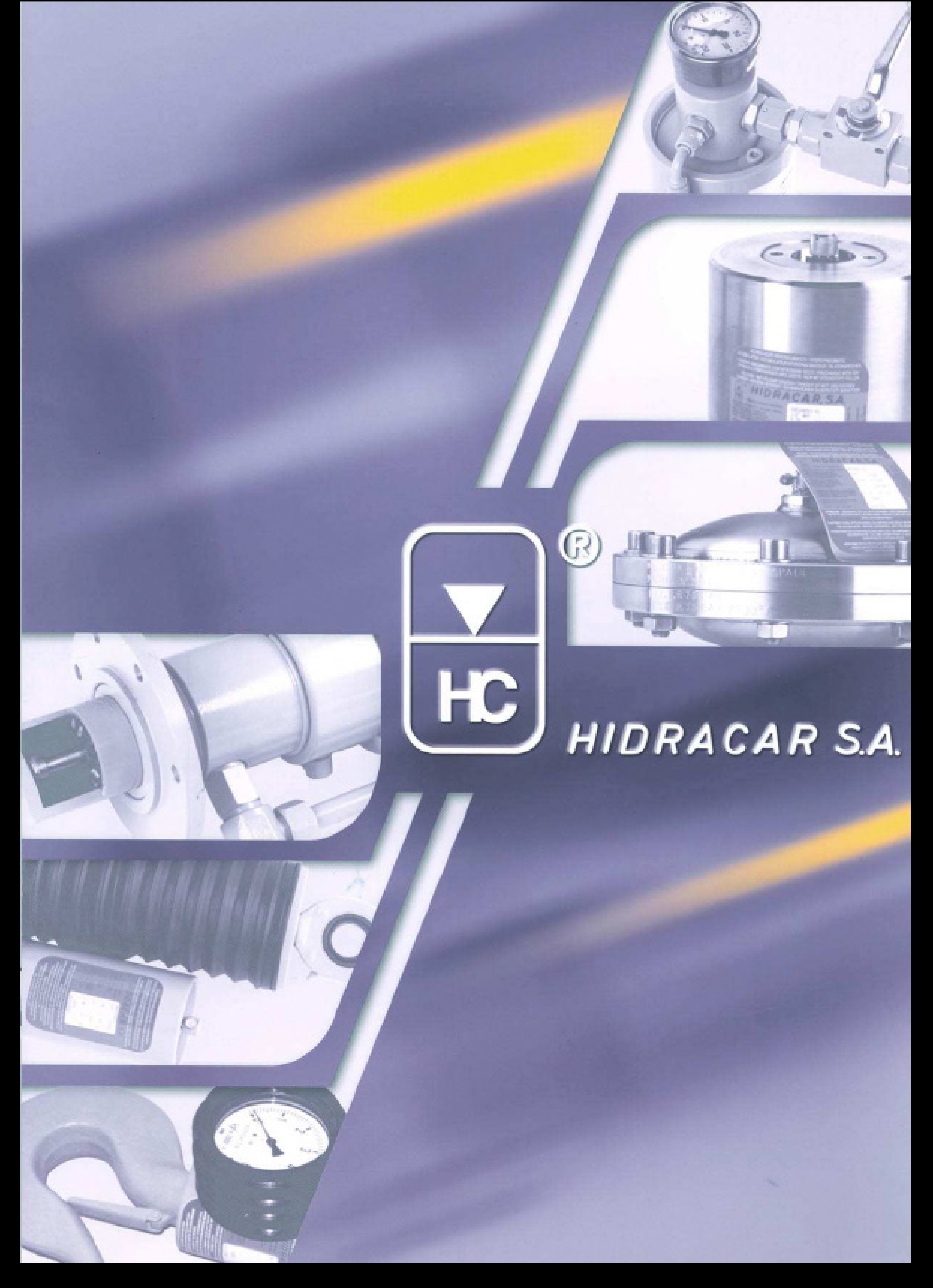
HC
HIDRACAR S.A.


WE DESIGN AND MANUFACTURE:...
Bladder, Membrane & Bellows Pulsation Dampers
(all dismountable units)
Piston Accumulators
Oleo-pneumatic Suspensions for Vehicles with a High Relation Loaded / Unloaded
Shock Absorbers
Oleo-hydraulic Starters for Diesel Engines
HIDRACAR S.A.
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since 1974
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Pol. Ind. Les Vives - c/ Anaïs Nin, 14
08295 Sant Vicenç de Castellet, Barcelona (SPAIN)
www.hidracar.com E-mail: hidracar@hidracar.com
Tel.: +34 93 833 02 52 Fax: +34 93 833 19 50

HIDRACAR S.A.

WHEN YOU BUY A

HIDRACAR

ACCUMULATOR OR PULSATION DAMPENER, YOU GET:

- **More than 35 years of experience in designing, manufacturing and applying hydro-pneumatic accumulators.**
- **A pressure apparatus that meets the CE regulations.**
- **The machining precision of CNC lathes.**
- **Safety:**
  - *All our accumulators undergo hydraulic tests at 1.5 times its maximum design pressure.*
  - *Civil liability insurance coverage (FIATC Cía. de Seguros).*
- **Quality control:**
  - *We have the ISO 9001 certification.*
  - *Computerised manufacturing registry control that makes possible to identify every single accumulator manufactured by us since 1976.*
  - *The charging gas valve keeps its seal up to 700 bar.*

With all the features shown above, do you still have any doubt? If so, please, contact us, we will clarify any data or give you any extra information you could need.

We remain waiting for your enquiries.

Certificate

Standard **ISO 9001:2008**

Certificate Registr. No. 0.04.07074

TÜV Rheinland Ibérica Inspection, Certification & Testing S.A.
certifies:

Certificate Owner: **HIDRACAR, S.A.**
Pol. Ind. "Les Vives", s/n
C/ Anaïs Nin, 14
E-08295 Sant Vicenç de Castellet (Barcelona)

Scope: Design and Manufacture of Hydropneumatic Accumulators, Pulsation Dampers, Dynamometers, Shock Absorbers, Oleohydraulic Starters and Suspension Cylinders.

An audit was performed, Report No. 07074. Proof has been furnished that the requirements according to ISO 9001:2008 are fulfilled.

The due date for all future audits is 28-09 (dd-mm).

Validity: The certificate is valid from 2013-12-28 until 2016-12-27.
First certification 2007-12-28.

2014-02-10 TÜV Rheinland Ibérica Inspection, Certification & Testing S.A.
Garrotxa, 10-12 – E-08820 El Prat de Llobregat

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IAF ENAC CERTIFICACIÓN Nº 161 C - SC 037

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Precisely Right.

HIDRACAR S.A.

HIDRACAR ACCUMULATOR REFERENCE CODE IDENTIFICATION

This is the standard *HIDRACAR S.A.* accumulator reference code layout (without colour; here only for code section identification purposes):

X # # # X # # X # - X X X X / X X

- The first letter (**X**) indicates the type of accumulator:

  U for bladder **M** for membrane **F** for bellows **P** for piston

- The following three digits (###) identify the volume of the accumulator:

U001	0.09 litres	M008	0.80 litres	U040	3.80 litres	M100	10.0 litres	U250	25.0 litres
P001	0.14 litres	U010	0.95 litres	M040	4.00 litres	F100	10.0 litres	P250	25.0 litres
U002	0.18 litres	P010	1.00 litres	F040	3.70 litres	F100i	10.0 litres	P300	30.0 litres
M002	0.20 litres	M012	1.20 litres	F040i	3.70 litres	P100	10.0 litres	U320	32.0 litres
F002	0.15 litres	U015	1.50 litres	P040	4.00 litres	P120	12.0 litres	U350	35.0 litres
P002	0.20 litres	F015	1.50 litres	P050	5.00 litres	P140	14.0 litres	P350	35.0 litres
U003	0.35 litres	F015i	1.50 litres	U060	5.60 litres	U150	15.0 litres	P400	40.0 litres
F003	0.30 litres	P015	1.50 litres	M060	5.60 litres	M150	15.0 litres	P500	50.0 litres
P003	0.35 litres	P020	2.00 litres	F060	5.60 litres	F150	15.0 litres	P600	60.0 litres
M004	0.40 litres	P025	2.50 litres	F060i	5.60 litres	F150i	15.0 litres	P700	70.0 litres
P005	0.50 litres	U030	2.60 litres	P060	6.00 litres	P150	15.0 litres	P800	80.0 litres
U007	0.65 litres	M030	2.80 litres	P070	7.00 litres	P160	16.0 litres	P900	90.0 litres
F007	0.70 litres	F030	2.60 litres	P080	8.00 litres	U200	20.0 litres	P990	99.0 litres
F007i	0.70 litres	F030i	2.60 litres	P090	9.00 litres	P200	20.0 litres		
P007	0.70 litres	P030	3.00 litres	U100	10.4 litres	P220	22.0 litres		

- The second letter (**X**) refers to the type of gas charging valve: **A** for a ¼" BSP valve

- The second set of two digits (##) refers to the design pressure of the accumulator (number to be multiplied by 10 to give the actual pressure in bar units):

  Examples:

  02 (0)2 x 10 = 20 bar **18** 18 x 10 = 180 bar **41** 41 x 10 = 410 bar

- The third letter (**X**) identifies the material of the separator element between the charging gas (N_2 or air) and the liquid in the circuit (except for the piston accumulators, for which it identifies the material of "o"-rings):

N Nitrile rubber (NBR) **E** EPDM rubber **V** FKM rubber **B** Butyl rubber
S Silicone rubber **G** Hydrogenated NBR **R** Low temperature Nitrile rubber
T TFM y PTFE **F** FKM (70% Fluorine) **C** Neoprene rubber **A** Aflas **H** Hypalon
I Stainless steel

- Followed by a last digit (#) which refers to the number of connecting ports (see the standard thread size available on each technical note; these are referenced at the very end of the code as such if different from our standard thread size):

1	One connection port	2	Two connection ports

- Finally, the last set of two to four letters (XXXX) (or its absence) identifies the raw material of the accumulator body and bladder or membrane inserts:

AI AISI 316L Stainless steel   DU Duplex   SDU Super Duplex   TI Titanium
HAST Hastelloy   AC Carbon steel   ALLY Special alloy
SA Carbon steel – internal nickel coating accumulator for water service
PP Polypropylene   PC PVC   PCC Chlorinated PVC   PD PVDF

- In some instances an extra codification for one or more special characteristics is added, separated by a slash after the basic part of the reference code:

E Special manufacture   DR Quick dismantling design   CR Reinforcing jacket
IN Indicator rod attachment   BA With a connection for an additional cylinder
NS Apparatus without welded seams   IC Internal HALAR® coating   SB No insert bladder
TF PTFE connection port   TFG Graphite-PTFE connection port
PE Polyethylene connection port   PD PVDF connection port   PC PVC connection port
HC Hastelloy connection port   CC Heating jacket
(90°) Connection port at 90º   (LINIA) In-line accumulator

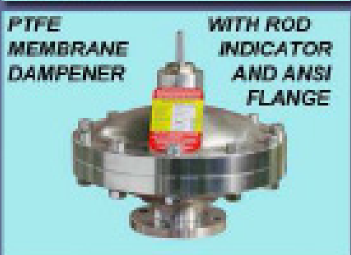
Let's see an overall example:

F007A11I1-AI/CC
F007A11I1-AI/CC

F	Bellows type	007	0.65 litres volume
A	fitted with a ¼" BSP valve	11	110 bar design pressure
I	Stainless steel bellows	1	One connection port
AI	Stainless steel body	CC	Heating jacket

So this reference corresponds to a stainless steel, bellows type, accumulator with an internal volume of 0.65 litres, designed for working at a pressure of 110 bar, fitted with a stainless steel bellows, one standard connection port, a ¼" BSP gas charging valve and heating jacket.

8th Rev., May 2015



HIDRACAR S.A.

