OPERATING PRINCIPLE

VENT SILENCER

There are a number of pressure-reducing systems used in industry to reduce pressure or discharge a pressurised flow (safety valve, pressure-reducing valve, etc.).

The passage of a pressurised fluid through a restricted cross-section (orifice, perforations, etc.) causes the fluid to expand. The change in cross-section and the significant difference in pressure between upstream and downstream causes high-speed jets to appear. This restricted zone is known as the "Vena contracta".

The ratio of the pressures upstream and downstream of the expansion will define the velocity and pressure inside the vena contracta. When the velocity of the fluid in the vena contracta is less than the speed of sound, the system is subsonic. When the velocity is equal to the speed of sound, the system is said to be sonic. The flow is then clogged and the velocity inside the vena contracta is at a maximum, while the pressure is at a minimum.

However, velocities greater than the speed of sound (supersonic) can be reached at the outlet of the expansion system when there is a sharp pressure drop.

During expansion, turbulence is created. Most of the potential pressure energy is converted into heat and a small proportion into acoustic energy. It is this conversion into acoustic energy that creates the noise. This expansion noise is typical of jet noise. The same sound spectrum can be found behind aircraft nozzles or volcanoes.

Noise generation can be divided into 5 regimes. The higher the speed, the greater the upstream/downstream pressure ratio and the greater the noise :

Plan 1 The flow is subsonic.

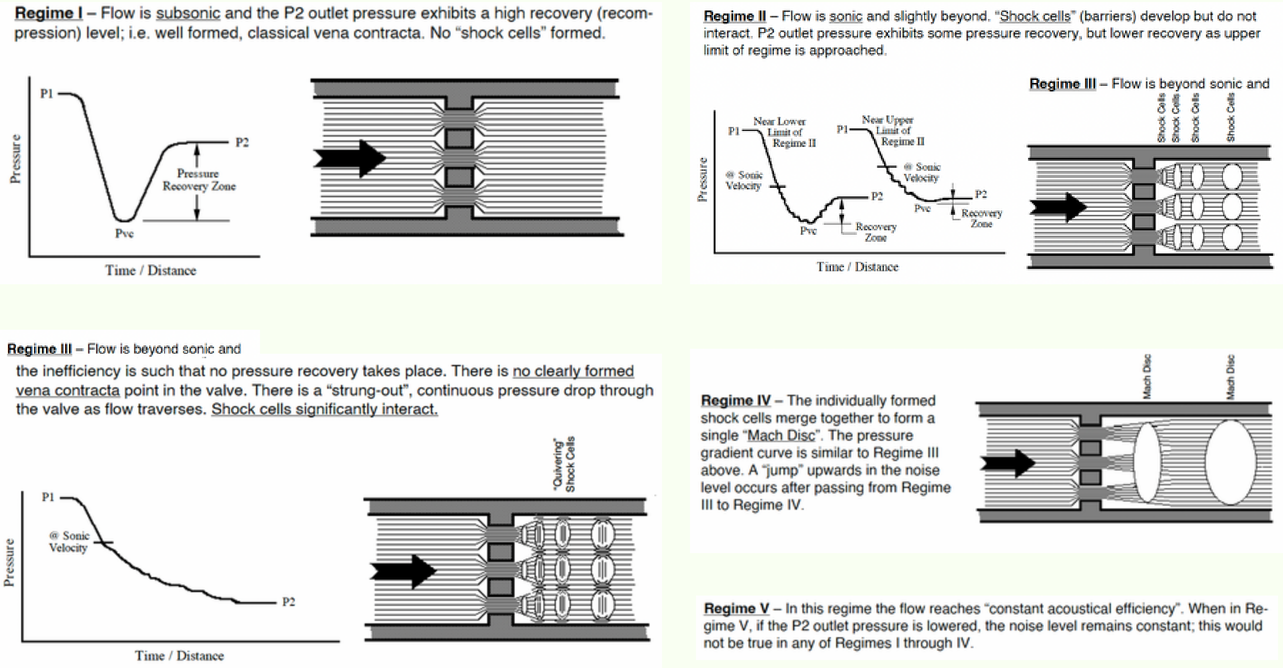
Plan 2 The flow is sonic.

The pressure at the outlet of the vena contracta increases and there is a difference compared with the ambient pressure. Shock cells appear to harmonise the pressures. The speed in these cells exceeds the speed of sound.

Plan 3 Shock cells interact strongly

Plan 4 The shock cells disappear and Mach discs appear

Plan 5 Noise is maximised and the increase in upstream/downstream pressure ratio does not increase in noise.



Mixing noise is a broadband noise. It is due to the small (high frequencies) and large (low frequencies) turbulent structures of the jet and is present whatever the speed.

Shock noise is only present in the sonic regime. It is generated by the presence of shock cells or the Mach disc. It is made up of a tonal component, the screech, and a broadband component. The screech frequency is calculated using the following formula :

$$f = \frac{S.M.c}{D}$$

<u>With</u> :
S: Strouhal number
M: Mach number at regulator outlet
c: Speed of sound
D: Jet diameter

To reduce trigger noise, a VS silencer can be added, consisting of a regulator and a dissipative part. The expansion valve consists of at least one perforated tube and, if necessary, a metal mesh.

The VS silencer has several transformation and noise reduction mechanisms :

- The silencer's pressure reducer allows the trigger to be staged. As the trigger is released several times, the upstream/downstream pressure ratio is reduced and the trigger noise level is reduced.

- The diameter of the valve perforations shifts the sound spectrum towards the high frequencies. As the diameter of each jet is small, the screech frequency is high. Part of the spectrum is then beyond the audibility limit, which reduces the overall noise level.

- The wire mesh acts as a diffuser. It reduces turbulence and only the mixing noise remains. The overall noise level is reduced.

- The dissipative part of the silencer is designed to attenuate medium and high frequencies. As the acoustic waves pass through the fibres, they cause the fibre skeleton to vibrate, resulting in mechanical dissipation of the sound energy and consequent conversion of the energy into heat. In addition, the friction of the air molecules in the porous medium leads to visco-inertial dissipation of the acoustic energy.