8.3 General considerations

Without meaningful standards being adopted in environmental control (to which also the prevention of valve noise appertains), chemical or petrochemical plants would today, not be approved. For this reason, “acoustic planning” for the dominating noise sources is categorically required. This applies particularly for compressors, process ovens, cooling fans and not least for control valves and pipelines. In order to keep the emitted sound power within limits quite extensive corrective measures are required. Since noise attenuation measures within a severe costs/benefit analysis must also make sense, one will only implement noise reducing precautions where it is absolutely necessary. As a result, the competitiveness of the whole enterprise, who wants to construct their plant near a residential area, may be questioned if the permissible sound power level near the plant boundaries has to be especially low. Figure 8.3.-1 shows typical sound power levels of noise sources in a petrochemical plant today and in the past.

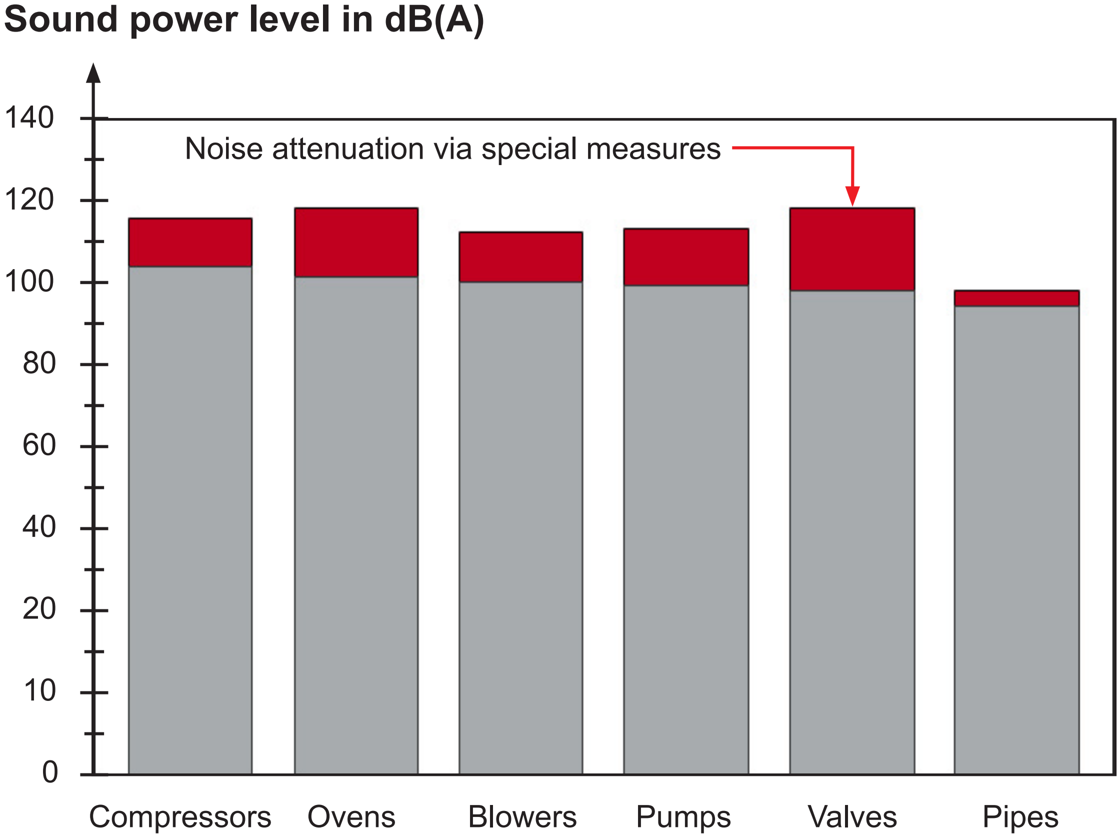

Figure 8.3.-1: Emission levels of typical noise sources in refineries [43]

From Figure 8.3.-1 it becomes evident that valves, together with pipelines, represent an acoustic source of the first order. By constructive improvements in recent years it has been possible to reduce the average plant sound power level by approx. 10 dB(A.

Noise, in the physical sense, means pressure cycling within the surrounding air where the amplitude height of the pressure waves is tantamount to the loudness or volume. The frequency (number of the oscillations per second) expresses the pitch of noise.

The loudness or volume is usually expressed in decibel (dB), a dimensionless, logarithmic proportion of two numbers, which is related to a base value being an effective pressure $p_0 = 0.0002\ \mu\text{bar}$ or $2 \cdot 10^{-10}$ bar. This level corresponds approximately to the sensitivity of human hearing. In this way, the sound pressure level L_p becomes:

$$\boxed{L_p = 20 \cdot \log \frac{p}{p_0}} \qquad (8\text{-}1)$$

If the effective value of the measured sound pressure level is, 1.0 μbar, for example, the ratio of 1.0/0.0002 = 5000. If one takes the logarithm of this value and multiplies this number by 20, it gives a sound pressure level of 74 dB, which is considerably more convenient to handle than the effective sound pressure in μbar.