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"We make liquids flow smoothly through pipes"

BLADDER, MEMBRANE & BELLOWS

PULSATION DAMPENERS

TO STABILIZE THE FLOW AND PRESSURE IN CIRCUITS WITH VOLUMETRIC PUMPS

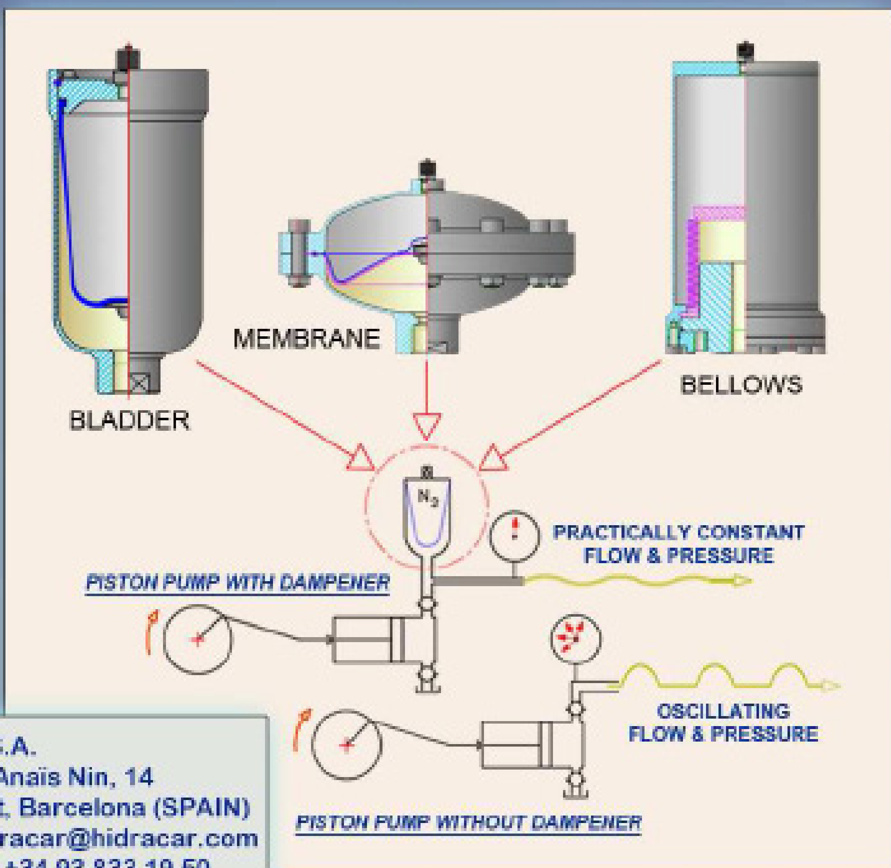
- ✓ ALLOW PUMPS TO WORK WITHOUT SHOCKS, INCREASING ITS LIFE AND THE LIFE OF FILTERS, FLOWMETERS AND OTHER ACCESSORIES
- ✓ GIVE MORE ACCURACY TO PRESSURE GAUGES AND FLOWMETERS
- ✓ PREVENT LEAKAGE IN PIPE CONNECTIONS, CREATED BY PRESSURE PEAKS

SIZES RANGE FROM 0.07 TO 35 LITRES AND WORKING PRESSURES UP TO 1,000 bar

MATERIALS:

BODY: AISI 316L, POLYPROPILENE, PVC, PVDF & OTHERS

SEPARATOR: NITRILE, EPDM, FKM, SILICONE, PTFE, STAINLESS STEEL & OTHERS



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Tel.: +34 93 833 02 52 Fax: +34 93 833 19 50

FLOW GRAPHICS OF DIFFERENT PISTON PUMPS SHOWING THE LIQUID VOLUME AND FLOW ACROSS THE PULSATION DAMPER

T = time employed by the crankshaft when turning one revolution (ex. 0,4 sec.=150 r.p.m.)
C = capacity of the piston head (ex. 509 c.c. for the three pump types)
δ = theoretically the amount of liquid going in and out of the dampener in each cycle
M.I.F. = max. instantaneous flow   M.F. = mean flow

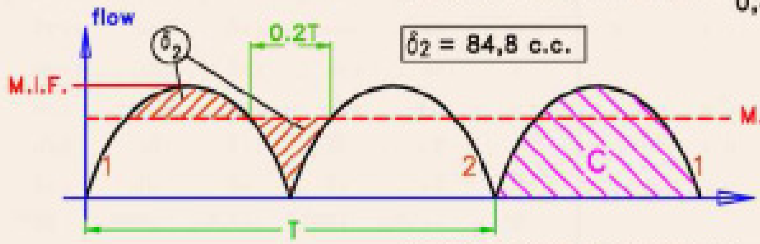
ONE SINGLE PISTON PUMP

$$\frac{C}{2} = \delta_1$$

Max. flow through the damper = $\frac{254,5\text{x}60}{0,43\text{x}0,4\text{x}1000}$ = 88,8 liters/minute

TWO SINGLE PISTON PUMP (cranks at 180°)

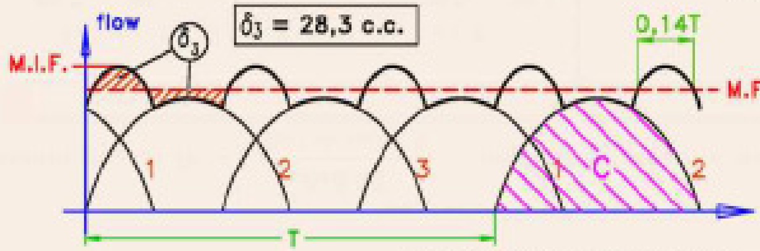
$$\frac{C}{6} = \delta_2$$



Max. flow through the damper = $\frac{84,8\text{x}60}{0,2\text{x}0,4\text{x}1000}$ = 63.6 liters/minute

THREE SINGLE PISTON PUMP (cranks at 120°)

$$\frac{C}{15} = \delta_3$$



Max. flow through the damper = $\frac{28,3\text{x}60}{0,14\text{x}0,4\text{x}1000}$ = 30,3 liters/minute

EASY DAMPENER SIZE SELECTION ACCORDING TO THE CAPACITY PER HEAD (*), AND % OF RESIDUAL PULSATION ADMITTED

DAMPER TYPES REF.			DAMPENERS VOLUME (litres)			1 PISTON PUMP		2 PISTONS PUMP		3 PISTONS PUMP	
						% (+,-) OF RESIDUAL PULSATION ADMITTED					
						±3%	±6%	±3%	±6%	±3%	±6%
BLADDER	MEMBRANE	BELLOWS	BLAD.	MEMB.	BELL.	(*) CAPACITY PER HEAD					
U001			0,07			6cc	12cc	16cc	32cc	50cc	100cc
U002	M002	F002	0,15	0,2	0,15	12 "	24 "	35 "	70 "	105 "	210 "
U003	M004	F003	0,35	0,4	0,3	24 "	48 "	70 "	140 "	210 "	420 "
U007	M008	F007	0,65	0,8	0,7	50 "	100 "	155 "	310 "	465 "	930 "
U010			0,95			75 "	150 "	230 "	460 "	675 "	1350 "
U015	M012	F015	1,4	1,3	1,4	95 "	190 "	310 "	620 "	900 "	1800 "
U030	M030	F030	2,6	2,7	2,6	210 "	420 "	615 "	1230 "	1850 "	3700 "
U040	M040	F040	3,7	3,9	3,7	290 "	580 "	875 "	1750 "	2650 "	5300 "
U060	M060	F050	5,6	5,1	5,6	405 "	810 "	1200 "	2400 "	3650 "	7300 "
U100	M100	F090	9,5	10	10	750 "	1500 "	2270 "	4540 "	6900 "	13800"
U150	M150	F150	15	15	15	1195 "	2390 "	3600 "	7200 "	10950"	21900"
U350			35			2800 "	5600 "	8425 "	16850"	25000"	50000"

NOTE: THE TABLE VALUES ARE APPROXIMATE AND CORRESPOND TO A CONSTANT TEMPERATURE OF THE LIQUID AND ENVIRONMENT

FORMULA TO OBTAIN THE PUMP CAPACITY PER REVOLUTION $\frac{\text{FLOW (L/h)}}{60 \text{ x s.p.m.}}$

(L/h =litres/hour)
(s.p.m.= strokes per minute) crankshaft revolutions per minute

WE CAN CHANGE THE DATA WITHOUT PREVIUS NOTICE

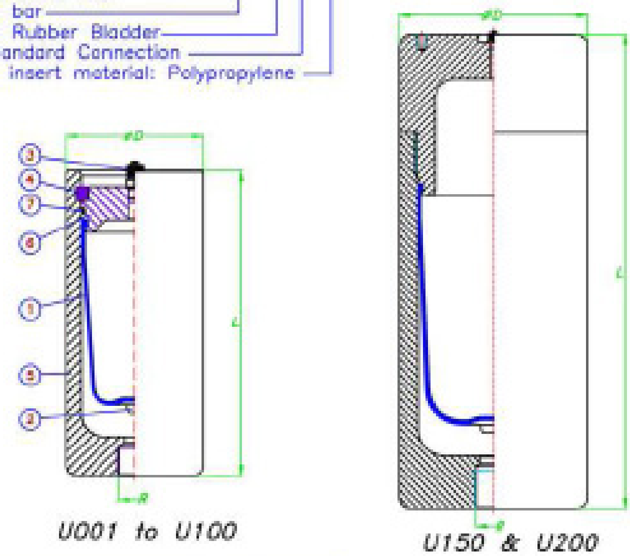
OTHER PRODUCTS WE MANUFACTURE: OLEOPNEUMATIC SHOCK ABSORBERS, OLEOHYDRAULIC TENSIONERS, OLEOHYDRAULIC STARTERS FOR EMERGENCY MARINE DIESEL ENGINES OLEOPNEUMATIC SUSPENSIONS FOR VEHICLES WITH HEAVY LOADS

AUTO 2014 / B-DOS / PUBLIPULSANTES-ING / REV16 (2014)
Rev 16

ORDER EXAMPLE: U007 A01 V 1 PP

Capacity: 0.65 litre
A01≡10 bar
V= FKM Rubber Bladder
3/4" Standard Connection
Body & insert material: Polypropylene

FOR HIGHER PRESSURES, SIZES, MATERIALS AND THREAD CONNECTIONS, PLEASE CONSULT



Value of "K": $\frac{\text{Maxi. Pressure}}{\text{Filling gas Pressure}} \leq$ K (@Constant Temp.)

PULSATION DAMPER REF.	VOLUME (litres)	D (mm)	L (mm)	R (BSP)	WEIGHT (Kg) PC & PD	WEIGHT (Kg) PP	K VALUE
U001	0.09	60	105	3/8"	0.35	0.25	2.5
U002	0.18	80	135	1/2"	0.70	0.50	
U003	0.36	90	170	3/4"	1.20	0.80	3.0
U007	0.65	100	230		1.80	1.20	3.5
U010	0.95	130	245	1"	3.00	2.00	3.0
U015	1.50		295		3.50	2.40	3.5
U030	2.60	160	325		5.00	3.50	
U040	3.80		422		5.80	4.00	5.0
U060	5.60	198	458	1-1/2"	13.00	9.00	
U100	10.40	250	500	2"	20.40	14.00	4.0
U150	15.00		672		23.30	17.00	2.5
U200	20.00		880		27.70	21.00	3.0

N°	DENOMINATION	QT.	MATERIALS
7	"O"-RING	1	NBR, EPDM, FKM & BUTYL
6	COVER	1	(+) PP, PD or PC
5	BODY	1	(+) PP, PD or PC
4	RETAINING RING	1	(+) PP, PD or PC
3	INFLATING AIR VALVE	1	AISI 316L 1/4"BSP
2	INSERT (BUTTON)	1	(+) PP, PD or PC
1	BLADDER	1	NBR, EPDM, FKM & BUTYL

ATTENTION! ALWAYS MUST BE MOUNTED VERTICALITY (VALVE 3 ON TOP)

MAX. WORKING PRESSURE: 10 bar-g

Note: The size U001 does not have an O-Ring (7)

Standard Bladder Rubbers: N=NBR, E=EPDM, V=FKM, B=BUTYL

WORKING LIMITS TEMPERATURES(°C):		MINIMUM SAFETY FACTOR: 4:1
(-5°, +50°C for PVC & PP)	(+) PC = PVC	
(-10°, +70°C for PVDF)	(+) PP = Polypropylene	
	(+) PD = PVDF	

THE MAXI TEMPERATURE CAN BE REDUCED DEPENDING ON THE LIQUID IN CONTACT

TOLERANCES: External dimensions±1.5% Volume±2.5% Weight ±5%

These Pulsation Dampeners ought to be filled with gas at a value of 0.80x the pressure to stabilize and that at the working temperature

NOTE: The precharge with gas or air must be done slowly and with our charging tool Ref. BV010A1TM

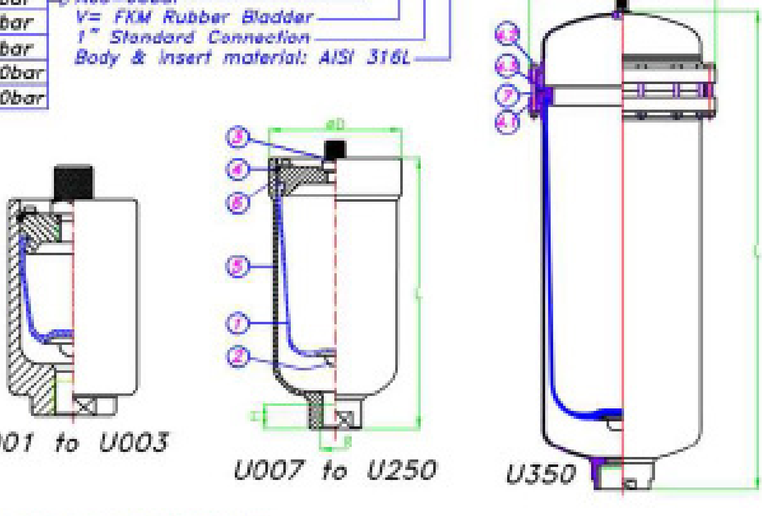
HIDRACAR SA 08295 S.VTE. CASTELLET (BARCELONA) SPAIN TEL.34.93.8330252 FAX.34.93.8331950	Customer	Customer Ref.	Replaced Drg.N° AV.PL.BP.IN.DOC(Rev.12)	Drawn E.Ponsa	Approved M.Carcaré	
	Title PLASTIC PULSATION DAMPERS (standard units)		Drg.No AV.PL.BP.IN.DOC.	Rev. 13	Date Nov-14	Scale none

ORDER EXAMPLE: U030 A03 V 1 AI

A02≡20bar
A03≡30bar
A04≡40bar
A05≡50bar
A18≡180bar
A26≡260bar

Capacity: 2,6 litres
A03≡30bar
V= FKM Rubber Bladder
1" Standard Connection
Body & insert material: AISI 316L

FOR HIGHER PRESSURES, SIZES, MATERIALS AND THREAD CONNECTIONS, PLEASE CONSULT



H = MAXI. LENGTH OF THREAD CONNECTION

Value of "K": $\frac{\text{Maxi. Pressure}}{\text{Filling gas Pressure}} \leq$ K (@Constant Temp.)

