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CONSIDERATIONS IN THE DESIGN OF BLOW-OFF VENT SILENCERS

E G Spalding, MA, CEng, FIMechE

Delta-P International

SUMMARY

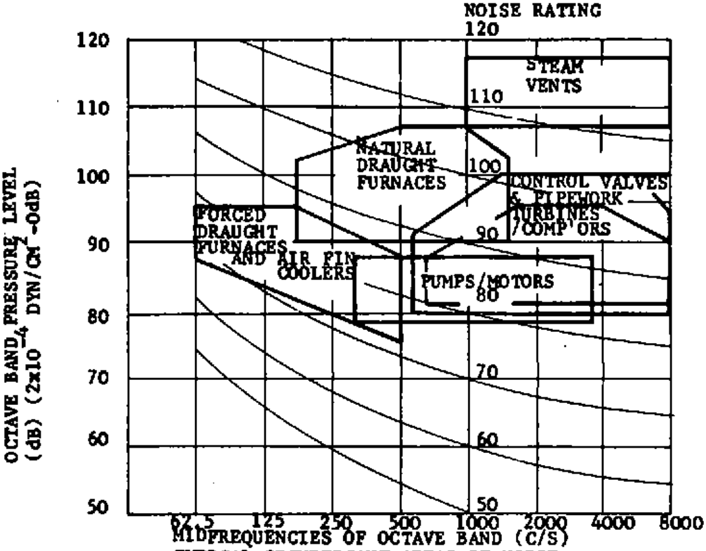
The current awareness in industry of the need to control noise in plant facilities has lead to a demand for a variety of silencing equipment. Different noise sources require widely differing types of equipment, all of which have to be designed to meet increasingly demanding specifications at minimum cost. This paper discusses the various parameters to be considered in the design of silencers for Blow-off Vents and outlines some simplified methods of dealing with the related theoretical complexities.

INTRODUCTION

Plants ranging from power stations and natural gas pumping stations to process plants, generate noises from a variety of sources. In particular, we can see a selection of these noises produced in an oil refinery in the chart shown overleaf, (1) which shows the noise levels at various frequencies arising from different items of plant in the refinery.

It is well known that from subjective considerations high frequency noises create the greatest discomfort to plant operators and people living in the vicinity of the plant. From the point of view both of high frequency and sound pressure level, it can be seen from the chart that the noise generated by steam vents is the biggest offender. Both gas and steam vents have noise level peaks in the region of 1000 to 3000 Herz and the Sound Pressure Level of vent noises is generally in the region of 110 to 150 dB.

Based upon data obtained from many field surveys over the years, empirical methods of predicting unsilenced noise levels and peak frequencies of blow-off vents have been developed and reduced to simple charts which give fairly well correlated results.



TYPICAL SIGNIFICANT AREAS OF NOISE EMISSION FROM PETROLEUM PLANT

DISCUSSION

In the design of a silencer for a gas or steam blow-off vent, a number of parameters have to be considered, including:

(a) the noise attenuation to be achieved
(b) size and weight
(c) durability giving long life and no maintenance
(d) pressure drop
(e) cost

Cost is mentioned last quite deliberately, since in the past, silencers have tended to be fitted on the basis of being a necessary evil and process plant designers' main idea was to fit a silencer primarily at minimum cost in view of the fact that it was not a directly productive piece of equipment contributing to the overall efficiency of the plant. Nowadays, Companies are more concerned about their corporate image and the possibility of having to shut down a plant if the noise levels in the vicinity create a public nuisance. In other words, the performance of silencing equipment has to meet specified attenuation levels as a matter of paramount concern and with modern measuring equipment, close checks of performance can be made.

However with cost and size in mind, it is necessary to have reasonably accurate methods of designing equipment to ensure that specifications are met without excessive design margins.

In any particular blow-off vent application the following points have to be considered in selecting the type and size of silencer:

- (a) type of application and service (whether intermittent or continuous)
- (b) intensity of unsilenced noise
- (c) peak frequency of the noise
- (d) noise rating criteria
- (e) gas or steam conditions
- (f) flow rate
- (g) allowable pressure drop

Continuous venting under near stable conditions may be regarded as continuous service whereas intermittent service has to be evaluated in terms of frequency and noise level, duration of blowdown and frequency of occurence. Most noise standards permit intermittent levels of 5 - 10 dB above continuous levels, for example BS 4142.

The known formulae for calculating unsilenced vent noise levels are generally exceeding complicated. However a generalised equation for radiated sound power from a turbulent gas jet based upon Lighthills' equation (2) can be expressed as:

$$W_A = f(R, K, P, T, d, M, Z)$$

where
W_A = radiated sound power
R = Gas Constant
K = Ratio of Specific Heats
P = Upstream Pressure
T = Upstream Temperature
d = nozzle diameter
M = molecular weight
Z = compressibility factor

This equation may be resolved to chart form (3) for ready determination of the SPL of a vent noise. The Chart shown gives the unsilenced SPL in dB, 10 ft. from the Source at a given pressure and temperature for air ejecting through a one inch valve. Corrections on supplementary charts give the changes in SPL for various valve sizes, gas types and distance. Saturated steam does not necessarily follow the generalised equation as liquid dampening occurs during expansion to atmosphere.

The next point to be considered is the peak frequency of the noise. Low frequency noises are produced from low pressure, large flow rates and large valves, whereas high frequency noise is usually associated with high pressure, high velocity and small valves. The peak frequency of the unsilenced noise can be derived from the Strouhal formula:

$$f_{max} = 0.2 \frac{V}{d}$$

where f = Peak frequency - Herz
V = velocity - ft.per sec
d = valve throat dia - ft.

This equation can also be resolved to chart form (3), giving the peak frequency for various values of temperature, molecular weight and valve size.

From the peak frequency, we can select the type of silencer to be used. In the case of high frequency attenuation, an absorptive type is required; whereas in the case of a low frequency, a reactive type of silencer is more suitable. In practice in view of the broad-band noise spectrum a combined type of silencer is widely used in industry. For very large blow-off vents, handling in the region of one million lb/hr of gas, splitter panel type silencers are generally used.

In the case of high velocity vents, diffusers are incorporated which distribute the gas over a larger area to facilitate the effective use of the absorbing materials. Diffusers also give an increase in attenuation due to the regeneration of noise at a higher frequency which is more readily absorbed in the absorptive media.(4)

In certain cases the structural design of the silencer may be governed by the requirement, under emergency conditions, of handling gas flow rates greatly in excess of the normal acoustic design rate, in which case the acoustic performance of the silencer has to be ignored.

CONCLUSIONS

The considerations discussed in connection with the design of blow-off vent silencers indicate that it is possible to reduce the design procedures to a fairly simple process. However it should be realised that silencer design is nevertheless still an art rather than a science. It is necessary to have a constant feed-back of field data, since there are many exceptions and special factors of which a designer must be aware, which can only be obtained by practical experience.

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