



**1-9000 SERIES
LIMIPHON
VALVES**

1-9000 SERIES LIMIPHON VALVES



INTRODUCTION

The noise of control valves is a complex problem, because it simultaneously involves fluid mechanic phenomena as well as often important technological and constructive problems.

Some information about the causes of the noise generated by conventional control valves is summarised in fig. 1.

LIMIPHON valves are designed and constructed to solve the acoustic problems valves are subject to when reducing the pressure of a gas (aerodynamic noise) and when controlling the flow rate of a cavitating liquid (hydrodynamic noise).

AERODYNAMIC NOISE

LIMIPHON valves theoretically allow to meet any noise level requirement.

Pratically the lowest noise level really obtainable is the one directly produced by the flow inside the piping.

HYDRODYNAMIC NOISE

For service with liquids under cavitating conditions, LIMIPHON valves solve the problem totally since they are sized to prevent the cavitation. Therefore the acoustic disturbance produced by the liquid flow is the only remaining one, but this is normally negligible, if the velocity has been suitably chosen.

Noise type		Predominant Frequencies (Hz)	Main characteristics parameters	Limiphon solution
Mechanical vibrations	Non resonant	< 1500	Valve design.	Full guide design and high trim stiffness. Reduced fluid velocities in any section (30 m/s max). No vibration danger.
	Resonant	2000 to 7000	Fluid momentum.	
Cavitation		500 to 4000	Flow rate, pressure, temperature, vapour pressure. K_c and F_L coefficients	F_L and K_c characteristic coefficients pratically next to 1. Significant cavitation phenomena absence.
Aerodynamic		2000 to 6000	Flow rate, pressure. F_L and F_d coefficients	Very low F_d values (even < 0.01). Normal sizing criteria under acoustic viewpoint, i.e. subsonic. Reduction of noise levels down to 30 dB.

Fig. 1 - Noise of conventional control valves.

AERODYNAMIC NOISE

High aerodynamic noise levels may frequently be generated by conventional valves, in which the pressure reduction of a compressible fluid is completed by throttling the flow in a single stage.

The cause of such inconvenience is due to the high velocity reached at the “vena contracta” and to the strong turbulence arising downstream of the seat ring together with “shock cells” of supersonic nature generated downstream of the seat ring.

LIMIPHON valves produced by PARCOL solve the aerodynamic noise problem with three contrivances:

- 1) splitting the flow rate in many diverted flows
- 2) splitting the pressure drop in multiple stages
- 3) expanding the flow sections from the inlet to the outlet

Due to multiple stage design, critical drops, pressure recoveries and high enthalpy changes are eliminated. By this way the pressure drop is more regularly distributed than in conventional valves, where it is mainly concentrated at the “vena contracta”, between the plug and seat.

The process leading the pressure drop can be compared to the process occurring in a very long and winding pipe with a continuous sequence of by-passes always open.

The pressure drop of the fluid at the last stage outlet is reduced if compared with the total Δp .

During the trim selection process, a maximum endeavour is made to keep the last stage under subcritical conditions.

Hence the value of the total sound power generated by the valve is far lower than what it is with conventional design valves.

From a thermodynamic viewpoint (see diagram in fig. 2) the fluid transformation inside LIMIPHON valves is very close to an isenthalpic process, while in throttling type valves the overall isenthalpic process is composed of an isentropic transformation (pressure reduction in vena contracta without heat exchange or external work) and a polytropic transformation (pressure recovery).

The troublesome thermal effects of isentropic transformation, which in case of gas may cause ice formation out of the valve (Joule-Thompson effect) and in case of vapours may generate condensates, strongly erosive for the trim, are therefore avoided. In LIMIPHON valves the seat consists of a disk provided with a sealing projection and a drilled disk stack, assembled in order to create a sequence of radial paths from inside to outside (see fig. 3).

The flow rate through the seat is split into a number of flows, proportional to the plug travel, which the fluid stream is continuously compelled to split into and re-join from. The energy loss is generated by the turbulence created by direction changes and, mainly, by impacts between flows when re-joining.

Flow sectional areas can be gradually increased along the path from inside to outside to control the fluid velocity that would otherwise increase with the decrease of specific gravity of the gas.

The narrower the flow sectional areas of the independent flow paths, the higher the prevailing noise frequency.

The parameter characterising this phenomenon is the valve style modifier F_d (see Bulletin 1-I), the values of which are extremely low in case of LIMIPHON stacks, thanks to the large number of parallel flows and small size of flow sectional areas.

The lower the F_d value, the higher the noise prevailing frequency and, consequently, the higher the acoustic attenuation of body and piping metal walls.

HYDRODYNAMIC NOISE

The hydrodynamic noise (of liquids) arises considerably only in case of cavitation.

The cavitation phenomenon, with formation of vapour bubbles and their subsequent implosion, can generate high noise levels (even over 110 dB(A)).