PULSATION DAMPER Reference	VOLUME (litres)	DESIGN PRESSURE (bar-g @20°C)	D (mm)	L (mm)	R (BSP)	H (mm)	WEIGHT (Kg)	K VALUE
U001	0.09	260	55	100	3/8"	14	0.1	2.5
U002	0.18	180	70	118	1/2"		1.8	
U003	0.36		85	161		16	3.6	3.0
U007	0.65	50	90	205	3/4"	20	2.5	3.5
U010	0.95	40	110	200		25	4.3	3.0
U015	1.50			245			4.6	3.5
U030	2.60	30	140	295	1"	27	5.3	
U040	3.80			390			5.7	5.0
U060	5.60	40	170	414	1-1/2"	30	10.0	
U100	10.40	30	220	442	2"		14.5	4.0
U150	15.00			625			18.5	5.0
U250	25.00	20	270	691	2-1/2"		26.0	4.0
U350	35.00		302	797			28.5	3.5

No	DENOMINATION	QT.	MATERIALS
7	"O" RING	1	NBR, EPDM & FKM
6	COVER	1	AISI 316L
5	BODY	1	AISI 316L
4.3	RETAINING RING	1	St-52Elec. Nikel plat.
4.2	BOLTS & NUTS	14	DIN 912 & 934 A4-70
4.1	RETAINING RING	2	St-52Elec. Nikel plat.
4	RETAINING RING	1	DIN17224 (AISI 316L)
3	INFLATING N 2 VALVE	1	AISI 316L (1/4" BSP)
2	INSERT	1	AISI 316L
1	BLADDER	1	NBR, EPDM & FKM

ATTENTION! ALWAYS MUST BE MOUNTED VERTICALITY (VALVE 3 ON TOP)

Standard Bladder Rubbers: N=NBR, E=EPDM, V=FKM

(Other Rubbers: Butyl, Hypalon, HNBR, etc.)	N	E	V
Rubbers Max. Working Temperatures (°C)	+80 −15	+130 −30	+170 −10

Working Temperatures versus Working Pressures **

For a temperature of 80°C correspond design pressure x 0.87
" " " " 130°C " " " x 0.78
" " " " 170°C " " " x 0.72

THE MAXI TEMPERATURE CAN BE REDUCED DEPENDING ON THE LIQUID IN CONTACT

TOLERANCES: External dimensions±1.5% Volume±2.5% Weight±5%

These Pulsation Dampeners ought to be filled with gas at a value of 0.80x the pressure to stabilize and that at the working temperature

NOTE: The precharge with gas or air must be done slowly and with our charging tool Ref. BV160A1TM

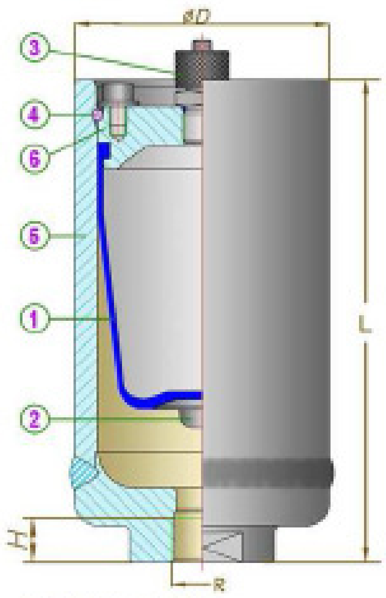
HIDRACAR SA 08295 S.VTE. CASTELLET (BARCELONA) SPAIN TEL.34.93.8330252 FAX.34.93.8331950	Customer	Customer Ref.	Replaced Drg.N° AV.AI.MP-BP.IN.DOC(Rev.16)	Drawn E.Ponsa	Approved M.Carcaré	
	Title S.S.MEDIUM & LOW PRESSURE BLADDER PULSATION DAMPERS (standard units)		Drg.No AV.AI.MP-BP.IN.DOC.	Rev. 17	Date Nov-14	Scale none

Wall thickness according to AD-2000 and ASME codes

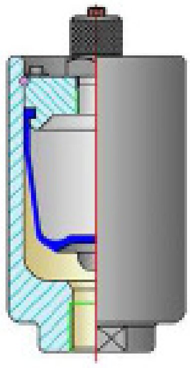
FOR HIGHER PRESSURES, OTHER SIZES, MATERIALS AND CONNECTION THREAD GAUGES, PLEASE CONSULT

TOLERANCES: External dimensions: ±3% Volume: ±2.5% Weight: ±5%

U003 to U250



H = MAX. LENGTH OF THE THREADED CONNECTION



U001 & U002

Standard bladder rubbers:
N= NBR E= EPDM V= FKM
(other rubbers: Butyl, Hypalon, HNBR, etc....)

Rubbers maximum working temperatures (°C):

N	E	V
+80 / -15	+130 / -30	+170 / -10

Working temperature versus Working pressure

A working temperature of 80°C lowers the working pressure x 0.87
" " " " 130°C " " " " x 0.78
" " " " 170°C " " " " x 0.72

THE MAX. TEMPERATURE CAN GET REDUCED DEPENDING ON THE PROCESS LIQUID

These pulsation dampeners should be filled with gas at 80% of the working pressure and at the working temperature in order to stabilize the flow.

Value of "K" : $\frac{\text{Max. pressure}}{\text{Gas filling pressure}} \leq K$ (@ constant temperature)

PULSATION DAMPENER MODEL	VOLUME (litres)	DESIGN PRESSURE (bar-g @ 20°C)	D (mm)	L (mm)	R (BSP)	H (mm)	WEIGHT (kg)	K VALUE
U001	0.09	200	55	100	3/8"	14	1.0	2.5
U002	0.18	180	70	118	1/2"		1.8	
U003	0.36		85	161		16	3.6	3
U007	0.65	120	90	205	3/4"	20	3.8	3.5
U010	0.95	110	112	200		25	6.0	3
U015	1.50			245			6.8	3.5
U030	2.60		140	295	1"	27	10.5	
U040	3.80			386			12.2	5
U060	5.60	120	170	414	1 1/2"	35	24.0	
U100	10.4	100	224	442	2"		46.0	4
U150	15.0			625			52.5	5
U250	25.0		270	691	2 1/2"		70.0	4

No.	DENOMINATION	QTY.	MATERIAL
6	GAS LID	1	AISI 316L
5	BODY	1	AISI 316L
4	RETAINING RING	1 / 2	DIN 17224 (AISI 316L)
3	GAS CHARGING VALVE	1	AISI 316L (1/4" BSP)
2	INSERT (BUTTON)	1	AISI 316L
1	BLADDER	1	NBR, EPDM, FKM and others

A20 ≡ 200 bar
A18 ≡ 180 bar
A12 ≡ 120 bar
A11 ≡ 110 bar
A10 ≡ 100 bar

ORDER REFERENCE CODE EXAMPLE: U003 A18 V 1 AI
- Capacity: 0.36 litres
- A18≡ 180 bar
- V = FKM rubber bladder
- 1/2" standard connection
- Body and insert material: AISI 316L

ATTENTION! MOUNT THE DAMPENER ALWAYS UPRIGHT (w/ #3 VALVE ON TOP)

IMPORTANT: The pre-charge with nitrogen gas or compressed air must be performed slowly and with the help of our charging tool (ref. BVWA1TM)

HIDRACAR S.A.	Customer	Customer ref.	Replaces drawing	Drawn by	Approved by
Pol. Ind. "Les Vives" - c/ Anaïs Nin, 14 08295 Sant Vicenç de Castellet (Barcelona) - SPAIN www.hidracar.com - e-mail: hidracar@hidracar.com Tel.: +34 938330252 Fax: +34 93 833 19 50			AV.AI.MP.IN.DOC. (Rev. 15)	E.Ponsa	M. Carcaré
	Title: MEDIUM PRESSURE STAINLESS STEEL BLADDER PULSATION DAMPENERS (standard units)		Drawing: AV.AI.MP.IN.DOC.	Rev. 16	Date: Nov 2014 / Scale: N/A

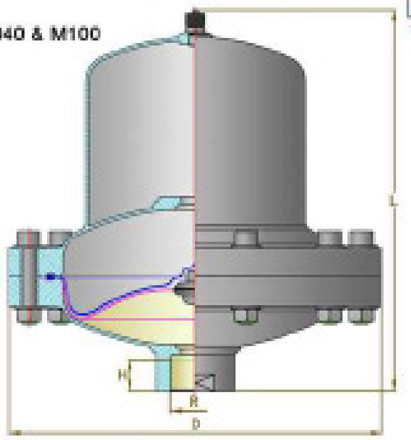
Wall thickness according to AD-2000 code

FOR OTHER SIZES, MATERIALS AND CONNECTION THREAD GAUGES, PLEASE CONSULT

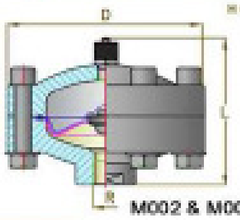
ALSO AVAILABLE FOR PRESSURES UP TO 320 bar-g

TOLERANCES: External dimensions: ±3% Volume: ±2.5% Weight: ±5%

M040 & M100



H = MAX. LENGTH OF THE THREADED CONNECTION



M002 & M004

PULSATION DAMPENER MODEL	VOLUME (litres)	DESIGN PRESSURE (bar-g @ 20°C)	D (mm)	L (mm)	R (BSP)	H (mm)	WEIGHT (kg)
M002	0.2	200	140	100	1/2"	14	5.2
M004	0.4	100	164	122		16	8.2
M008	0.8	50	180	150	3/4"	20	3
M012	1.2	40	224	160			7.5
M030	2.8	30	289	180	1-1/2"	30	15.5
⊕M040	4			275			17
M060	5.6	20	340	233	2"		24.5
⊕M100	10			398			26

No.	DENOMINATION	QTY.	MATERIAL
6	UPPER SHELL	1	AISI 316L
5	LOWER SHELL	1	AISI 316L
4.2	NUTS	8 to 12	DIN 934 A4-70
4.1	WASHERS	8 to 12	DIN 934 A4-70
4	BOLTS	8 to 12	DIN 934 A4-70
3	GAS CHARGING VALVE	1	AISI 316L (1/4" BSP)
2	INSERT (BUTTON)	1	AISI 316L
1.2	UPPER MEMBRANE	1	SILICONE
1	LOWER MEMBRANE	1	PTFE (TFM 1705)

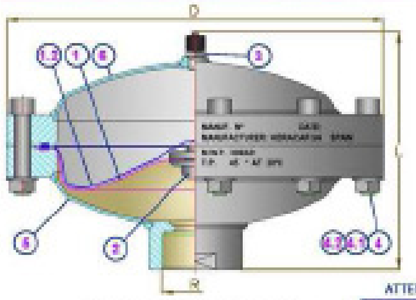
Value of "K" : $\frac{\text{Max. pressure}}{\text{Gas filling pressure}} \leq 2$ (@ constant temperature)

⊕ In these models the value of "K" ≤ 1.5 (@ constant temperature)

A02 ≡ 20 bar
A03 ≡ 30 bar
A04 ≡ 40 bar
A05 ≡ 50 bar
A10 ≡ 100 bar
A20 ≡ 200 bar

ORDER REFERENCE CODE EXAMPLE: M012 A04 T 1-AI
- Capacity: 1.2 litres
- A04≡40 bar
- T = TFM1705 membrane
- 3/4" Standard connection
- Body & insert material: AISI 316L

TEMPERATURE RANGE
from -40°C to +200°C



M008 to M030 & M060

Working temperature versus Working pressure

A working temperature of 100°C lowers the working pressure x 0.82
" " " " 150°C " " " " x 0.75
" " " " 200°C " " " " x 0.68

THE MAX. TEMPERATURE CAN GET REDUCED DEPENDING ON THE PROCESS LIQUID

These pulsation dampeners should be filled with gas at 80% of the working pressure and at the working temperature in order to stabilize the flow.

