PRACTICAL APPROACH TO NOISE SUPPRESSION OF HIGH PRESSURE VENTS

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In order to appreciate the noise control measures required for high pressure venting and pressure reduction applications, it is necessary to consider some of the fundamental principles involved.

When a gas at high pressure flows to a region of lower pressure the flow becomes sonic when the critical pressure for the gas concerned is reached. The critical pressure (Pc) for any gas, in terms of the initial pressure is given by:-

$$Pc = P_1 \left(\frac{2}{\gamma + 1}\right)^{\frac{\gamma}{\gamma - 1}}$$

Where P_1 = Initial Pressure

γ = Ratio of spe ific heats $\left(\frac{C_p}{C_v}\right)$ of the gas

At this point the valve is said to be choked.

There are two noise producing mechanisms associated with choked flow (i) shock noise caused by the interaction of shock waves with the turbulent mixing which occurs downstream of the valve and (ii) jet noise caused by turbulent mixing and the sheer action between the high velocity discharge and the surrounding still gas.

The overall acoustic power level generated may be estimated by a number of methods. The one given here is based on the acoustic efficiency of the flow and has been found to give results which correlate with measured data with an acceptable degree of accuracy.

$$PWL_v = 10 \log_{10} (0.5 \, M V_t^2 \times \mu) + 120$$

Where PWL_v = Overall sound power level (re 10^{-12} watts)

M = Mass flow bq/sec

V_t = Velocity at valve throat

μ = Acoustic efficiency ($\simeq 10^{-2}$)

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In order to determine the frequency spectrum from the generalised sound power level it is necessary to find the peak frequency. This is given by the expression:-

$$fpv = \frac{S_v \; V_t}{dv}$$

where fpv = Peak frequency due to valve

S = Peak Strouhal Number (approximates to 170-200 depending upon pressure drop across valve).

d_v = Diameter of valve (mm)

The sound power level in the octave band containing the peak frequency will be approximately 5dB below the overall level and the levels in the octave bands higher than the one containing the peak frequency will fall off by approximately 3 dB per octave, while the fall off for the lower octave bands will be approx 11dB.

In venting operations where the initial pressure is sufficiently high, choked flow will also occur at the pipe termination.

The sound power level for this is calculated in the manner described using the appropriate conditions applying at the pipe end. The acoustical efficiency of this vent noise falls between 10^{-3} and 10^{-4}.

To convert the calculated sound power levels into sound pressure levels at some distant reference point, it is necessary to examine the specific application in order to determine their radiation patterns.

Fig.1(a) shows a pressure reduction valve with its associated piping. Noise is generated for approximately 20 diameters downstream of the valve and will be propogated for immense distances along the pipe: The noise radiated into the surrounding atmosphere will depend upon the area of exposed piping and the attenuation affected by the pipe wall. Noise will radiate from the upstream pipework, but for a shorter distance and will be about 10-15 dB lower than that downstream.

Fig.1(b) illustrates the situation where the valve is situated adjacent to the pipe termination (less than 10 diameters) so that for practical purposes the valve noise may be regarded as radiating as a free jet with maximum levels being at approximately 45° to the axis of the pipe.