It should be noted that in this case the acoustic problem is less serious for the valve integrity than the effect of cavitation.

Therefore cavitation must be, in any case, carefully avoided, apart from whatever acoustic consideration, similarly to what suggested for mechanical vibrations.

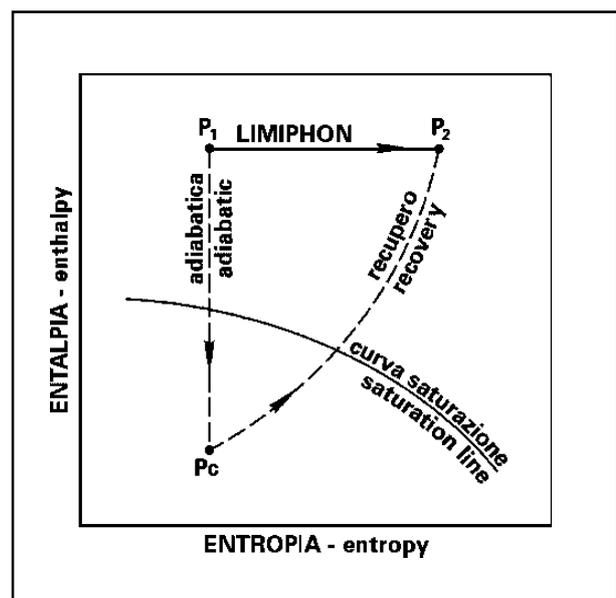


Fig. 2 - Thermo-dynamic processes inside control valves - LIMIPHON valves (continuous line) and throttling valves with pressure recovery (dotted line).

LIMIPHON valves can completely solve the problem, because their recovery coefficient F_L (and consequently K_C) is practically equal to 1 and therefore the pressure inside the trim cannot be lower than the outlet pressure. Under critical conditions (high Δp values with hot liquids) increasing flow area of last stages of LIMIPHON stack may be necessary (or convenient), to reduce the Δp at the last stage, where the cavitation may more easily take place.

VALVE SIZING

COMPRESSIBLE FLUIDS

LIMIPHON valves operating on gas or vapours must be sized according to the following procedure:

- 1) Sizing of connection diameters corresponding to the maximum allowable noise level.
The calculation may be carried out by following the same procedure adopted for the valve noise prediction and assuming specific acoustic parameters (F_d , F_p , etc.).
- 2) Calculation of valve Cv (see equations of bulletin 1-I).
- 3) Selection of seat diameter as a function of the fluid velocity, which can cause erosion and/or vibrations, and of the noise generated when passing through the seat.
- 4) Identification of a family of standard trims meeting the required Cv and compatible with the expected lifetime for the different construction materials (velocity check).
- 5) Calculation of noise level for all selected trims according to the procedure described in Parcol Noise Manual.
- 6) Final choice of the trim as a function of the predicted noise level, actuator performance and valve body dimension.

INCOMPRESSIBLE FLUIDS

- 1) Definition of flow through sections (connections, seat, trim) as a function of the maximum velocity beyond which erosive and/or vibratory phenomena may take place.
- 2) Calculation of required C_v (see Bulletin 1-I).
- 3) Identification of standard trims not subject to cavitation (mainly at the last stage) under the expected operating conditions.

- 4) Final choice of trim and valve travel.

For further details see the example attached to the Cv table.

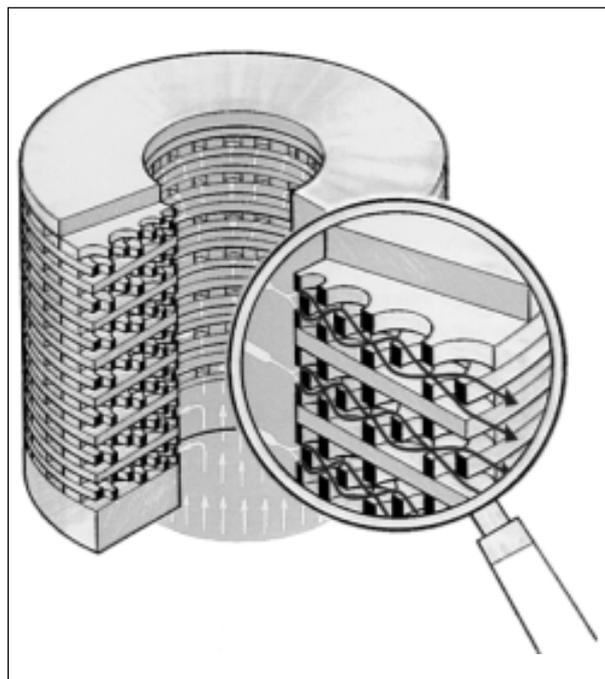


Fig. 3 - Operation schematic of a LIMIPHON valve - The incoming fluid is split-up in a number of parallel flows, each of them being compelled to split again and re-join in other successive stages. The number of stages is equal to half the number of turns.