ATTENTION! MOUNT THE DAMPENER ALWAYS UPRIGHT (w/ #3 VALVE ON TOP)

IMPORTANT: The pre-charge with nitrogen gas or compressed air must be performed slowly and with the help of our charging tool (ref. BVWA1TM)

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Pol. Ind. "Les Vives" - c/ Anaïs Nin, 14 08295 Sant Vicenç de Castellet (Barcelona) - SPAIN www.hidracar.com - e-mail: hidracar@hidracar.com Tel.: +34 938330252 Fax: +34 93 833 19 50			AM.AI.BP.IN.DOC. (Rev. 19)	E.Ponsa	M. Carcaré
	Title: LOW & MEDIUM PRESSURE STAINLESS STEEL DOUBLE MEMBRANE PULSATION DAMPENERS		Drawing: AM.AI.BP.IN.DOC.	Rev. 20	Date: Nov 2014 / Scale: N/A

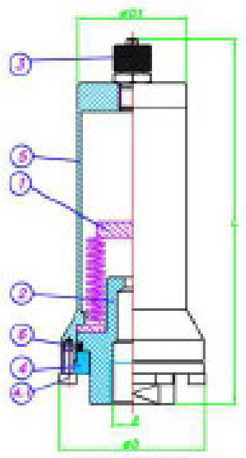
ORDER EXAMPLE: F030 A04 T 1 AI

A03=30bar
A04=40bar
A05=50bar
A05=60bar

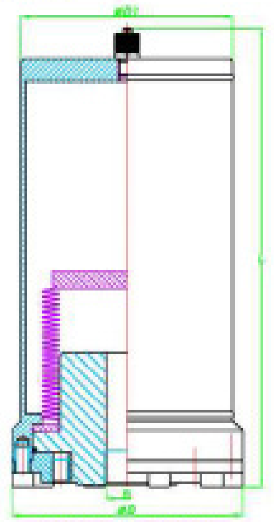
- Capacity: 2,6 litres
- A04=40bar
- T= PTFE Bellows
- 1" Standard Connection
- Body & nozzle material: AISI 316L

$\frac{\text{Maxi. Pressure}}{\text{Filling gas Pressure}} \leq 2$ (@Constant Temp.)

PULSATION DAMPER MODEL	MAXI. δV ADMITED (c.c.)**	VOLUME (litres)	DESIGN PRESSURE (bar-g)	D (mm)	D1 (mm)	L (mm)	R (BSP)	WEIGHT (Kg.)
F002	15	0.15	60	70	53	178	1/2"	1.8
F003	45	0.30	50	84	64	234		2.6
F007	120	0.70		105	84	250		3.0
F015	250	1.50	40	123	104	276	3/4"	7.5
F030	600	2.60		170	156	306	1"	12.0
F040		3.80				368		12.5
F060		5.60				475		13.5
F100	1500	10.00	30	250	206	441	2"	24.0



F002 to F007



F015 to F100

N	DENOMINATION	QT.	MATERIALS
6	SEAL GASKET	1	SILICONE
5	BODY	1	AISI 316L
4.1	BOLTS	7 to 10	DIN 912 A4-70
4	RETAINING NUT	1	AISI 316L
3	FILLING VALVE	1	AISI 316L (1/4" BSP)
2	NOZZLE	1	AISI 316L
1	BELLOWS	1	PTFE

Working Temperatures versus Working Pressures

For a temperature of 100°C correspond design pressure x 0.82
" " " " 150°C " " " x 0.75
" " " " 200°C " " " x 0.68

WORKING LIMITS TEMPERATURES(°C): -40° / +200°C

Those Pulsation Dampeners ought to be filled with gas at a value of 0.80x the pressure to stabilize and that at the working temperature

TOLERANCES: External dimensions ±.5% Volume ±2.5% Weight ±5%

ATTENTION! ALWAYS MUST BE MOUNTED VERTICALITY (VALVE 3 ON TOP)

** ΔV≥C/2 for a single head pump ("C"=Head pump volume)
ΔV≥C/6 for a duplex heads pump
ΔV≥C/15 for a three heads pump

NOTE: The precharge with gas or air must be done slowly and with our charging tool Ref. BV025A1TM

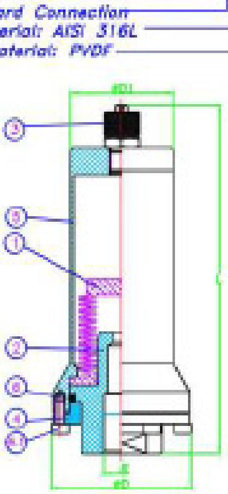
HIDRACAR SA ® 08295 S.VTE. CASTELLET (BARCELONA) SPAIN TEL.34.93.8330252 FAX.34.93.8331950	Customer	Customer Ref.	Replaced Drg.N° AFT.AI.BP.IN.DOC (Rev.16)	Drawn E.Ponsa	Approved M.Carcaré
	Title PULSATION DAMPER WITH PTFE BELLOWS, SS BODY (All parts in contact with liquid in PTFE and Stainless Steel)		Drg.No AFT.AI.BP.IN.DOC	Rev. 17	Date Nov-14 / Scale

ORDER EXAMPLE: F030 A02 T 1 AI/PD

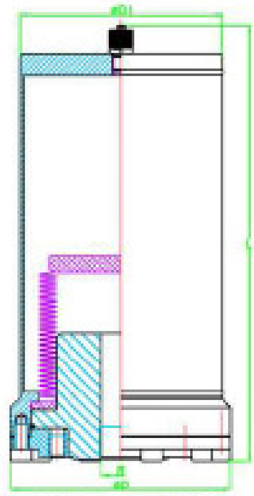
- Capacity: 2,6 litres
- A02=20bar
- T= PTFE Bellows
- 1" Standard Connection
- Body material: AISI 316L
- Nozzle material: PVDF

$\frac{\text{Maxi. Pressure}}{\text{Filling gas Pressure}} \leq 2$ (@Constant Temp.)

PULSATION DAMPER MODEL	MAXI. δV ADMITED (c.c.)**	VOLUME (litres)	D (mm)	D1 (mm)	L (mm)	R (BSP)	WEIGHT (Kg.)
F002	15	0.15	70	53	178	1/2"	1.6
F003	45	0.30	84	64	234		2.2
F007	120	0.70	105	84	250		2.7
F015	250	1.50	123	104	276	3/4"	7.1
F030	600	2.60	170	156	306	1"	11.5
F040		3.80			368		12.1
F060		5.60			475		12.9
F100	1500	10.00	250	206	441	2"	19.5



F002 to F007



F015 to F100

N	DENOMINATION	QT.	MATERIALS
6	SEAL GASKET	1	SILICONE
5	BODY	1	AISI 316
4.1	BOLTS	7 to 10	DIN 912 A4-70
4	RETAINING NUT	1	AISI 316L
3	FILLING VALVE	1	AISI 316 (1/4" BSP)
2	NOZZLE	1	(+)(PVDF, PTFE, PVC or PE)
1	BELLOWS	1	PTFE

Working Temperatures versus Working Pressures

For a temperature of 100°C correspond design pressure x 0.82
" " " " 150°C " " " x 0.75

WORKING LIMITS TEMPERATURES(°C):		
(-5° / +50°C for PVC)	(+) Polyethylene= PE	MAX.WORKING
(-15° / +70°C for PVDF & PE)	(+) PVC = PC	PRESSURE: 20 bar-g
(-40° / 150°C for PTFE)	(+) PVDF = PD	
	(+) PTFE = TF	

THE MAXI TEMPERATURE CAN BE REDUCED DEPENDING ON THE LIQUID IN CONTACT

TOLERANCES: External dimensions ±.5% Volume ±2.5% Weight ±5%

ATTENTION! ALWAYS MUST BE MOUNTED VERTICALITY (VALVE 3 ON TOP)

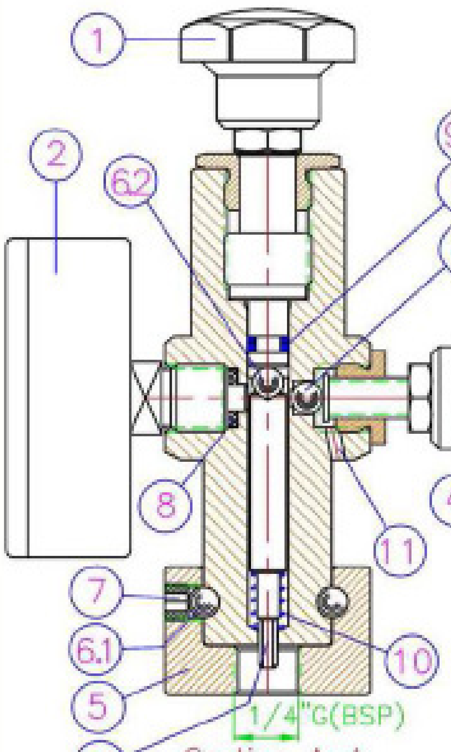
** ΔV≥C/2 for a single head pump ("C"=Head pump volume)
ΔV≥C/6 for a duplex heads pump
ΔV≥C/15 for a three heads pump

Those Pulsation Dampeners ought to be filled with gas at a value of 0.80x the pressure to stabilize and that at the working temperature

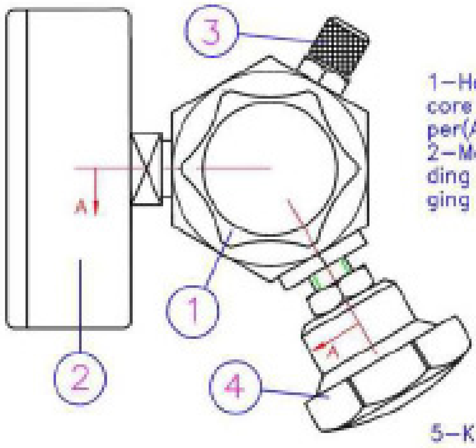
NOTE: The precharge with gas or air must be done slowly and with our charging tool Ref BV016A1TM

HIDRACAR SA ® 08295 S.VTE. CASTELLET (BARCELONA) SPAIN TEL.34.93.8330252 FAX.34.93.8331950	Customer	Customer Ref.	Replaced Drg.N° AFT.AI.BP.IN.PL.DOC (Rev.13)	Drawn E.Ponsa	Approved M.Carcaré
	Title PULSATION DAMPER WITH PTFE BELLOWS, SS BODY (All parts in contact with liquid in PTFE, PVDF, PVC or PE)		Drg.No AFT.AI.BP.IN.PL.DOC	Rev. 14	Date Nov-14 / Scale none

Body & nuts material: 1.0718 (electroless nickel coating)



Section A–A



1–Handle for open the core in the Pulsation Dam_ per(Accumulator)inflating valve
2–Manometer(scales accor_ ding to the different char_ ging pressures)

3–Check valve to connect with the gas filling hose
4–Venting handle to release the gas

5–Knurled nut to attach to <u>ours standar Pulsation Dam_ pers inflating gas valve</u>
6–Venting closure ball
6.1–Retaining knurled nut balls
6.2–Transfer ball
7–Allen Screw
8–Pressure gage seal
9–"O"Ring(ref.HC2008 NBR)
9.1–Back up Ring(ref.HC8008 NBR)
10–Spring
11–Venting hole
12–Core depressor pin

MANOMETER SCALES	Drg.N°(***)
End scale= 6 BAR →	***=006
16	016
25	025
60	060
160	160
250	250
400	400
600	600
1000	1000

NOTE: The scale end of the manometer should be approx. 30% higher than the value of the gas precharge.

HIDRACAR SA 08295 S.VTE. CASTELLET (BARCELONA) SPAIN TEL.34.93.8330252FAX.34.93.8331950	Customer	Customer Ref.	Drawn		Checked	
			E.Ponsa		M.Carcaré	
	Title CHARGING & CONTROL GAS BLOCK FOR OUR PULSATION DAMPERS AND ACCUMULATORS	Drg.No BV(***)A1TM	Rev.	Date	Date	Scale
			05	12.11.13	17.11.04	1:1

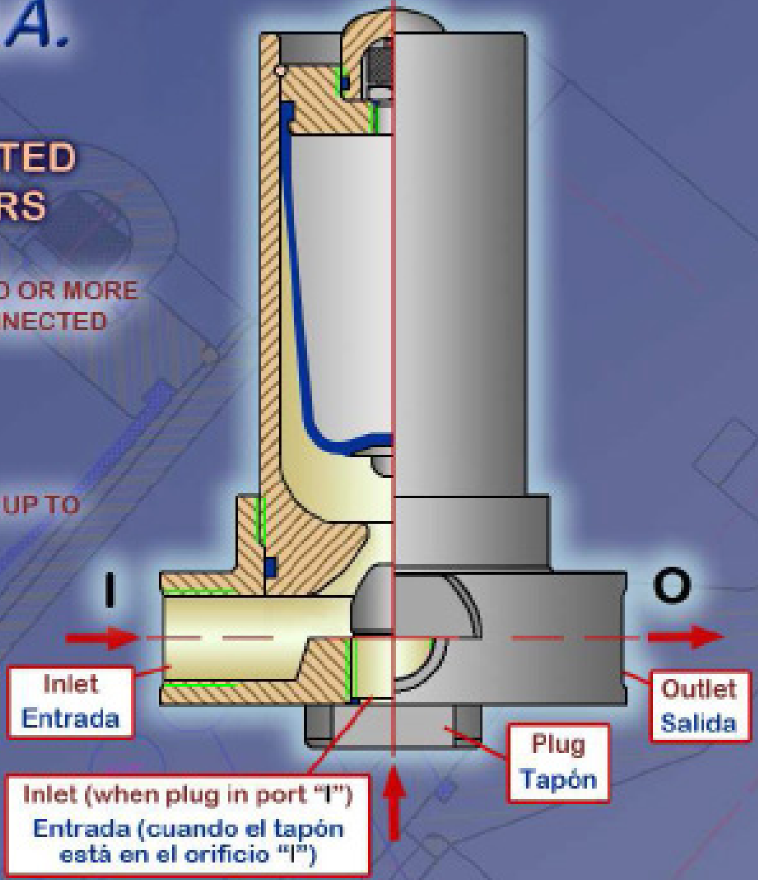
HIDRACAR S.A.