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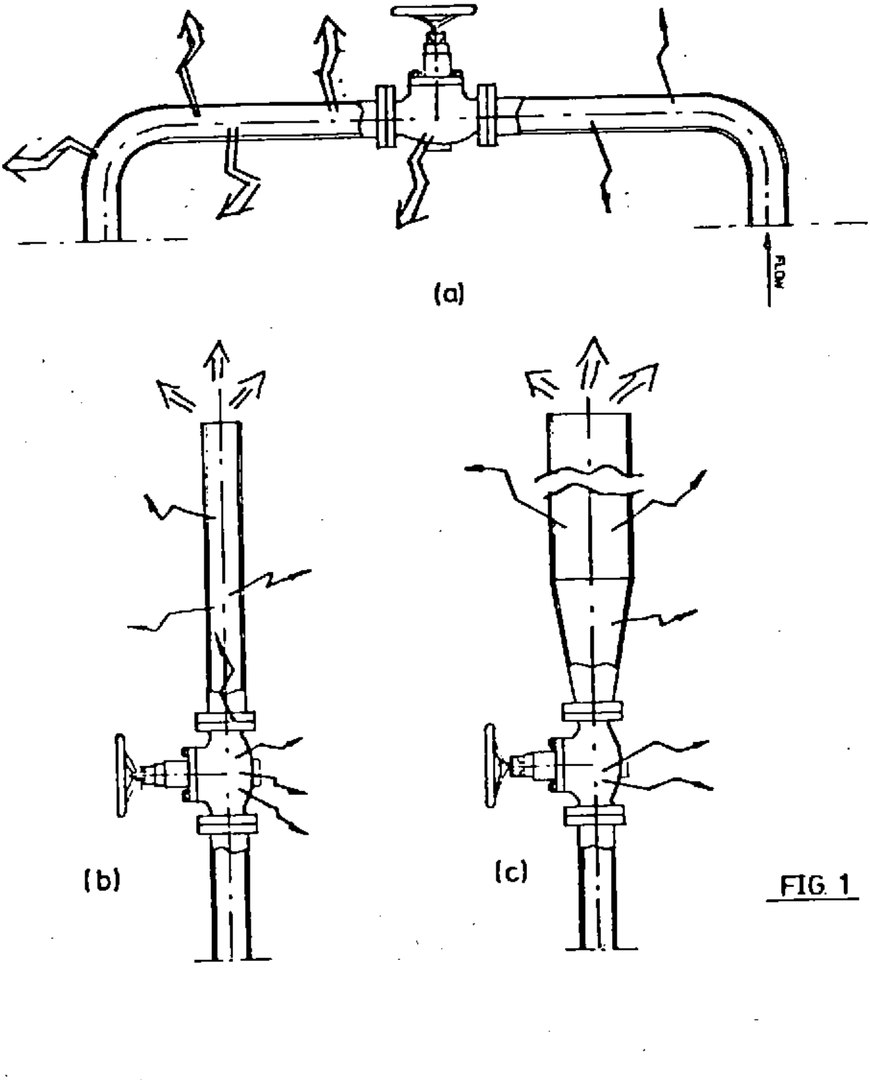

FIG. 1

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The example illustrated at Fig.1(c) shows the case where the valve is remote from the pipe end so that the noise generated at the valve is propogated along the pipe to radiate into the surrounding atmosphere. Its radiation pattern will be that of sound radiated by a piston in a circular tube.

If choked flow conditions exist at the pipe end the noise generated will have the radiation characteristics of a free jet. The final levels at the reference point will be the logarithmic addition of the two sources. Noise will also radiate from the pipe walls as already indicated.

Lagging can sometimes be effective in reducing pipe noise, especially at the higher frequencies. Complete enclosure of the valve and exposed pipework will be more effective and may be the only way to deal adequately with low frequency noise.

For pressure reduction systems, in-line silencers can be effective especially if the pipework is exposed for long distance.

For venting operations any required silencer should be fitted as close as possible after the valve and care must be taken that the flow in the downstream piping is not high enough to regenerate noise.

All silencers should normally include one or more diffusers which will raise the fundamental frequency of the jet and reduce noise by reflection as well as shortening the length of the high velocity jet core and giving a smoother and more even flow through the silencer.

The setting of criteria for venting applications becomes difficult in such cases as safety valves, where the frequency of operation is indeterminable, or where the system storage capacity is such that the peak noise level is only attained at the start of the venting.

1. Noise Abatement at Gas Pipeline Installations. Vol II American Gas Association.

2. Noise and Vibration Control. L L BERANEK. McGraw Hill 1971.

3. Vent and Blowdown Silencing. J.F.B.,B.P.C unpublished notes 1972.

4. Technical Note 1/76. J.A.C., B.I.S unpublished notes 1976.