AERODYNAMIC NOISE PREDICTION

The trim selection of LIMIPHON valves is carried out by keeping the last stage, as far as possible, in sub-critical condition; the prediction of the valve noise level is carried out under this assumption.

The sound power generated by a turbulent flow is a function of the mechanical fluid power and is a small fraction of it, the so called "acoustic efficiency":

$$\eta = W_a / W_m$$

where: $W_m = \frac{1}{2} \cdot q_m \cdot u^2$

The above equation must be integrated with suitable parameters, which take into account the acoustic attenuation of the pipe, the body shape and, mainly, the incomplete transformation of W_m in turbulent flow generated by the isentropic re-compression downstream of the throttling section.

The amount of energy dissipated inside the valve under sub-critical conditions is expressed by the F_L coefficient. This coefficient was intended for use on liquids, but presently is the only one available to evaluate the conditions of compressible fluids in vena contracta.

The transformation process of mechanical energy into acoustic energy inside the valve under subsonic conditions is schematically shown in fig. 4 where the original energetic level is assumed as the one of the fluid in vena contracta.

For sound pressure level prediction see PARCOL Noise Manual.

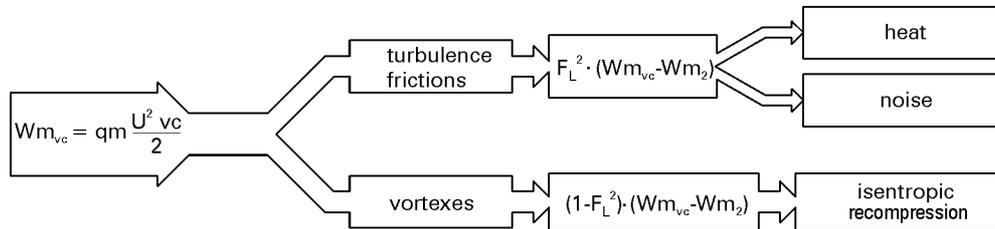


Fig. 4 - Transformation of mechanical energy into acoustic energy in a sub-critical process.

- F_L = Recovery coefficient dimensionless
- qm = Mass flow rate kg/s
- u_{vc} = Velocity in vena contracta m/s
- Wm_2 = Fluid mechanical power at valve outlet watt
- Wm_{vc} = Fluid mechanical power in vena contracta watt

TECHNICAL CHARACTERISTICS

BODY

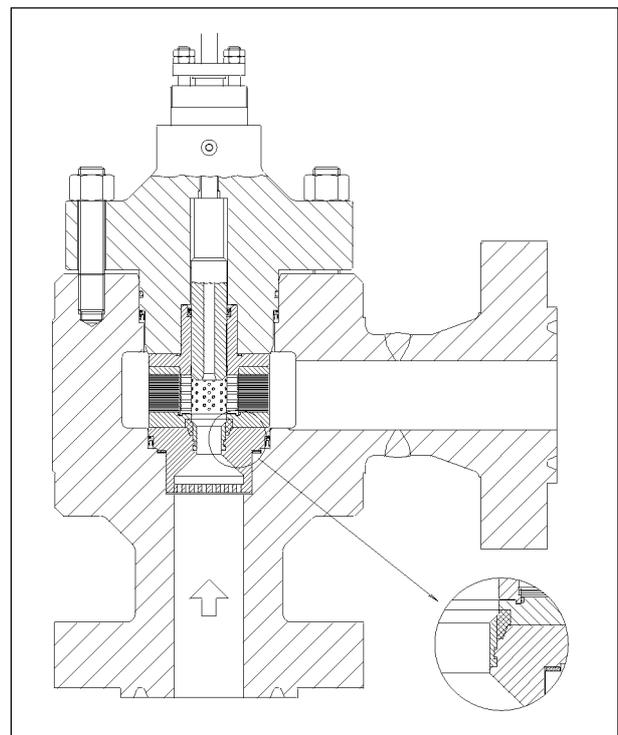
- Types : 1-9100 - straight-way globe valve
1-9400 - 90° angle valve
1-9600 - 90° angle - side inlet - flow over the seat
1-9800 - globe off-set valve.
- Materials : Cast, forged or welded carbon steel, chrome-molybdenum or stainless steel.
- Connections : UNI, ANSI, DIN flanges or ANSI B 16.25 BW ends.
- Ratings : PN 10, 16, 25, 40, 63, 100, 160, 250, 320, 400.
ANSI 150, 300, 600, 900, 1500, 2500.