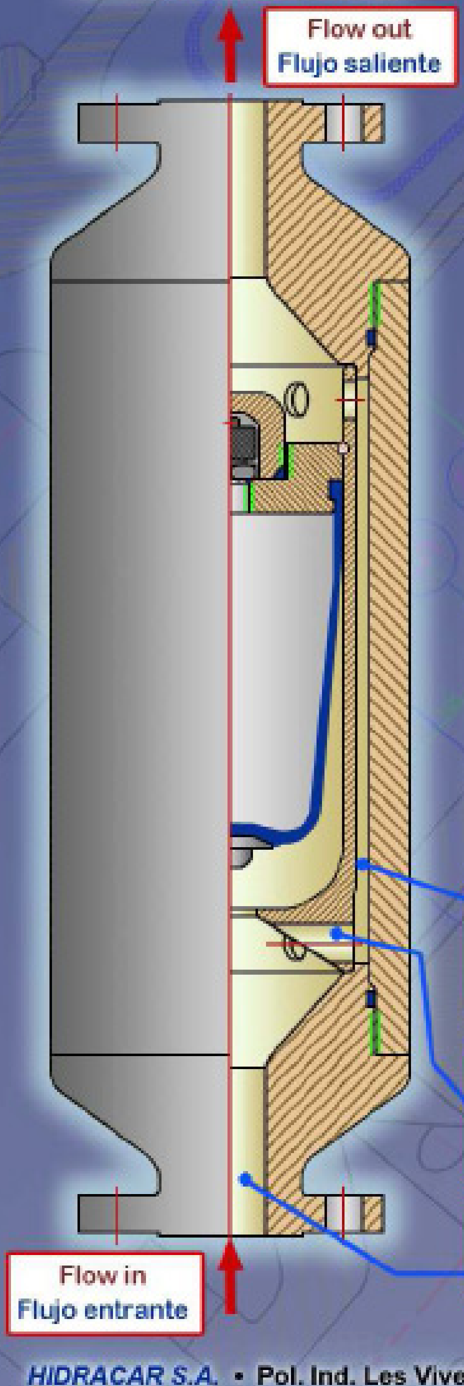
180º & 90º INLINE MOUNTED PULSATION DAMPENERS

THE 90º MODEL CAN INCORPORATE TWO OR MORE PORT CONNECTIONS SO IT CAN BE CONNECTED TO DIFFERENT PUMPS.

MADE IN POLIPROPILENE, PVC AND STAINLESS STEEL.

DESIGN PRESSURE: 10 bar (PLASTIC), & UP TO 80 bar (STAINLESS STEEL).





AMORTIGUADORES DE PULSACIONES PARA MONTAJE EN LÍNEA A 180º Y 90º

EL MODELO DE 90º PUEDE TENER DOS O MÁS ORIFICIOS DE CONEXION DE MODO QUE PUEDA CONECTARSE A DIFERENTES BOMBAS.

FABRICADO EN POLIPROPILENO, PVC Y ACERO INOXIDABLE.

PRESIÓN DE DISEÑO: 10 bar (PLÁSTICO), Y HASTA 80 bar (ACERO INOXIDABLE).

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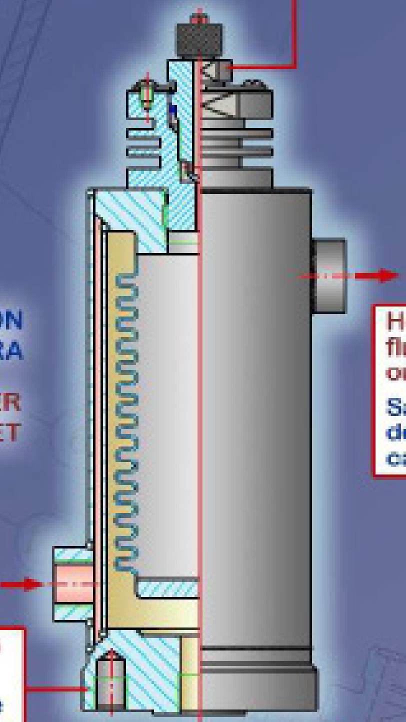
HIDRACAR S.A.

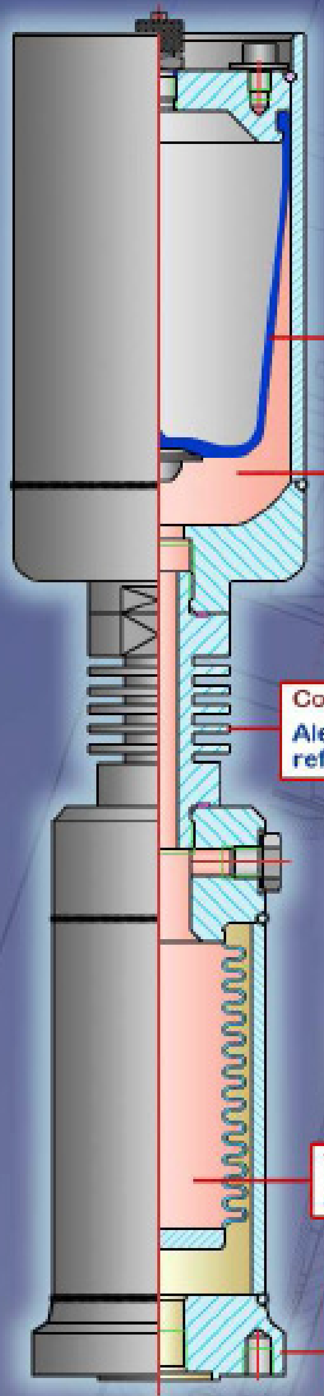
STAINLESS STEEL BELLOWS PULSATION DAMPENER

TWO SPECIAL MODELS OF DAMPENER SUPPLIED TO SEVERAL IMPORTANT GERMAN PISTON PUMP MANUFACTURERS



AMORTIGUADOR DE BAJA PRESIÓN CON CAMISA CALEFACTORA

LOW PRESSURE DAMPENER WITH HEATING JACKET



AMORTIGUADOR DE ALTA PRESIÓN PARA FUNCIONAMIENTO A ALTA TEMPERATURA

HIGH PRESSURE DAMPENER FOR WORKING AT HIGH TEMPERATURE

AMORTIGUADOR DE PULSACIONES CON FUELLE DE ACERO INOXIDABLE

DOS MODELOS ESPECIALES DE AMORTIGUADORES DE PULSACIONES SUMINISTRADOS A VARIOS IMPORTANTES FABRICANTES ALEMANES DE BOMBAS DE PISTONES

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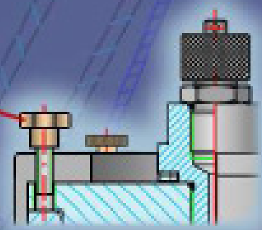
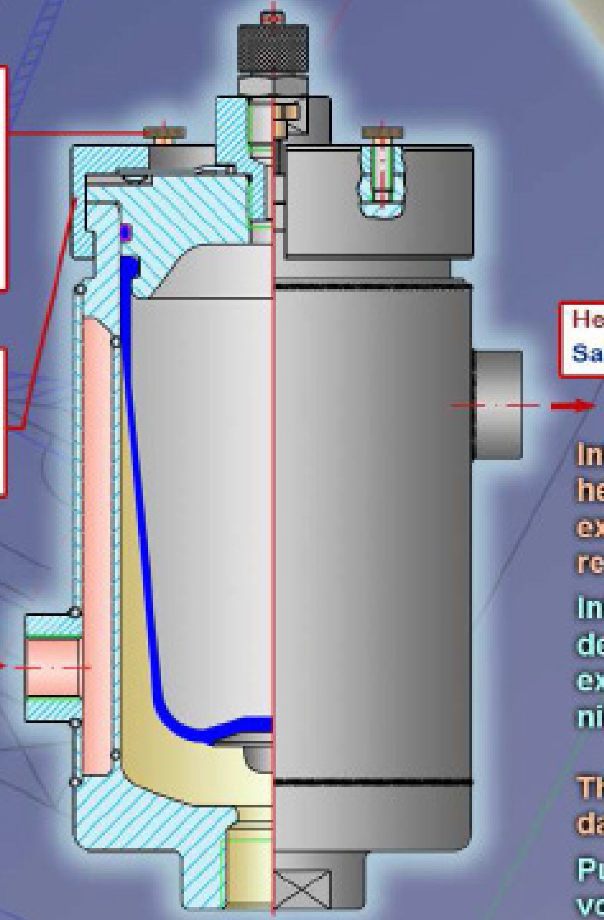
HIDRACAR S.A.

STAINLESS STEEL PULSATION DAMPENER WITH HEATING JACKET AND QUICK BLADDER EXTRACTION SYSTEM

AMORTIGUADOR DE PULSACIONES DE ACERO INOXIDABLE CON CAMISA CALEFACTORA Y SISTEMA DE EXTRACCIÓN RÁPIDA DE LA VEJIGA





Integrates both the circuit liquid heating function and the ease of extraction of the bladder without requiring any tool.

Integra la capacidad de calentamiento del líquido del circuito y la facilidad de extracción de la vejiga sin requerir ningún tipo de herramienta.

They can be made in all our standard dampener volumes.

Pueden fabricarse para todos nuestros volúmenes estardar de amortiguadores.

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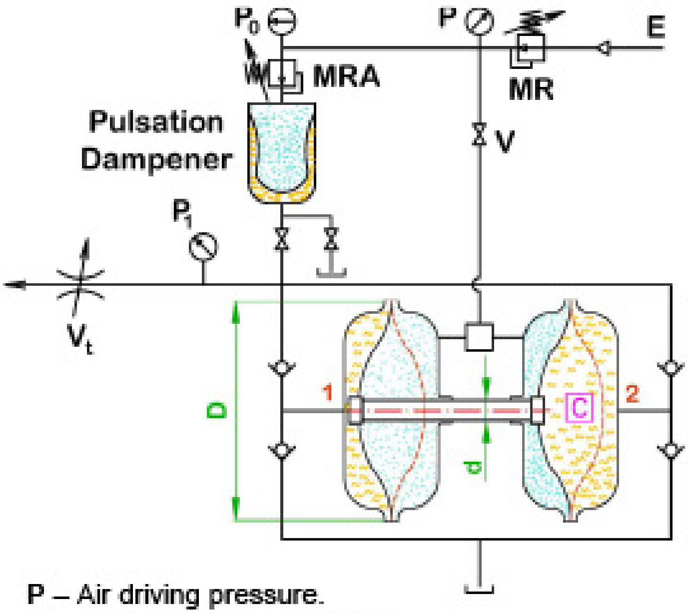
HIDRACAR S.A.

Rev. 07
16 / 7 / 2012

PULSATION DAMPER APPLICATION ON AN AIR VARIABLE PRESSURE DRIVING MEMBRANE PUMP



E – *Compressed air from the factory circuit.*
MR – *Air pressure reducer.*
MRA – *Dampener air precharging pressure reducer.*
V – *Isolating valve.*
V_t – *Throttle valve to increase the dampener efficiency.*

START RUNNING INSTRUCTIONS

I) Valve "V" closed. Fill the Dampener with air at an estimated pressure. Follow the formulas beside.

II) Open Valve "V" and adjust the working pressure needed in the liquid circuit.

III) With the air reducer valve "MRA" adjust the entrance of air into the Dampener until the pressure gage reads the accepted or calculated residual pulsation pressure.

P – Air driving pressure.
P_1 – Liquid pumped pressure.
P_0 – Dampener precharging air pressure.

$$P \times (D - d)^2 = P_1 \times D^2$$

NEVER start pumping liquid without air inside the dampener. The Bladder, Membrane or Bellows of the Dampener can be damaged.

