noise to acceptable limits.

INTRODUCTION

The object of this paper is to discuss characteristics of burner noise, annoyances, possible resultant hazards, and methods and designs to reduce the intensity of the noise.

In a process plant such as an oil refinery or chemical facility, many different sources contribute to the ambient noise level. Noise is an inherent part of such operations. Equipment as pumps, fans, compressors, valves, turbines, and heaters are normally working twenty-four hours a day, seven days a week.

The government, in the form of the Occupational Safety and Health Act of 1970, has responded to the noise problems. Included in this Act are limits on the workers' exposure to noise over specified time periods. Although some environmental regulations have been softened a bit, the general feeling is that future environmental noise standards will require lower levels of noise intensity.

Compliance with the OSHA regulations, or those of any other regulatory body, industry groups, or individual company, will require capital expenditures. These may occur "early on", when a new piece of equipment is being designed and built or when existing equipment is being up-graded to meet new standards. The money spent to provide noise abatement in the workplace does not directly improve the product but does increase the cost of manufacture. It makes good business sense, therefore, to provide noise reduction in the most cost-effective way. Plant engineers and others involved with project responsibility should become knowledgeable of the technical and economic considerations of noise management. So informed, they should be able to provide quality input to planning and purchasing when noise reduction equipment is being considered.

The following is devoted to the noise created by oil and gas burners in process furnaces. The origins and nature of the noise produced by these burners will be presented, relative to the nature of the fuel, heat release rate, speed of fuel/air mixing, fuel pressure drop and type of burner.

Burner Noise

When fuel is fired in process heaters, acoustical energy (noise) is produced. This noise consists of two components, flow noise and combustion roar. The intensity of the flow noise depends upon several factors, but the frequency will generally will be in the 1000 - 8000 Hz range. Combustion roar is normally in the 250 to 500 Hz range. Noise escapes from the heater to the surrounding environment through the air registers of the burner and any other furnace opening.

The intensity of the acoustical noise generated is affected by the burner design and mounting in addition to a variety of operating conditions:

1. The resultant noise level is proportional to the speed of fuel/air mixing. As the rate of heat release per unit volume increases, the noise intensity increases.

2. Fuels with higher flame speeds (hydrogen content) will generate higher noise levels.

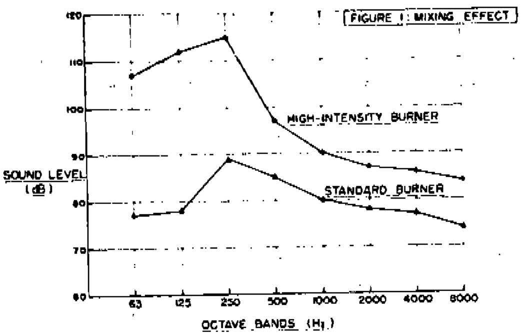
3. Pressure drop increases burner tip exit velocity and therefore flow noise increases.

4. The heater designer need not use burner noise level as the significant criteria in his selection of the number and size of burners to be used. Heat distribution and transfer should be the bases of his selection, because the noise levels from one large burner or multiple smaller burners with the same overall heat release are approximately the same.

Combustion laboratory tests, using standard octave - band analyses, support the preceding statements.

Test Findings

In Figure 1 there are two similarly shaped burner-noise profiles. The lower curve is a plot of data taken on a standard burner fired on No.6 oil with a steam-atomized oil gun at a 7 mmBtu/hr (2.1 MW) rate. The upper curve presents the sound-pressure level data from a high-intensity burner firing at the same 7 mmBtu/hr (2.1 MW), rate using the same type steam-atomized oil gun. The distance from the sound measurement point to the burner unit was exactly the same in both cases. Because of the high energy, rapid fuel/air mixing of the high-intensity burner, the flame volume is approximately 1/4 that of the standard natural draft burner. Thus, the heat-release per unit volume is in a ratio of 4 to 1; and the difference in sound-pressure levels over the frequency spectrum ranges from a minimum of 9 dB to a maximum of 30 dB.

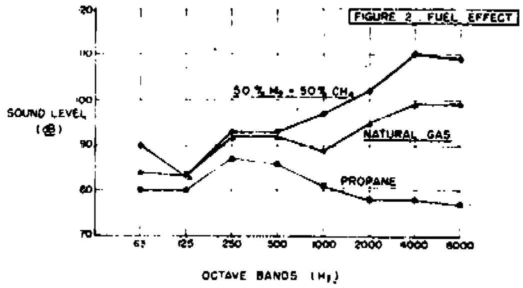


DIFFERENCE IN SOUND LEVEL (dB)

30	34	26	12	10	9	9	10

It is significant that both curves are obviously of a similar family, although they originate from two combustion units that are greatly dissimiliar in basic design and operation. Equally significant is the fact that the largest deviation between curves is in the low frequencies (500 Hz and below), generally accepted as being generated by the combustion process.