BONNET

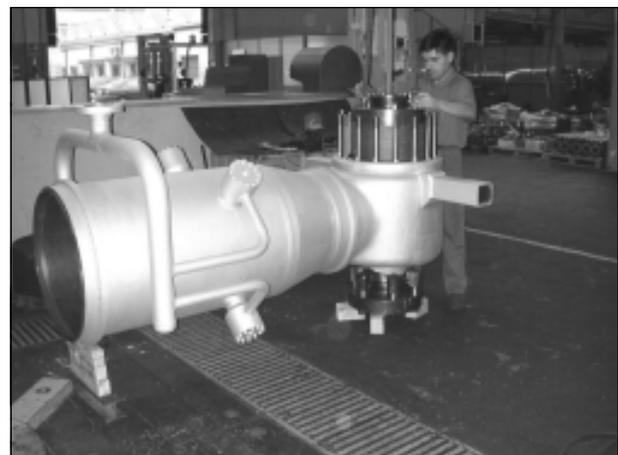
- Materials : Forged or welded in the same material as the body.
- Construction : Plain or finned, flanged or pressure sealed.
- Packing : Teflon - graphite, pure graphite, teflon V-rings.

PLUG

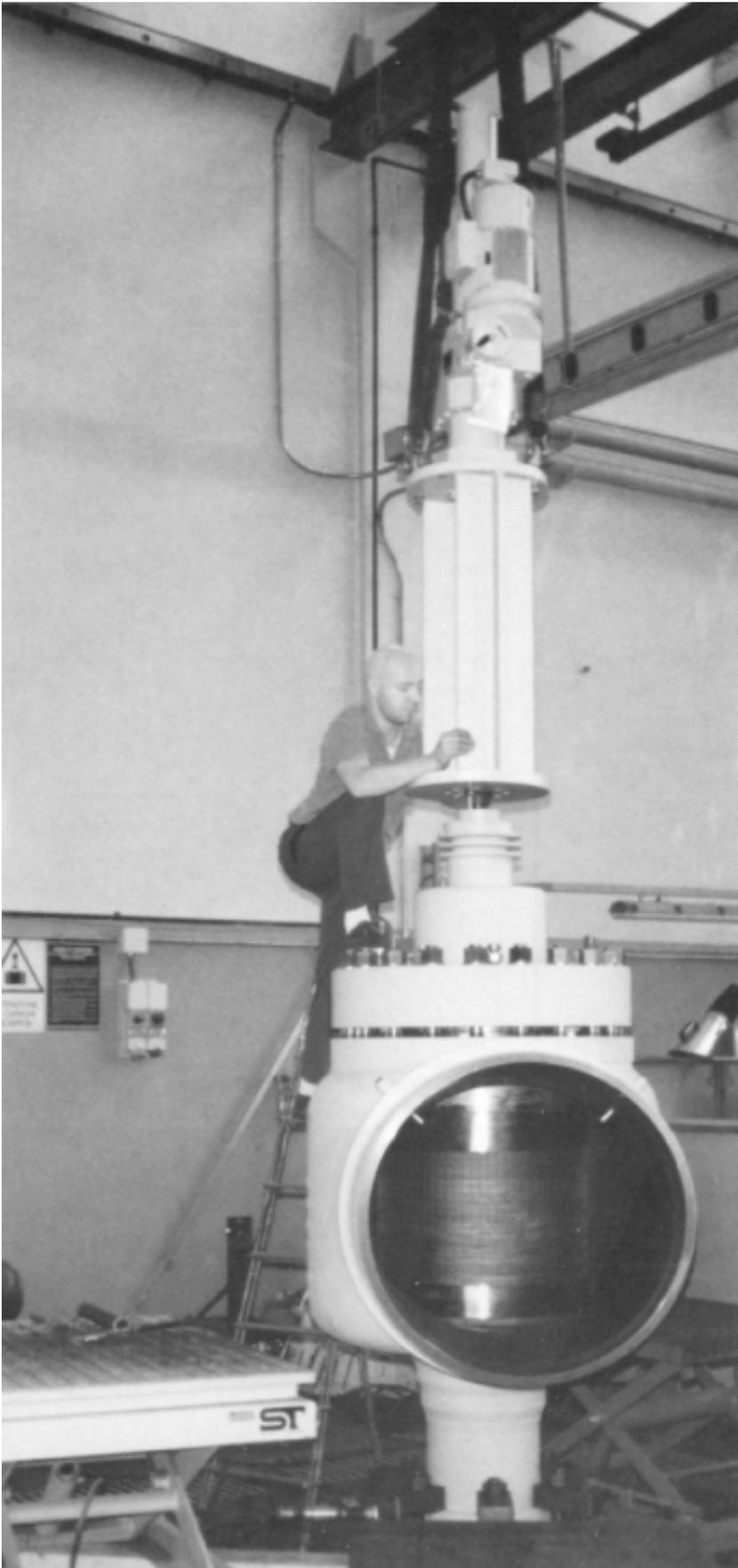
- Construction : It consists of a solid or shaped cylinder.
It is available either as balanced or unbalanced design.