$P_1 = [P \times (D-d)^2] / D^2$; $(D-d)^2 / D^2$ = PUMP CONSTANT = K

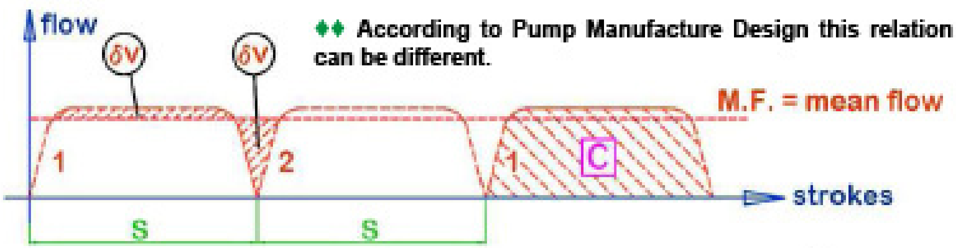
$P_0 \approx 0.75 \times P_1 \longrightarrow \boxed{P_0 \approx 0.75 \times P \times K}$

NOTE: P_0 ought to be measured with the dampener empty of liquid.

P_1 versus P_0 @ Constant Temperature	
P_1	P_0
8	6
7	5
6	4.5
5	3.5
4	3
3	2
2	1.5
1	0.7

∂V - *Liquid going into / out the dampener.*
C – *Liquid volume pumped per stroke.*
S – *Pump stroke.*

♦♦ Relation between C and ∂V: $\boxed{\partial V \approx 0.2 \times C}$



♦♦ According to Pump Manufacture Design this relation can be different.

FORMULA TO CALCULATE THE PULSATION DAMPER SIZE (V_0)♦ :

$$\boxed{V_0 \approx 15 \times \partial V}$$

♦ FOR A RESIDUAL OSCILLATING PRESSURE OF APPROX. +/- 5% @ CONSTANT TEMPERATURE (To reduce this percentage, increase the Dampener size or, for more accuracy, see our Pulsation Damper Technical and Practical Article)

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HIDRACAR S.A.

"T" ADAPTERS WITH PRESSURE GAUGE

BT#A-AI

BT#A-PC/AI

ADAPTADORES EN "T" CON MANÓMETRO

"T" adapters made of stainless steel, with stainless steel pressure gauge casing; or made in PVC with stainless steel pressure gauge casing.
They are fitted with a stainless steel 1/4" BSP valve.

Adaptador en "T" de acero inoxidable con carcasa del manómetro en acero inoxidable; o en PVC con carcasa de manómetro en acero inoxidable .
Se suministran con una válvula BSP de 1/4" de acero inoxidable.

Brass pressure gauge connection.

Conexión del manómetro de latón.

Pressure gauges available for pressures (#) of: 6, 10, 16, 25, 40, 60, 100, 120, 250, 300, 400 and 600 bar.

Manómetros disponibles para presiones (#) de: 6, 10, 16, 25, 40, 60, 100, 120, 250, 300, 400 y 600 bar.

The design pressure is 600 bar for the stainless steel adapters and 10 bar (they could possibly withstand up to 20 bar) for the PVC ones.

La presión de diseño de los adaptadores es de 600 bar para los de acero inoxidable y de 10 bar (y eventualmente de hasta 20 bar) para los de PVC.

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Tel.: +34 93 833 02 52 Fax: +34 93 833 19 50

HIDRACAR S.A.

SISTEMA DE SEGURIDAD ANTI-EXPLOSIÓN (*) POR INCENDIO MEDIANTE FUSIBLE DE TEMPERATURA

FIRE OVERPRESSURE EXPLOSION RISK PREVENTION (*) TEMPERATURE FUSE SAFETY SYSTEM

FST-AI/PP

(*) Our pulsation dampeners are designed with a minimum safety coefficient of 4:1 for stainless steel models and up to 8:1 for the plastic ones.

(*) Nuestros amortiguadores de pulsaciones están diseñados con un coeficiente de seguridad mínimo de 4:1 para los de acero y de hasta 8:1 para los de plástico.

Releases the gas inside the accumulator when the surrounding temperature reaches 160° C; and this way relieves the internal pressure and prevents the risk of explosion.

Permite que el gas del interior del acumulador escape al exterior cuando la temperatura ambiente alcanza los 160° C; y así alivia la presión interior y evita una potencial explosión.

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HIDRACAR S.A.

TOOL FOR A QUICK EXTRACTION OF THE BLADDER FROM ACCUMULATORS

DRB.A/B

HERRAMIENTA DE EXTRACCIÓN RÁPIDA DE LA VEJIGA DE LOS ACUMULADORES

Suitable for the whole range of our bladder type accumulators, except for U350.

Para toda la gama de nuestros acumuladores de vejiga, excepto el U350.

Enables bladder extraction without being necessary to disconnect the accumulator from the circuit.

Permite extraer la vejiga sin necesidad de desmontar el acumulador del circuito.

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GAS CHARGING VALVE THREAD ADAPTOR

ADAPTADOR DE ROSCA PARA VÁLVULA DE CARGA DE GAS

ADACNEU.5

Adapts the thread of 1/4" BSP standard charging valves to the thread of the Vg8 valves so a tyre inflating kit can be used for charging with compressed air.

Adapta la rosca de las válvulas de carga estándar BSP de 1/4" a las de las válvulas Vg8 para poder cargar con aire comprimido, mediante la utilización de un kit de hinchado de neumáticos.

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ACCESSORY FOR CHARGING, PURGING AND VERIFYING THE PRESSURE OF OUR PULSATION DAMPENERS

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ACCESORIO DE CARGA, PURGADO Y VERIFICACIÓN DE LA PRESIÓN DE NUESTROS AMORTIGUADORES DE PULSACIONES

ADAPTADOR "S"
(W21.8x1/14" HEMBRA)
"S" ADAPTER
(W21.8x1/14" FEMALE)

ADAPTADOR "T"
(W24.3x1/14" HEMBRA)
"T" ADAPTER
(W24.3x1/14" FEMALE)

ADAPTADOR "Y"
(5/8" ISO 228)
"Y" ADAPTER

ADAPTADOR "Z"
(W21.8x1/14" MACHO)
"Z" ADAPTER
(W21.8x1/14" MALE)

BV#A1TM

Supplied with optional pressure gauges and connection hose adapter (S, T, Y or Z); as well as a connection hose for either low and medium pressures or for high pressures (600 and 1,000 bar) as required.

Se suministra con manómetros y adaptador de conexión (S, T, Y o Z) opcionales; así como con manguera de conexión para presiones bajas y medias o para presiones altas (600 y 1.000 bar) según el rango de presiones que se precise.

Range of available pressures (#):
10, 16, 25, 40, 60, 100, 160, 250, 300, 400, 600 and 1,000 bar.

Rango de presiones (#) disponibles:
10, 16, 25, 40, 60, 100, 160, 250, 300, 400, 600 y 1.000 bar.

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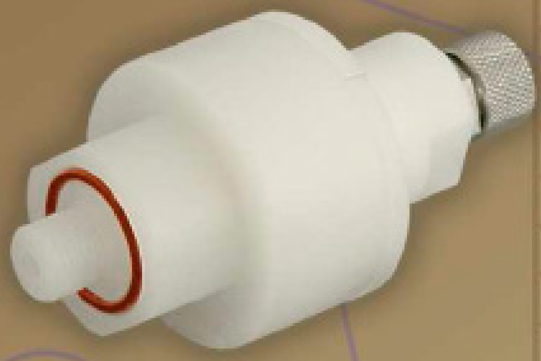
HIDRACAR S.A.

ANTI-CORROSION VALVE

Prevents that, when a corrosive liquid is circulating through the circuit, and in case the separator element (bladder, membrane or bellows) of the dampener gets broken, the corrosive liquid could corrode the stainless steel gas charging valve and escape to the exterior.

This anti-corrosion valve is supplied together with the standard gas charging valve.



004-AI + PVDF

VÁLVULA ANTI-CORROSIÓN

Evita que, cuando por el circuito circula un líquido corrosivo, y en caso de rotura del elemento separador (vejiga, membrana o fuelle) del amortiguador, el líquido pueda corroer la válvula de carga de gas de acero inoxidable y fugar al exterior.

Esta válvula anti-corrosión se suministra conjuntamente con la válvula de carga de gas estándar.

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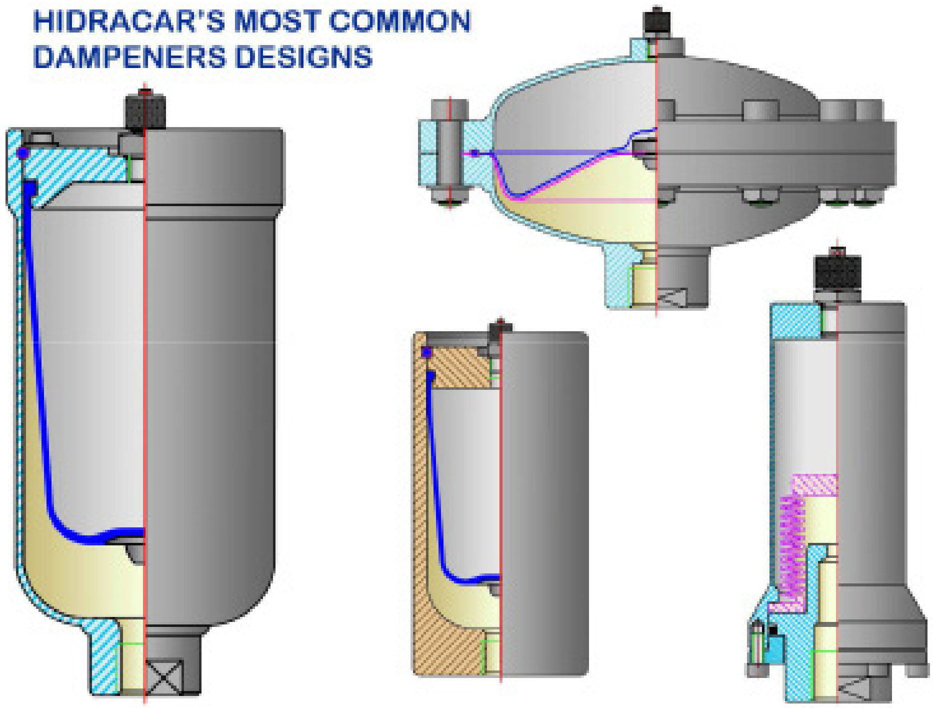
HIDRACAR S.A.

SOME TECHNICAL AND PRACTICAL RECOMMENDATIONS ABOUT PULSATION DAMPENERS IN CIRCUITS WITH DOSING OR VOLUMETRIC PUMPS

DESCRIPTION OF A PULSATION DAMPENER AND HOW IT WORKS

A pulsation dampener is a vessel with pressurized gas inside, normally **nitrogen**. The initial filling or inflating gas pressure inside the dampener must always be lower than the pressure of the circuit where it is installed. The inflating gas pressure of the dampener will be called "P_0".

In all pulsation dampeners there is an element to isolate the gas from the circuit liquid; its main function being to avoid gas leaks. This part that separates both fluids is made basically in two kinds of material: Rubber (**nitrile, EPDM, FKM, butyl, silicone,** etc,...) or a thermoplastic material, usually **PTFE**. When rubber is used the separator element is called bladder and if the **PTFE** is used the dampener can be either membrane or bellows type according to the form of the separator element. The bellows can also be made in stainless steel. The use of one type of separator or another will generally depend on the particular characteristics of the circuit, such as: The working pressure, temperature and the possible corrosive effect of the circuit liquid over the separator element.



THE FUNCTION of a pulsation dampener is to stabilize the variable and oscillating flow generated in a hydraulic circuit in each cycle by volumetric piston or membrane pumps such as dosing or metering pumps. The main characteristic of these pumps being to deliver a constant volume of liquid in every cycle independently of the circuit resistance or pressure (We will later see the characteristics of this kind of pumps).

When there is a pulsation dampener installed in the circuit, the volume supplied by the pump in every impulse or work cycle it generates is divided in two parts; one goes to the circuit and the other part goes into the pulsation dampener. This volume stored into the dampener is returned right after back into the circuit while the pump is in its suction or chamber filling stage. The amount of liquid going in and out of the dampener in each alternating cycle of the pump will be called "**δV**".

When **δV** gets introduced into the dampener the gas contained inside will be compressed and, therefore, its volume reduced and the pressure increased. The final gas volume (**V_2**) will be the initial gas volume minus the volume of liquid introduced (**δV**).