Many burner applications require that fuel gases of widely varying compositions be fired in the same burners. Figure 2, Fuel Effect, presents noise plots of three different gases when fired separately through the same inspirating type burner. Each gas was fired at an identical heat release rate.



DIFFERENCE IN SOUND LEVEL (dB)

PROPANE TO NATURAL GAS	4	3	5	6	8	17	21	22
PROPANE TO 50% H_2 + 50% CH_4	10	3	6	7	16	24	32	32

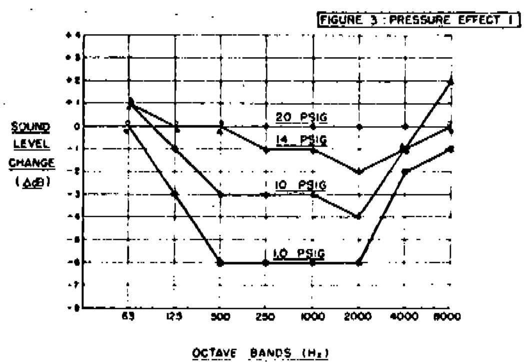
The lowest profile is from firing propane with a specific gravity of 1.5 and an LHV (lower heating value) of 2350 Btu/scf (94,000 KJ/Nm^3). The pressure drop across the burner jet was 8 psig (55 kPa).

Natural gas firing (mostly methane) generated the data for the middle plot. This gas has a specific gravity of 0.6 and a LHV of 950 Btu/scf (39,200 KJ/Nm^3). Here the required pressure across the same jet must be increased to 18 psig (124 kPa) to hold the same heat release rate.

The upper profile is from a mixture of 50% (vol) natural gas and 50% (vol) hydrogen with a specific gravity of 0.33, an LHV of 615 Btu/scf (25,375 KJ/Nm^3), and a pressure drop across the same jet of 27 psig (186 kPa).

Generally, the flow noise of the gas system is unimportant compared with the combustion roar. In the case of inspirating burners, where combustion air is drawn into the gas burner gun and mixed with the fuel gas prior to ignition, the gas/air system noise intensity is normally higher than the combustion roar. Note in Figure 2 that as the gas pressure increased from 8 psig (55 kPa) for propane, to 18 psig (124 kPa) for natural gas and 27 psig (186 kPa) for the mixed gas, the intensity level in frequencies of about 500 Hz increased markedly.

Figure 3 presents the deviation in sound level intensities resulting from fuel pressure drop variations. The 20 psig (138 kPa) zero, or base line, represents the levels recorded in the firing of a raw gas burner at that pressure. A constant heat release rate was maintained by increasing the orifice size such that noise levels were recorded at 14 psig (96 kPa), 10 psig (69 kPa), and 1 psig (7 kPa).



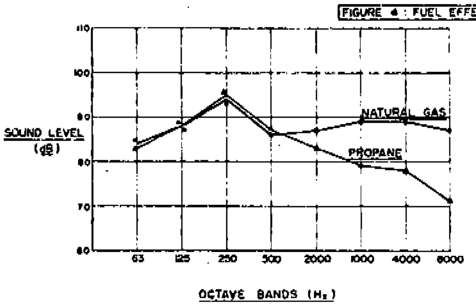
Following the 14 psig (69 kPa) line, note that it varies only 1 dB, plus and minus, from the 20 psig (138 kPa) base line, except for a 2 dB reduction in the 2000 Hz octave band. Therefore, a reduction in fuel pressure drop in this burner from 20 (138) to 14 psig (96 kPa) will accomplish little noise reduction, while suffering a loss in turndown capability.

Reducing the pressure drop from 20 psig (138 kPa) to 10 psig (69 kPa) - maintaining the same heat release - the average noise reduction will be approximately 3 dB, with a maximum of 4 dB at a single octave point.

The plot of the firing 1 psig (7 kPa) is extreme as far as any practical operation of this burner is concerned; but it does indicate that going to such extremes reduces the sound-pressure level by a maximum of only 6 dB.