LIMIPHON valve 1-9411 for H.P. boiler feed-water pump by-pass.



Assembling of a 1-9415 Limiphon valve with angle body and downstream desuperheating.



High pressure turbine by-pass
DN 12" x 34"

Materials : 17-4-PH, F6NM, AISI 316 + Stellite, Special Chromium steels.

Throttling characteristic : It is determined by the distribution of the ports discovered by the plug during its stroke.
Normally it is linear but on request can be supplied also as modified linear.

Inserts : In the tight and balanced construction there is a sealing ring inside the sliding chamber of the plug (cage or guide).
Such a ring is made of teflon or pure graphite according to the working temperatures.

DISK STACK

Construction : It consists of a number of drilled disks packed by bolts or welded, clamped between the body and bonnet. The disk stack is usually protected by a drilled cage made of hardened material.

Materials : AISI 304, AISI 316, Special Chromium steels, Monel, 17-4-PH.

SEAT

Construction : It consists of a ring clamped between body and disk stack and bearing the seating surface for the plug.

Leakage classes : - IV or V class IEC 60534-4 for metal-to-metal seating.
- Higher classes with teflon insert.
- For seat diameter up to 4", a special insert which allows tight sealing is available (max $\Delta p = 300$ bar, max T = 200 °C).

Built-in filter : To avoid disk stack clogging, LIMIPHON control valves are normally supplied with a built-in filter integral with the seat or tightened between seat and body in models with flow under the seat.

ACTUATORS

PARCOL diaphragms, series 1-X-200, can be fitted up to a maximum stroke of 200 mm.

PARCOL single or double acting pneumatic cylinders, series 1-X-400 are available.

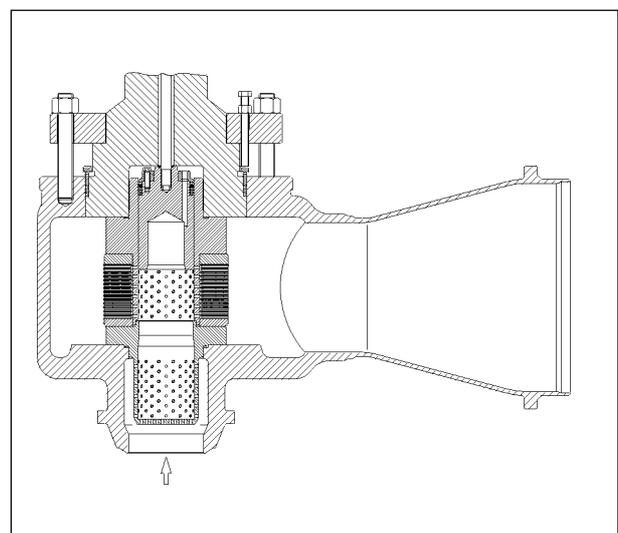
Oleodynamic cylinders are available on request together with control accessories and an electric drive motor.

APPLICATIONS

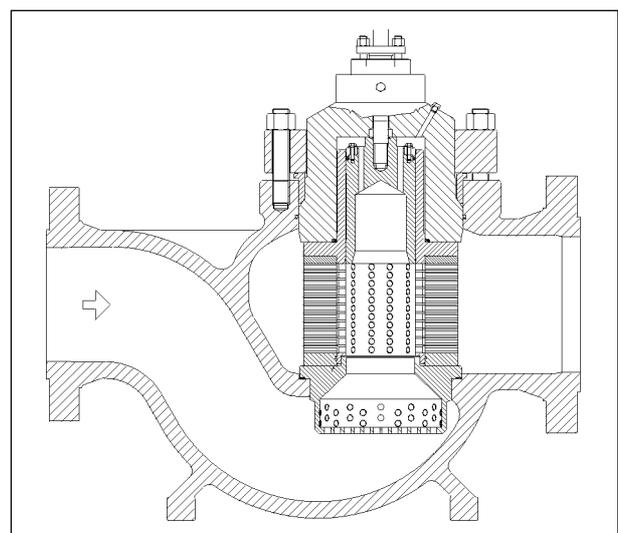
Fluids : For general use with all types of liquids, gases or vapour. Fluids containing particles which could leave deposits should be avoided.

Temperature and pressure : no specific limitations, provided the set standard materials and ratings are fulfilled.

Differential pressure : Liquids: $p_1 - p_2 = 350$ bar
Gases and vapours: $p_1/p_2 = 100$
 $p_1 - p_2 = 250$ bar.



Pressure reducing 1-9411 LIMIPHON control valve for high pressure superheated steam.



Pressure reducing 1-9111 LIMIPHON control valve for service on compressible fluids.