The initial gas volume is, to start, the total volume of the dampener or the size of the dampener. The size of the dampener is an unknown value to be calculated in every case depending on the kind of pump. This volume or size of the dampener will be called "**V_0**"

From all this, we can establish that: $\mathbf{V_2 + \delta V = V_0}$

Every dampener has a constant derived from its size and its filling or charging gas pressure:

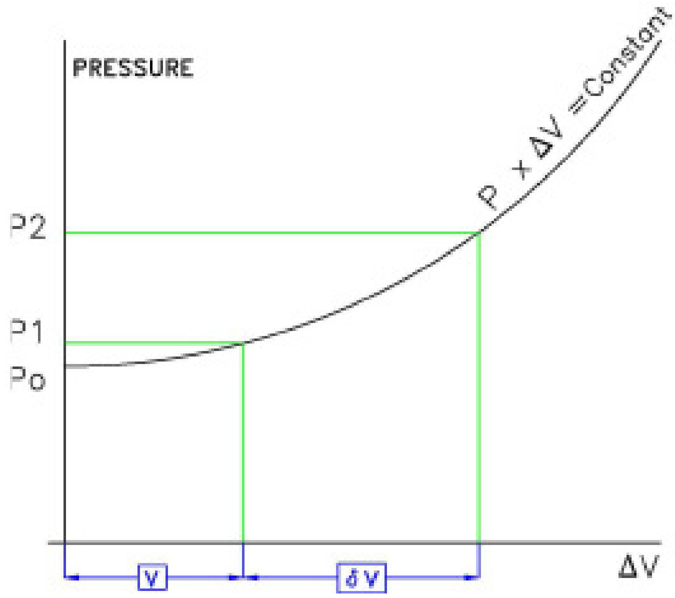
$$\mathbf{P_0 \times V_0 = constant}$$

In working practice, it is not convenient for the dampeners to get totally emptied of the liquid, previously stored, in each cycle, to avoid the anti-extrusion insert of the separator element from repeatedly hammering against the internal bottom surface of the dampener, what could wear prematurely the bladder or membrane out. A new formula results from it:

$$\mathbf{V_2 + \delta V + v = V_0}$$

where "v" is an unused volume of liquid inside the dampener. As a norm this volume is considered to be **10%** of the total dampener volume, as long as the temperature remains constant, and, therefore the former formula can be expressed as:

$$\mathbf{V_2 + \delta V + 0.1\ V_0 = V_0} \quad \text{and finally as:} \quad \mathbf{V_0 = (\ V_2 + \delta V\ ) / 0.9}$$

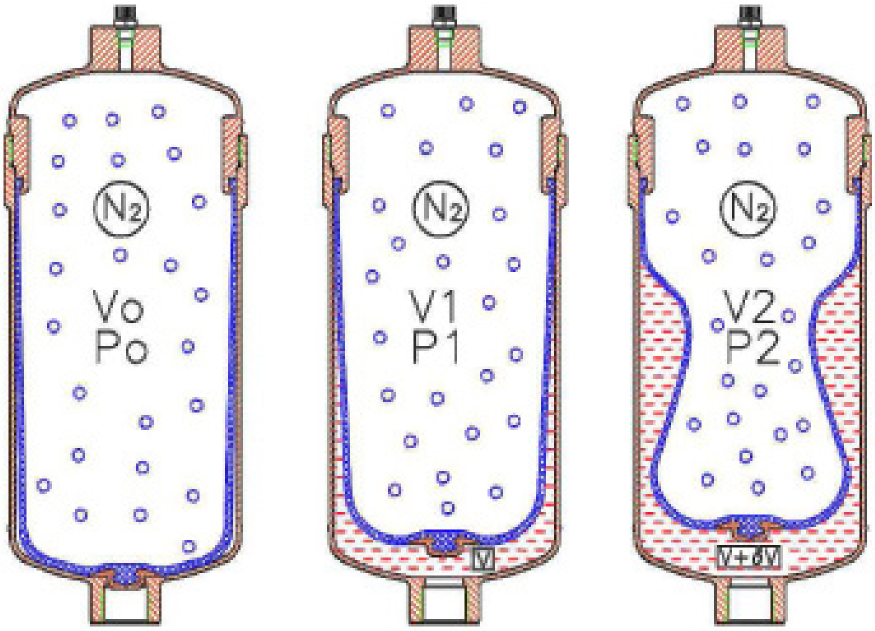


The graph above represents the curve (hyperbola) of gas compression inside the accumulator or pulsation dampener.

At the initial gas charge pressure value "**P_0**" there is no liquid inside the dampener and the gas fills the whole dampener interior. The curve cuts the ordinate axis in the point where corresponds to a zero value in the abscissa axis. This axis is where the amount or volume of liquid introduced into the dampener in each working cycle is represented.

The pressure "**P_1**" is the gas pressure when a volume "**v**" has been introduced into the dampener. The pressure "**P_2**" is the value reached by the gas when the additional volume "**δV**" is introduced into the dampener.

From this curve we can deduce that for a fixed dampener size if the value "**δV**" increases then the pressure value "**P_2**" will also increase; or the other way around: If we increase the dampener size keeping constant the value "**δV**" the final pressure gas value "**P_2**" will be lower.



Bladder type dampener in its three stages or internal gas volumes

DAMPENER SIZE CALCULATION

The data needed to calculate the dampener size are:

"**δV**" = Volume of liquid that the dampener must store (in the chapter describing the different types of dosing pumps we will see the relation between "**δV**" and the cubic capacity of each of the three most common types of pumps).

"P_1" and "P_2" are the minimum and maximum pressure values that are accepted in the circuit.

Note: A pulsation dampener does not eliminate 100% of the pressure oscillation produced in the circuits with volumetric or dosing pumps. Its function is to regulate or control the variations of pressure so it remains within previously set limits. This variation, as a +/- percentage of the theoretical pressure "P_t", is what determines, together with the value of "**δV**", the size of the pulsation dampener.

"P_t" is the pressure needed at the pump outlet, in order to overcome all the resistances that will arise, to circulate the liquid all the way to the end of the hydraulic circuit.

Let's see an example: If the theoretical or work pressure in a circuit is "P_t" and the residual pulsation admitted is +/- 5% of this pressure, values P_1 and P_2 will be:

$$P_1 = P_t - (5/100) \times P_t \quad \text{and} \quad P_2 = P_t + (5/100) \times P_t$$

With all this known data: **δV**, P_1 and P_2, we can already calculate the dampener size "V_0".

The ideal gas law in isothermal conditions (Boyle's law) (later on we will clarify this equation for this application) gives us the following equality:

$$P_0 \times V_0 = P_1 \times V_1 = P_2 \times V_2 = \text{Constant.} \quad (1)$$

If: $V_1 = V_0 - v$ and $v = 0.1 \times V_0$

we have: $V_1 = 0.9 \times V_0$ (2)

and also: $V_2 = V_1 - \delta V$ (3)

Finally, from (1) and (2) we obtain: $P_0 = 0.9 \times P_1$ (4)

and then from (1), (2), (3) and (4) we will get:

$$P_0 \times V_0 = P_2 \times V_2 ; \quad \underline{0.9\, P_1 \times V_0} = P_2 \times (V_1 - \delta V) = \underline{P_2 (0.9\, V_0 - \delta V)}$$

From the underlined ends of the equalities we obtain the final formula:

$$V_0 = \frac{P_2 \times \delta V}{0.9\,(P_2 - P_1)} \qquad (5)$$

This is the simplified theoretical formula to calculate the pulsation dampener volume as a function of **δV**, P_1 and P_2.

As we have already said, it is accepted as a norm that the charging gas pressure, "P_0" = **0.9** P_1. This difference between P_0 and P_1 prevents the complete emptying of liquid from the dampener in each work cycle. Having this extra quantity of liquid **"v"** (stored in the dampener in between P_0 and P_1) can also be used to compensate, in some instances, the potential changes in the gas pressure produced by variations in the exterior temperature that would modify the calculated theoretical "**δV**" and in that case it could not be completely introduced into or discharged out of the dampener.

The former equality (1) $P_0 \times V_0 = P_1 \times V_1 = \ldots = P_n \times V_n$ does not comply in practice because, when a volume of gas is compressed (in a short time), the temperature rises, what increases the pressure, and when a gas expands its pressure drops an extra value because the temperature is reduced (refrigerator effect). This effect happens with the majority of gases, included Nitrogen and air, which are the more commonly used for charging the dampeners (atmospheric air can be used for pressures below **10 bar**, providing there is no risk of chemical reaction between the Oxygen in the air and the pumped liquid).

The formula (1) gets, thus, transformed into:

$$P_0 \times V_0^{\gamma} = P_1 \times V_1^{\gamma} = \ldots = P_n \times V_n^{\gamma}$$

where γ = specific heat ratio of the gas at constant pressure and volume, respectively. For the majority of gases, γ = **1.41** This constant is also theoretical. In the practice the value that can be used is γ = **1.25** But in order not to complicate the formula of dampener size calculation we will use a new constant (**0.8**) that will give the same result.

$$V_0 = \frac{P_2 \times \delta V}{0.8 \times 0.9 \times (P_2 - P_1)} \qquad (6)$$

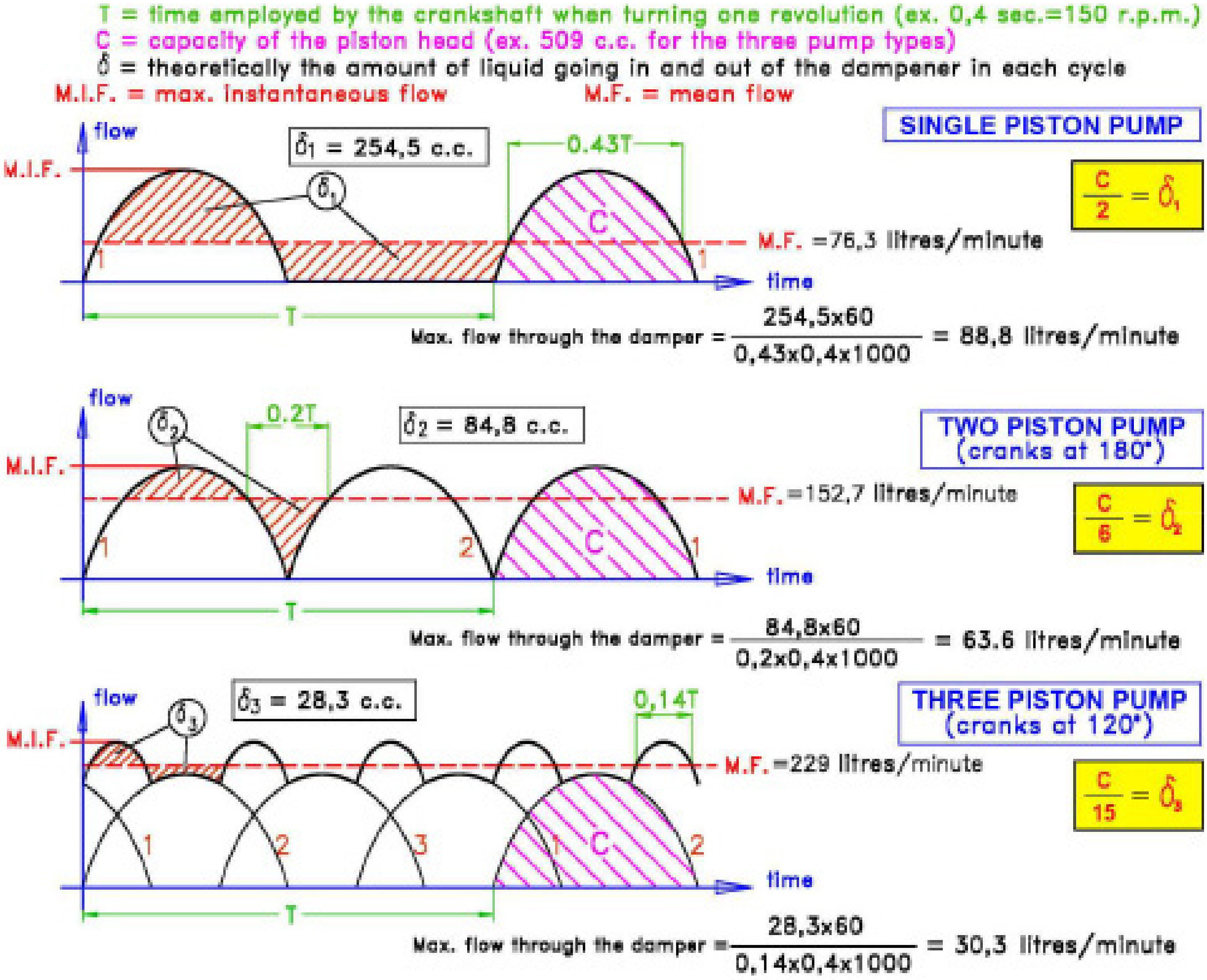
This formula can be used in practice for nearly all industrial applications. It will be very unlikely for the volumes given by this formula to fit any standard dampener volume size from a manufacturer. Except for very exigent applications we can recommend to use the manufacturer's standard closer lower size, favouring cost efficiency.

Note: We have not considered a possible temperature variation of the fluid or environment. This would change the charging gas pressure value at 20º (take note that for each 10ºC variation in temperature the gas pressure will change approximately by 3%).

DIFFERENT TYPES OF DOSING PUMPS TO WHICH DAMPENERS CAN BE MOUNTED

We will consider pumps with one, two or three pistons and crankshaft movement being these the most extended and used and also those in bigger need for a dampener (for air operated, peristaltic, etc... pumps please consult ***HIDRACAR S.A.*** technical department).

The graphics below correspond to these three types of piston pumps and represent the instantaneous flow during a complete crankshaft revolution. We have taken the same piston dimensions (diameter x stroke) for all three types of pumps.



These curves let us see how a pulsation dampener works: If we pay attention to the first curve, representing a single piston pump, we can observe that for this type of pump the use of a dampener is almost essential, as otherwise during half revolution of the pump crankshaft no liquid flow is delivered. Also if the pump does not include a dampener, the diameter of the pipe must be calculated for the maximum instantaneous flow, which takes place when the piston speed is also at its maximum, in the middle of piston stroke (the flow curve is a sinusoid).