It becomes obvious, then, that the sound pressure variations shown in Figure 2 cannot be attributed solely to changes in pressure drop. A search for other flow-noise dependent variables led to Figure 4. Here, the propane line represents propane firing at 16 psig (112 kPa) gas-pressure drop, while the natural gas profile resulted from an identical heat release rate in the same burner, but at only 12 psig (84 kPa). Although the propane flow was at a higher pressure drop, the natural gas generates higher flow noise levels of 6 - 12 dB. Comparing these values with the 6 dB maximum change for pressure variations over a 1 - 20 pressure range, it seems reasonable to conclude that flow noise is more dependent on the type of fluid flowing, rather than the pressure drop employed.

FIGURE 4 : FUEL EFFECT 2



DIFFERENCE IN SOUND LEVEL (dB)

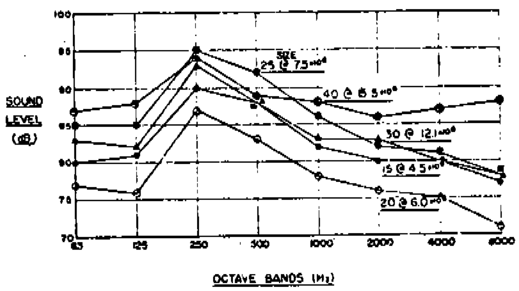
1	0	-1	-1	6	10	11	16

To examine the possible relationship between noise levels and firing rates, five sizes of combustion oil and gàs burners were fired at or near their nominal ratings. The fuels used were natural gas and steam-atomized No.6 fuel oil. Figures 5 and 6 record the resultant noise profiles and clearly demonstrate that the heat release rate is not an overall controlling factor. In fact, there is no consistant correlation at all; on gas firing there is almost an inverse correlation.

When a single burner is fired at varying heat release rates, a practically identical family of sound profiles is the result (see Figure 7). This is an excellent exhibit of the theorem "increasing firing rates increase noise levels". The application of this theorem need not be restricted to a single burner.

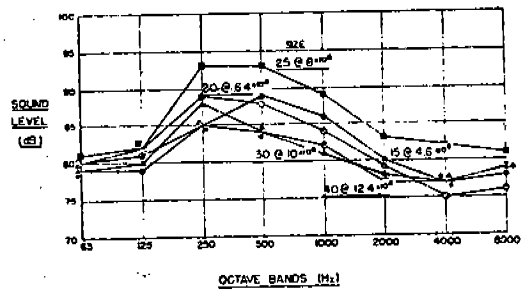
An earlier statement in this text directs that "the heater designer need not use burner noise level as the significant criteria in his selection of the

FIGURE 5 : BURNER SIZE EFFECT - OIL



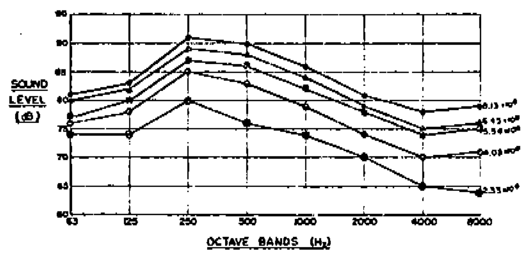
NO 6 OIL, STEAM ATOMIZED ℄ BURNER TO MICROPHONE • 10'-0"
VERTICALLY FIRED

FIGURE 6 : BURNER SIZE EFFECT - GAS



FUEL: PROPANE ℄ BURNER TO MICROPHONE • 10'-0"
VERTICALLY FIRED

FIGURE 7 : FIRING RATE EFFECT



FUEL: PROPANE ℄ BURNER TO MICROPHONE • 10'-0"
VERTICALLY FIRED

number and size of burners to be used. Heat distribution and transfer should be the bases of his selection." Refer to Figure 5. Remember that these noise profiles were generated by five different burner sizes, each operated at or near its design rating, with a negative draft on 0.2" WC (5 mm WC) on the air side. All profiles showed surprisingly little variation in sound-pressure levels, especially considering that the firing rates varied from a minimum of 4.5 mmBtu/hr (1.3 MW) to a maximum of 15.5 mm Btu/hr (4.6 MW).

In the peak octave bands of 125 - 250 Hz, the gross variation between any two units is 3 dB, while that between the lowest and highest sound-pressure levels is only 7 dB. This is a situation in which the use of two 6 mmBtu/hr (1.8 MW) burners would result in just about the same noise level produced in using one 12 mmBtu/hr (3.6 MW) burner. Three 4.5 mmBtu/hr (1.3 MW) units would be approximately the same as a single 16 (4.8) to 17 mmBtu/hr (5.0 MW)unit. In the 1000 - 8000 Hz band, note the very close groupings of the three burner sizes, ranging from 4.5 to 12 mmBtu/hr (1.3 to 3.6 MW).