Cv table - standard design for liquid ⁽¹⁾									
DN inch	D seat mm	travel mm	number of stages N ⁽²⁾						ANSI RATINGS
			N = 4	N = 6	N = 8	N = 10	N = 12	N = 14	
1 x 1	10	25	2.5	2	2	1.5	1.5	1.5	150÷2500
	13	25	3.5	3	2.5	2.5	2	2	
1.1/2x1.1/2	13	25	3.5	3	2.5	2.5	2	2	150÷2500
	19	34	7	6	5	4.5	4.5	4	
2 x 2	19	34	7	6	5	4.5	4.5	4	150÷2500
	28	45	16	14	12	11	10	9	
3 x 3	28	45	16	14	12	11	10	9	150÷2500
	38	60	29	25	22	20	18	17	
4 x 4	48	76	46	39	34	31	28	26	150÷2500
	60	76	61	51	45	40	37	34	
6 x 6	60	76	61	51	45	40	37	34	150÷2500
	73	100	92	77	67	61	56	52	
8 x 8	73	100	92	77	67	61	56	52	150÷2500
	95	100	126	104	91	82	75	69	
	117	125	193	160	140	126	115	107	

$\Delta p/\gamma_r \max$ ⁽³⁾ in open position	disk stack material	N = 4	N = 6	N = 8	N = 10	N = 12	N = 14
		AISI series 300	100	150	200	250	300
	hardened stainless steel	160	240	320	400	480	520

(1) LIMIPHON disc stacks designed with constant sections from inlet to outlet.

(2) Including the guiding cage.

(3) Δp is in bar, γ_r is the water specific gravity.

VALVE SELECTION - EXAMPLE

The following procedure should be followed to select the correct valve type:

1 - select the maximum allowed Δp for each stage as a function of the LIMIPHON stack material; (for instance 30 bar for AISI series 300 stainless steel)

2 - calculate the minimum required number of stages $N_{MIN} = \Delta p_{TOTAL} / \Delta p_{stage}$

(for instance: $p_1=156$ bar abs, $p_2=8$ bar abs, $\Delta p_{TOTAL}=148$ bar, $N_{MIN}=6$)

3 - calculate the minimum seat diameter to limit the kinetic load:

$$d_{MIN} = 0.65 \cdot \sqrt{Q \cdot \sqrt{\rho}}$$

where:

Q = required flow rate - m³/h
(for instance 300 m³/h)

ρ = fluid density - kg/m³
(for instance 931 kg/m³)

d_{MIN} = minimum seat diameter - mm
(for instance $d_{MIN}=62$ mm)

4 - calculate the minimum connection diameter to limit the kinetic load:

$$DN_{MIN} = 0.84 \cdot \sqrt{Q \cdot \sqrt{\rho}}$$

where:

DN_{MIN} = minimum connection diameter - mm
(for instance $DN_{MIN}=81$ mm)

5 - once the required Cv is known (for instance $Cv=27.5$), calculated as a function of flow rate Q and of Δp_{TOTAL} , select in the table for the Limiphon stack the Cv immediately larger meeting the requirements for N_{MIN} and d_{MIN} (for instance $Cv=77$ with valve body 4"x 4", N = 6 and $d_{seat}=73$ mm);

6 - check the last stage for cavitation:

$$\frac{\Delta p/N}{p_2 + \Delta p/N - p_v} < 0.8$$

where p_v is the vapour pressure of the liquid at the inlet temperature.

(for instance $p_v=3.62$ bar abs, the requirement is not met. To avoid cavitation at the last stage a LIMIPHON disk stack with N = 10 and Cv = 61 is required).

STANDARD CONSTRUCTIONS FOR STEAM AND GAS APPLICATIONS					
Straight way body 1-9100 type			90° angle body 1-9400 type		
VALVE SIZE in.	ANSI ratings	Ø SEAT mm	VALVE SIZE in.	ANSI ratings	Ø SEAT mm
1 x 1	150 ÷ 1500	13-19	1 x 1	150 ÷ 2500	13-19
1 x 2			1 x 2		
			1 x 3		
1.1/2 x 1.1/2	150 ÷ 1500	19-28	1.1/2 x 1.1/2	150 ÷ 2500	19-28
1.1/2 x 2			1.1/2 x 2		
			1.1/2 x 3		
2 x 2	150 ÷ 1500	28-38	2 x 2	150 ÷ 2500	28-38-48
2 x 3			2 x 3		
			2 x 4		
3 x 3	150 ÷ 1500	48-60	3 x 3	150 ÷ 2500	48-60-73
3 x 4			3 x 4		
			3 x 6		
4 x 4	150 ÷ 1500	60-73	4 x 4	150 ÷ 1500	60-73-95
4 x 6			4 x 6		
			4 x 8		
6 x 6	150 ÷ 900	73-95-117	6 x 6	150 ÷ 1500	73-95-117-147
6 x 8			6 x 8		
			6 x 10		
			6 x 12		
8 x 8	150 ÷ 900	117-147-167	8 x 8	150 ÷ 900	117-147-167-185
8 x 10			8 x 10		
			8 x 12		
			8 x 16		
10 x 10	150 ÷ 600	147-167-185	10 x 10	150 ÷ 600	167-185-215-246
10 x 12			10 x 12		
			10 x 14		
			10 x 20		
12 x 12	150 ÷ 600	185-215-246	12 x 12	150 ÷ 600	185-215-246-268
12 x 14			12 x 14		
			12 x 18		
			12 x 24		
14 x 14	150 ÷ 600	215-246-268	14 x 14	150 ÷ 600	215-246-268-307
14 x 16			14 x 16		
			14 x 20		
			14 x 24		

