6.5.4 Calculation of the Noise Emission

The sum of noise emissions in a plant is not only attributed to machinery, generators, etc., but also includes the noise caused by the streaming of vapours or gases, the cavitation of liquids, as well as by flowing or discharging through armatures.
Although safety valves are not a primary issue when considering noise emission, safety valves are evaluated more and more, especially when discharging into the open air. In this case high noise pollution can appear for a short time.
The noise calculations are based on the expansion of the steam/ gas at the end of a pipe. Safety valve specific conditions like the geometry of the outlet chamber stay unconsidered. It is not common to perform noise emission testing on an individual safety valve series or size. Also the frequencies of the noise are not determined. Unlike e.g. for control valves there is no low noise trim for safety valves available.
In some specifications there are limit values for noise which also include safety valves. If the calculated noise at the safety valve exceeds these limits an end of line silencer can be used. In this case the built-up back pressure created by the silencer should be regarded. Another way to reduce the noise level is to reduce the maximum mass flow by using a lift restriction. This is only possible as long as the required capacity is achieved.
LESER calculates with three standards:

- Noise emission according to ISO 4126-9
- Noise emission according to API 521
- Noise emission according to VDI 2713

Noise calculations according to these standards are performed independently from manufacturers designs. That means that calculated noise levels do not depend on manufacturers designs as long as they provide the same capacity.
In general, two physical values are concerned:

- The sound power level characterizes the overall energy which is emitted by a noise source (here: the safety valve) through an imaginary hemisphere. As a result, the sound power level is independent on the distance from the noise source.
- The sound pressure level characterizes the pressure oszillation due to the noise source dependent on the distance from it. This corresponds to the noise which affects the hearing of human beings.

Noise emission calculation with VALVESTAR®
An easy and user-optimized noise emission calculation can be done with the LESER sizing program VALVESTAR®. VALVESTAR® is available online at www.valvestar.com.

6.5.4.1 Calculation of the Noise Emission According to ISO 4126-9

Used Symbols	Designation	Units
d_A	Internal diameter of outlet pipe	mm
v	Specific volume of the stream at relieving pressure and temperature	m³/kg
u	Velocity of fluid in outlet pipe	m/s
r	Distance from noise source	m

Table 6.5.4.1-1: Symbols ISO 4126-9

The sound power level of the safety valve, P_{WL}, expressed in dB, can be estimated by the following equation:

$$P_{WL} = 20\log(10^{-3} d_A) - 10\log v + 80\log u - 53 \quad (6.5.4.1\text{-}1)$$

The sound pressure level, P_{SLr}, expressed in dB, at a distance r from the point of discharge to the atmosphere can be estimated by the following equation:

$$P_{SL_r} = P_{WL} - 10\ \log(2\pi r^2) \quad (6.5.4.1\text{-}2)$$

LESER Note: Noise calculation acc. to ISO 4126-9 is not implemented in VALVESTAR®.

6.5.4.2 Calculation of the Noise Emission According to API 521

Used Symbols	Designation	Units	
$L_{30\ (100)}$	Noise level at 30m (100ft) from the point of discharge	dB	
L	Noise level	dB	
L_p	Sound pressure level at distance r	dB	
r	Distance from the sound source (stack tip)	m	ft
q_m	Mass flow through the valve	Kg/ s	pound/ s
c	Speed of sound in the gas at the valve	m/s	ft/ s
k	Ratio of the specific heats in the gas	-	
M	Relative molecular mass of the gas	-	
T	Gas temperature	K	°R
PR, X	Pressure ratio across the safety valve	-	
Y	Sound pressure level, $L_{30\ (100)}$	dB	

Table 6.5.4.2-1: Symbols API 521

The noise level at 30 m (100 ft) from the point of discharge to the atmosphere can be approximated by the equation:

$$L_{30\ (100)} = L + 10 \cdot \lg(0{,}5 q_m \cdot c^2) \qquad (6.5.4.2\text{-}1)$$

Figure 6.5.4.2-1 illustrates the noise intensity measured as the sound pressure level Y at 30 m/100 ft *(Y* = $L_{30\ (100)}$) from the stack tip versus the pressure ratio PR (= X) across the safety valve.