One has to distinguish between the sound pressure level $\mathbf{L_p}$ and the sound power level $\mathbf{L_w}$. The **sound pressure level** $\mathbf{L_p}$ is the measured pressure at a specific point, e.g. at a distance of 1.0 m of the pipeline and 1.0 m downstream of the control valve. The sound power level is equal to the entire noise emitted by the valve and the pipeline and whose numerical value is larger than that of the sound pressure level. It is also expressed in **decibel (dB)**. The Reference Point is a sound power level of 10 to 12 Watt. The sound power level L_w is calculated as follows from equation (8-2):

$$\boxed{L_w = 10 \cdot \log \frac{P}{P_0}} \qquad (8\text{-}2)$$

The capital letters P and P_0 express, in this case, the acoustic power and not sound pressure levels. It is worth mentioning that the sound power level cannot be measured directly but is calculated from the reverberating sound pressure level and the covering “measuring surface”.

Since the loudness (volume) which is felt subjectively does not agree with the absolute volume in dB, a special filter is often connected to the noise level meter. This filter suppresses during a measurement and/or evaluation, the high and low frequencies in the same way as human ears do.

In this case an index is affixed to the measured value in decibel, i. e. the term reads 85 dB(A), for example. Sound pressure levels which seem to have the same degree of loudness are represented in Figure 8.3.-2.

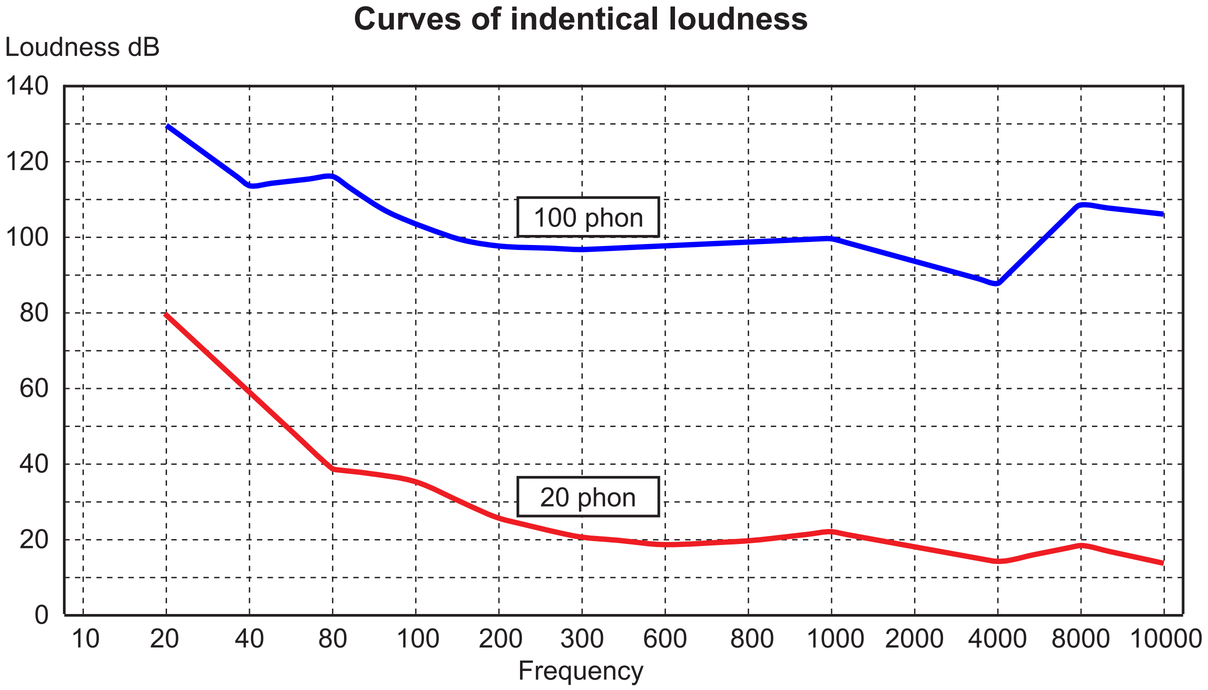

Figure 8.3.-2: Identical levels of loudness for the human ear vs. frequency, according to Robinson and Dadson

This means, for example, that a very deep tone of 20 Hz with a sound pressure level of 80 dB has, for the human ear, the same degree of loudness as a tone with only 20 dB and a frequency of 1000 Hz. This corresponds to a difference of as much as 60 dB! Besides the different sensitivity of the human ear, as far as the noise frequency is concerned, the absolute value of the sound pressure level also plays an important role.

With an increasing volume the difference of the sound pressure level at various frequencies become smaller (upper curve), so that at a constant noise level of 100 dB the difference in the degree of loudness for the human ear within the above mentioned frequency range between 20 and 1000 Hz is under this circumstances only about 30 dB.

The definition of the sound pressure level in dB(A) simplifies the judgment of noise enormous since only one numerical value must be indicated instead of the whole sound spectrum. However, one cannot ignore the full noise spectrum, if a purposeful noise reduction measure is required. Most common is, in this cases, the so-called octave spectrum, which lists the noise levels at the octave center frequencies of 500, 1000, 2000, 4000 and 8000 Hz.

For a more detailed analysis, a finer subdivision is necessary, i.e. the effective sound pressure levels may be measured at each third octave (Terz). Most precise, but also very expensive to achieve is a narrow-band analysis. If all single levels of an octave spectrum are known, the A-weighted sound pressure level can be determined by means of a relatively complicated procedure.

The resulting dB(A) figure can roughly be estimated from the level at 4000 Hz: The A-weighted sound pressure level (SPL) is always approx. 2-4 decibel louder than the dB value at 4000 Hz, i.e. one adds, roughly, 2-4 decibel to this figure in order to attain the A-weighted sound pressure level in dB(A).