VENTS

LIMIPHON valves can be usefully installed on vents, which, missing any pipe attenuation, can generate very high sound pressure levels (even 150 dB(A)).

Besides the direct use of LIMIPHON valves (see fig. 5a), 3-9800 series fixed port resistors (incorrectly called "silencers") may also be installed, which consist of LIMIPHON stacks mounted on the chimney end (see fig. 5b).

Due to the large dimension of the piping downstream of the LIMIPHON valve the (a) solution is convenient when the vent is close to the reduction station only. The (b) solution, on the contrary, turns out more economic when the vent is far from the release valve location. In this case noise calculation is required both for vent and valve, which is usually a low-noise.

For noise level prediction see PARCOL Noise Manual.

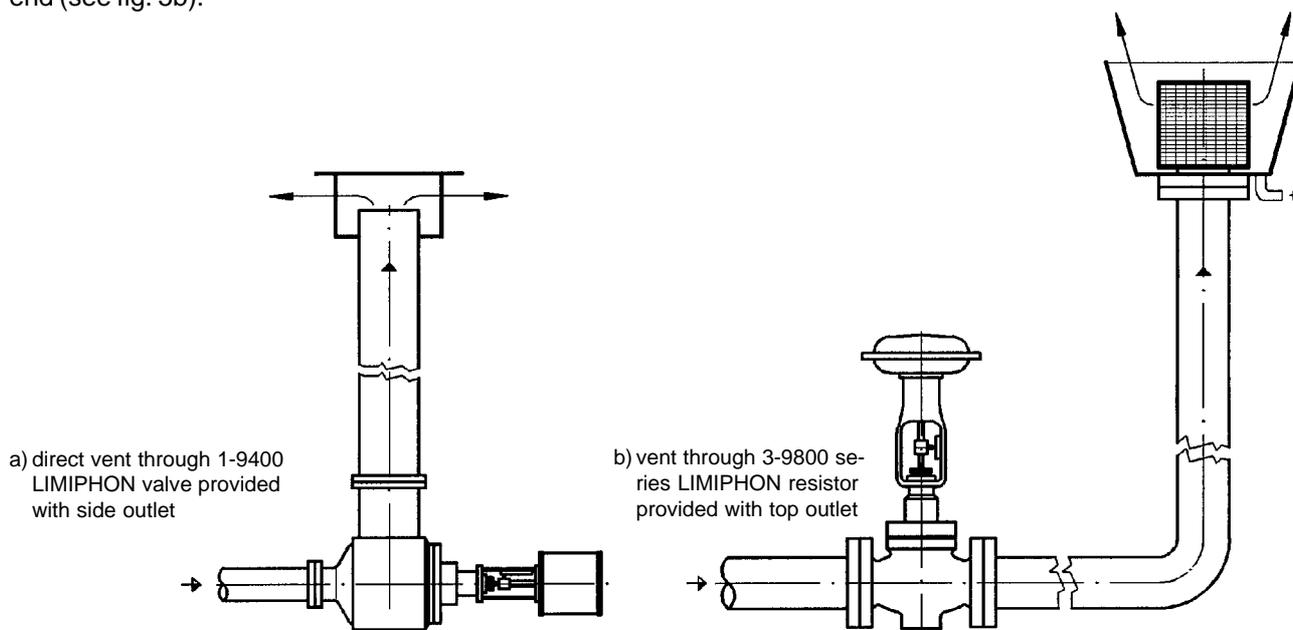
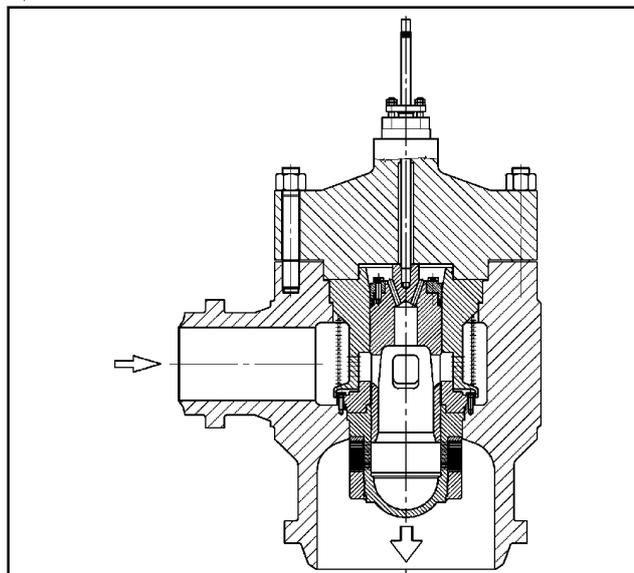