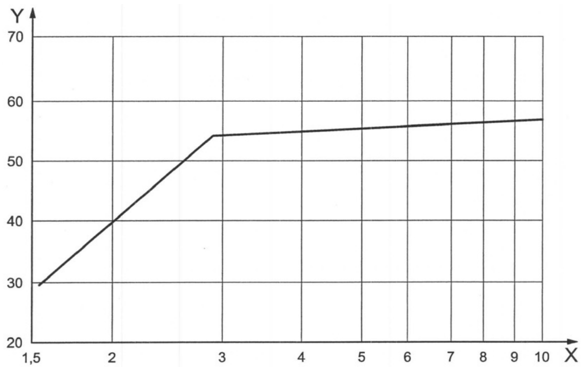

Figure 6.5.4.2-1: Sound pressure level at 30m (100ft) from the stack tip (Y = $L_{30\ (100)}$)

Note: PR is the pressure ratio and is defined as the absolute static pressure upstream from the restriction (e.g. pressure-relief valve nozzle) divided by the absolute pressure downstream of the restriction while relieving. In some cases, critical flow can occur not only in the pressure-relief valve nozzle but also at the discharge-pipe outlet to atmosphere. In this case, the noise level is additive (logarithmic). In the case of the discharge pipe, the pressure ratio is the absolute pressure within the pipe at the outlet divided by atmospheric pressure.

LESER Note: The above figure 6.5.4.2-1 from API 521 is limited to the maximum PR_{max} = 10. Therefore VALVESTAR® does not show results for PR>10.

Equations (6.5.4.2-2) and (6.5.4.2-3) show how to calculate the speed of sound,c.

In SI units:

$$c = 91{,}2 \cdot \left(\frac{kT}{M}\right)^{0,5} \quad m/s \qquad (6.5.4.2\text{-}2)$$

In USC units

$$c = 223 \cdot \left(\frac{kT}{M}\right)^{0,5} \quad ft/s \qquad (6.5.4.2\text{-}3)$$

By applying Equations (6.5.4.2-4) and (6.5.4.2-5), the noise level can be adjusted for distances that differ from the 30 m (100ft) reference boundary:

In SI units:

$$L_p = L_{30} - [20\lg(r/30)] \qquad (6.5.4.2\text{-}4)$$

In USC units:

$$L_p = L_{30} - [20\lg(r/30)] \qquad (6.5.4.2\text{-}5)$$

For distances greater than 305 m (1000 ft), some credit may be taken for molecular noise absorption. If pressure-relief valves prove to be excessively noisy during operation, the sound can be deadened by the application of insulation around the valve body and the downstream pipe up to approximately five pipe diameters from the valve.

> LESER Note: VALVESTAR® calculates and displays the sound power level L_p for a distance of 1m to the valve if calculation acc. to “API 520” is selected.

6.5.4.3 Calculation of the Noise Emission According to VDI 2713 for Steam

Used Symbols	Designation	Units
L_w	Noise level	dB (A)
L_A	Noise at a distance of r meters	
q'_m	Max. mass flow, calculated with p • 1,1 and α_d/0,9	kg/h
p	Set pressure	bar
α_d	Coefficient of discharge	–
T	Temperature	K
r	Radius of the "imaginary hemisphere" as the measurement distance from the source of the noise (usually 1m)	m
A	Surface of the "imaginary hemisphere" with the radius r ($A = 2\pi r^2$)	m²

Table 6.5.4.3-1: Symbols VDI 2713

The calculation of the noise level for steam:

$$L_W = 17 \cdot \lg\left(\frac{q'_m}{1000}\right) + 50 \lg T - 15 \qquad (6.5.4.3\text{-}1)$$

the distance-dependent noise level can be calculated as follows:

$$L_A = L_W - [10 \cdot \lg A] \qquad (6.5.4.3\text{-}2)$$

> LESER Note: VALVESTAR® calculates and displays L_A for a distance of 1m to the valve if calculation acc. to "AD 2000 A2" is selected.