When two sound sources and/or outlets exist, as in the older burner unit designs, Figure 8, the problem of noise control is compounded. It therefore stands to reason that any design innovation which can eliminate or combine sound outlet sources would be desirable. When operating the older burner designs on either fuel, the primary air path is open, as is the secondary air path. When operating on oil, the steam-jet noise will be in the immediate vicinity of the primary air opening. Compare this arrangement with a new LOW-AIR™ design (Figure 9). Here, the heavy bottom plate effectively obstructs a straight-path escape for the oil burner's jet noise and for the gas/fuel combustion noise that passes through the primary air path. The acoustical waves must first strike a reflecting plate, then make a 90° turn to exit via the main air ports. Although there is certainly some suppression advantage to the new design, of more importance is the fact that it is much easier to apply sound absorption devices, because only one exit area or outlet must be considered.

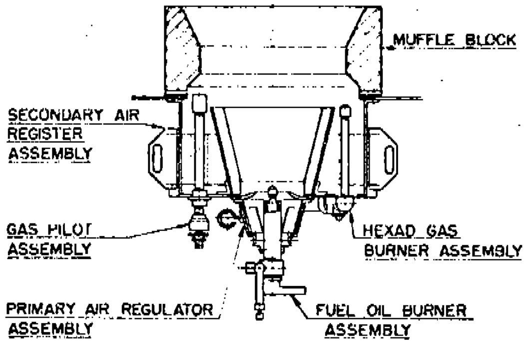


FIGURE 8 -- OLD BURNER

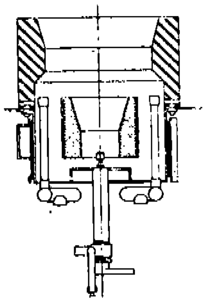


FIGURE 9 -- LOW AIR DESIGN

New burner designs resulting from the industry's concern for NOx reduction and control have further reduced noise levels. The new Lo-NOx™ burner, as shown in Figure 10, provides a longer travel path with multiple bends for the air/steam/oil flow noise and initial combustion roar. This design gives an 8 - 10 dB(A) noise reduction.

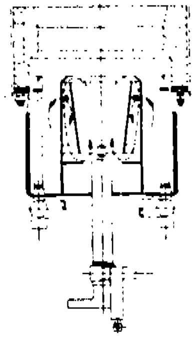


FIGURE 10 -- Lo-NOx DESIGN

Concern for improving burner energy efficiency has lead to the use of new "natural draft" burners in thermally insulated plenums with low pressure (0.5 "WC, 13 mm WC) preheated air (600 °F, 315 °C), that also provide further noise control. If the plenum lining is properly selected, the thermal insulation gives good acoustical adsorption. Typical burner and plenum arrangements are shown in Figures 11 and 12. These will result in a burner noise level for the entire process heater of less than 80 - 85 dB(A), which is below the present 90 dB(A) OSHA requirement.

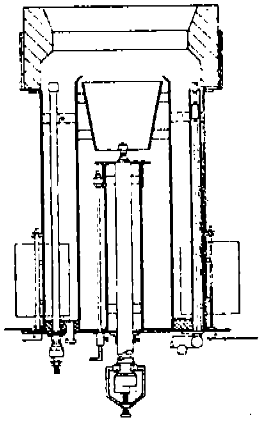


FIGURE 11 -- Lo-NOx ENERGY EFFICIENT DESIGN

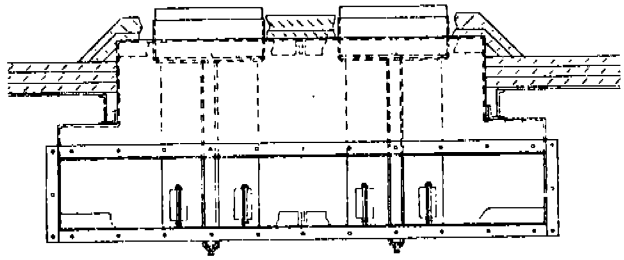


FIGURE 12 -- PREHEATED AIR PLENUM

CONCLUSION

While there are many methods for absorbing burner noise, by far the most simple, economic, efficient and flexible is the combination of plenum mounted "natural draft" burners with low pressure preheated air. Because the plenum is fitted with emergency air inlets, this approach will insure reliable, continuous heater operation in the event of any component failure in the preheater system.

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