Fig. 5 - Vent installation types



Pressure reducing 1-9611 Limiphon flow to close control valve - suitable for the most demanding service conditions - leakage class V with non balanced or pilot-operated plugs - filtering pre-charge (on request). High Δp , high turndown, low-noise (< 85 dBA) guaranteed in all operating conditions - anti-shock design suitable for high number of cold start-up. In combination with 3-4100 or 1-4442 desuperheating devices, is used for reducing /desuperheating applications on high capacity turbine by-pass.

LIMIPHON VALVES FOR REDUCING/DESUPERHEATING

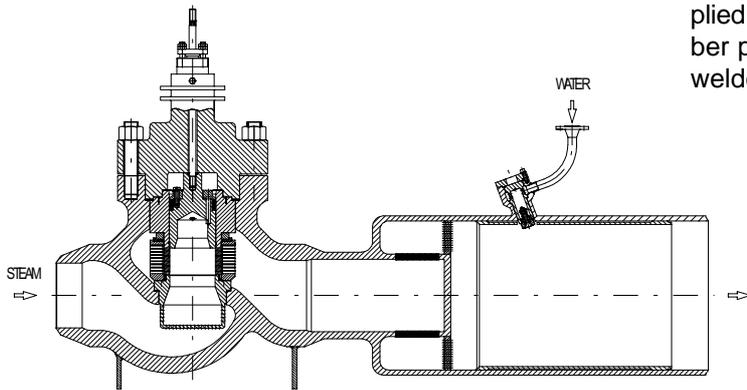
1-9000 series LIMIPHON valves are widely used in steam pressure reduction and desuperheating stations, quite frequent in turbine by-pass lines.

LIMIPHON valves are the technically ideal solution for the above process, as well as for all applications where a large pressure reduction takes place and where regular operation, absence of vibrations and maximum noise reduction under flow rate changes are required.

Typical and widespread diffused applications in any turbine H.P. and high power L.P. by-pass grant high turndown with regard to noise level and regular operation; such a characteristic is utmost important in starting circulation boilers. For the above service 1-9000 series Limiphon valves are normally linked to Parcol LV or Spraysat systems according to required performances.

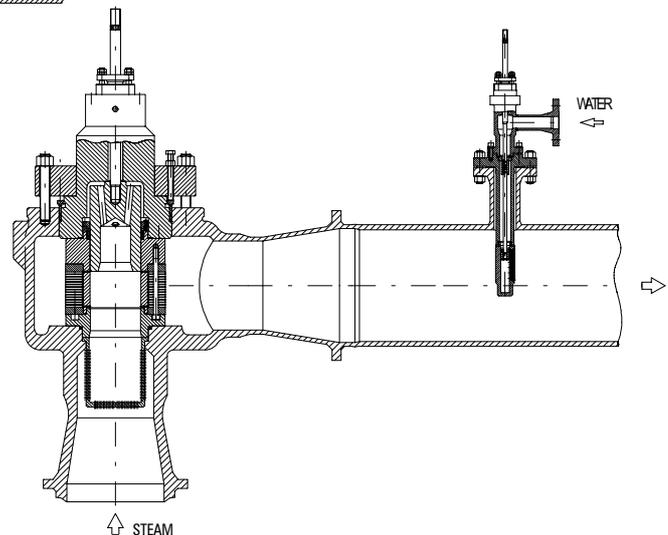


1-9445 Limiphon reducing/desuperheating valve supplied with angle body, bottom inlet and injection chamber provided with multiple LVM type spring nozzles welded downstream.



1-9154 reducing/desuperheating LIMIPHON valve provided with cast straight body, inlet under the seat, removable protective filter under the seat, balanced plug supplied with class V leakage sealing, HAS silencer at the outlet, injection chamber provided with LVL type spring nozzle.

Design suitable for reduced flow rate, p_1/p_2 and turndown values; suitable on the contrary for high Δp and maximum noise reduction.



1-9416 pressure reducing/desuperheating LIMIPHON valve supplied with angle body, bottom inlet, sliding and adjustable sealing between body and bonnet, balanced plug, class V leakage, removable protective filter under the seat, Spraysat type desuperheater.



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