With a dampener installed, from the point where it is mounted onwards, the maximum flow supplied to the circuit now practically becomes the mean flow of the pump, what makes possible to reduce the pipe diameter **by approximately 40%!!** And this because the maximum instantaneous flow of the pump is **2.8** times superior to its medium flow. In some cases this reduction of pipe diameter alone will compensate for the cost of the dampener; on top of the main advantage of stabilizing the circuit's pressure, with all of its obvious associated improvements (pressure in an hydraulic circuit is, basically, a function of the flow, and therefore if it varies, the pressure varies as well).

Carrying on with the first curve we can see that the task of the dampener is to store all the excess volume, over the mean flow line, of the total piston head during the piston impulse stroke; and then to return this volume "**δ_1**" back into the circuit during the piston suction stroke. So then, in this type of pump the volume stored by the dampener is half of the pump head or capacity per revolution.

As we analyse all three curves we can see that, as the number of pistons in a pump increase, the mean flow gets closer and closer to the maximum flow and the liquid volume "**δ_1**" stored by the dampener gets correspondingly reduced, and therefore the required size of the dampener also gets reduced (this is totally valid in a case like this, where all the pistons in the three pumps have the same diameter, stroke and number of revolutions per minute).

To summarise: The more pistons a pump has, the lower the dampener size is required and also the smaller both the pipe section and the port connection between the dampener and the circuit can be (always assuming the pumps provide the same flow independently of the number of cylinders).

The relation between "**δV**" and the capacity per head "C" is

δv = C / 2 For a one piston pump

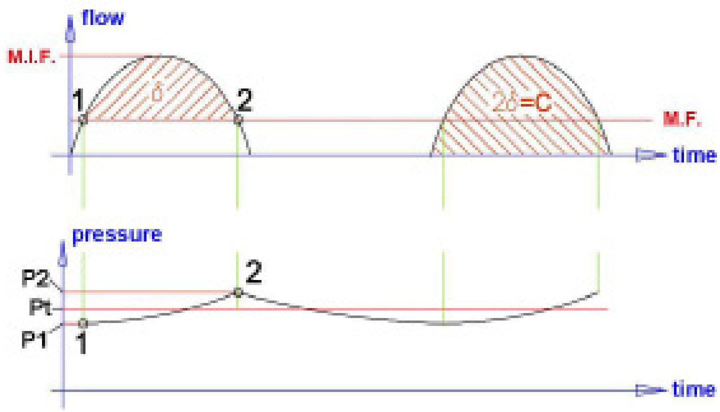
δv = C / 6 For a two piston pump

δv = C / 15 For a three piston pump

(Practical values for the calculation of the dampener size).

We know that when a gas is compressed its pressure increases, and decreases if it expands its volume. When a dampener is installed by the outlet of a piston pump the pressure of the liquid in the circuit will fluctuate according to the values of the volume of gas inside the dampener. This pressure variability, a +/- percentage of pressure P_t will be defined by the technical designer of the circuit or by final customer requirements.

The following graphs will help to better understand the above exposed:



The lower curve from the above graphs shows the pressure fluctuation of a circuit with a dampener installed. This curve relates to the pump flow variation curve. As we have seen before, a dampener stores the volume of liquid above the pump mean flow. For this reason, the minimum value of the pressure curve (point **1**) must coincide with the first crossing point of the instantaneous flow curve with the line of the mean flow; and the maximum value of the pressure curve (point **2**) must coincide with the second crossing point between them, the moment when all "**δV**" has been introduced inside the dampener.

Let's remember that the area comprised between the instantaneous flow curve and the abscissa axis (time) represents a volume which in the case of a single piston pump is equal to the pump capacity per stroke or revolution. (flow x time = volume) .

Let's see now the meaning of P_1, P_t and P_2 in the pressure / time curve:

In all hydraulic circuits the pressure at the pump outlet port is a function of the flow, pipe length and diameter, viscosity of the pumped liquid, internal pipe surface roughness, geometric height, etc... If the flow keeps constant over time, the pressure needed to pump the liquid will also be constant as long as there is no change either in flow resistance (for instance, due to sedimentation on filters, etc...) We call this constant working pressure or "P_t".

When a circuit must be designed, one ought to take the mean flow and the opposing resistances to calculate the pressure "P_t".

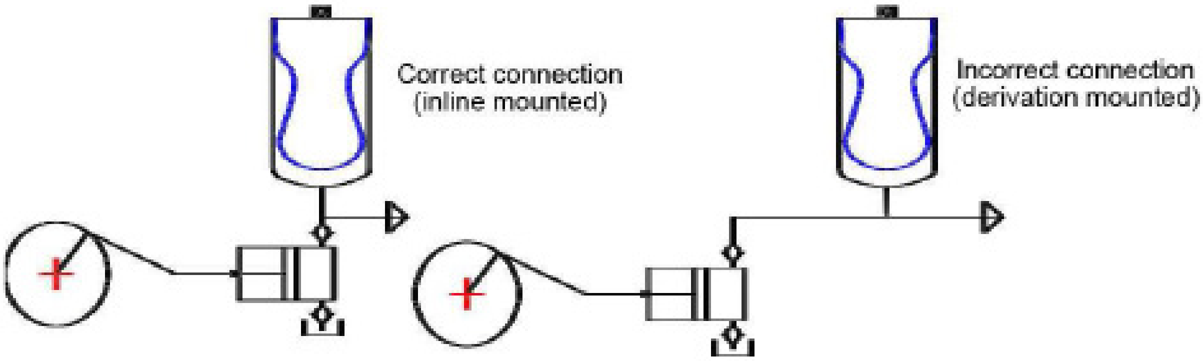
We see that on one side the dampener stabilizes the flow and for that also the pressure, but in fact the pressure goes from "P_1" to "P_2". The reason behind this is that the dampener has to stabilize the flow and for that it needs to compress and expand a volume of gas, and these pressure variations in +/- percentage of P_t are those that regulate the values accepted in the circuit.

We have already seen that this pressure fluctuation can be reduced down to very small values by increasing the volume of the dampener. "P_1" and "P_2" are the percentage values of "P_t", already commented which are pressure variations that the final customer must determine; though we do not recommend them to be less than +/- 2%, as the environmental temperature conditions will very probably modify the theoretical calculation.

MOUNTING SUGGESTIONS FOR MAXIMUM DAMPENER EFFICIENCY

As we have seen so far, taking into consideration the flow curves for the three types of pump, the single piston pump is the pump with the higher "**maximum instantaneous flow / mean flow**" ratio and also the one for which the liquid getting into and out of the dampener in each cycle, "**δV**", has a higher value; always considering both same piston diameter and pump stroke or displacement for all three pumps. Therefore in the next example we will refer to this type of pump.

We can say that for **99%** of industrial applications, if the recommendations that we detail below are followed, the dampener's efficiency will be guaranteed.



1.- The dampener must be mounted with its axis aligned with the axis of the pump outlet.

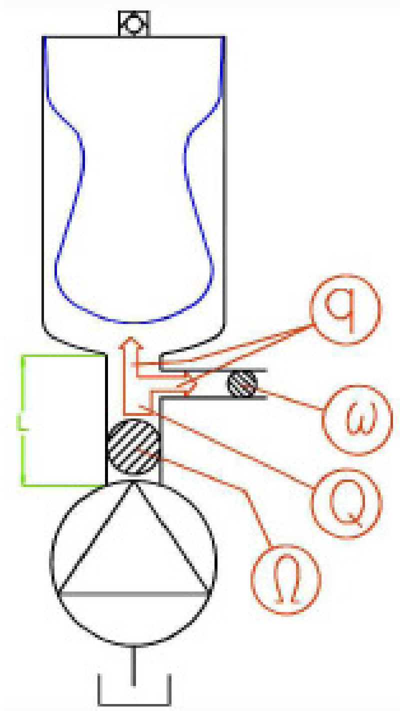
2.- The distance between the pump outlet port and the dampener port connection must be as short as possible.

3.- The pipe section between the pump and the dampener connection must be calculated for the pump maximum instantaneous flow.

4.- The remaining pipe section of the circuit must be calculated for the mean flow.

In the next drawing we will see more clearly all the concepts we have exposed so far.

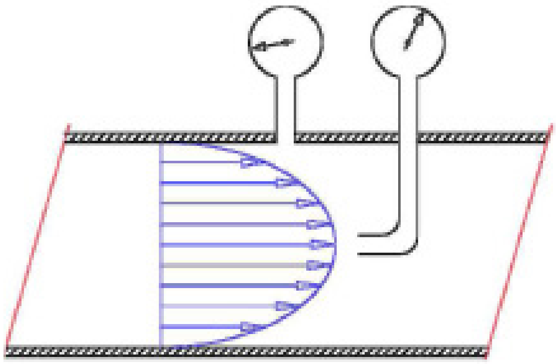
- **ω :** Pipe section for the mean flow.
- **Ω :** Small length of pipe section for the maximum instantaneous flow.
- **Q :** Maximum instantaneous flow.
- **q :** Mean flow.
- **L :** Distance between pump and dampener, as short as possible.



To show the difference between in-line and derivation mounting to a circuit, and the higher efficiency of the former, we will remember some fluid mechanics principles:

The flow of a liquid inside a pipe follow different speed lines: In the centre of the pipe the velocity is higher, while it becomes nearly zero close to the pipe inner wall (see next drawing). If the mean liquid velocity increases, the difference between the dynamic pressure (the pressure measured in the liquid movement direction) and the static pressure (the pressure measured perpendicular to the liquid movement direction) also increases.

The drawing below reflects this: in-line mounting corresponds to the dynamic pressure reading; the derivation mounting to the static pressure. *(Note: We assume the fluid circulates in a laminar regime)*



If the dampener is not only mounted in derivation but also far from the pump outlet the efficiency of the dampener will be reduced a great deal. And if on top of this it is installed in a pipe section with a smaller diameter than the main circuit pipe, then the effect of the dampener will be negligible.

WARNING¡: It is of utmost importance that the pulsation dampener admission duct is not narrower than its connection port. Any reduction in the diameter, when attached to low pressure circuits, will greatly reduce the performance and efficiency of the dampener.

SOLUTION TO PROBLEMS OF PARTICULAR PULSATION DAMPENER APPLICATIONS

I) CIRCUITS THAT HAVE TO BE CLEANED PERIODICALLY AT THE END OF EACH PROCESS

All pulsation dampeners, whatever its type - though certainly some more than others - have, because of its own design, hard to reach internal corners which are difficult to clean or to totally eliminate residues of the pumped product from.

The most reliable and efficient solution to this problem, in accordance with our longer than 35 years experience, is to use a quick dismantling system to extract the bladder out of the dampener, and then clean separately both the bladder and the interior of the dampener body. In the case of applications where the charging gas pressure is lower than **10 bar** and compressed air can be used to fill the dampener, it is the most effective solution. ***HIDRACAR S.A.*** has designed a quick bladder dismantling system that makes unnecessary any additional tool.

If for whatever the reason dismantling the bladder is out of the question, we recommend the pressure of the cleaning liquid to be higher than the pumping pressure of the process product; that way the internal corners between the bladder or membrane and the inner surface of the dampener will expand, allowing a better access to the cleaning fluid.

II) CIRCUITS WITH A VARIABLE WORKING PRESSURE

The problem arisen by the application of dampeners to this type of circuits has different solutions. But also in this case the experience has shown us that the best solution is, as always, the simplest one, or at least the solution requiring a lower implementation and maintenance cost and no extra energy.

Let's consider the following example: A circuit that must work at an initial pressure of **20 bar** and a final pressure of **200 bar**, with a **δV = 15 c.c.** and a maximum residual pulsation accepted at **200 bar** of +/- 5% (*). The pump is simple effect single piston type and its capacity per stroke is: **30 c.c.** To simplify calculations we will consider that the gas volume variation takes place at a constant temperature (isothermal curve complying with **P x V = Constant**).

((*): At 20 bar the residual pulsation will be much lower because, as shown below, the dampener size is calculated for the maximum circuit pressure and therefore when the circuit is working at the minimum pressure - here, 20 bar - the gas inside the dampener will expand and consequently the residual pulsation will decrease from the +/- 5% initially admitted).

Since: $P_2 \times V_2 = P_0 \times V_0$ $P_0 = 0.9 \times 20 = 18$ bar $P_2 = 200 + 5\% = 210$ bar

$$P_2 / P_0 = V_0 / V_2 = 210 / 18 = 11.66 \quad (7)$$

We will calculate the volume of a hypothetical dampener for the maximum pressure of **210 bar**.

$$V_{0\,(\text{at } 200 \text{ bar})} = (210 \times 15) / [0.8 \times 0.9 \times (210 - 190)] = 218.75 \text{ c.c.}$$ (from formula (6) in page 4)

This volume is equivalent to "V_2" from the equality (7), and consequently:

$$(210 / 18) = (V_0 / 218.75) = 11.66$$

and

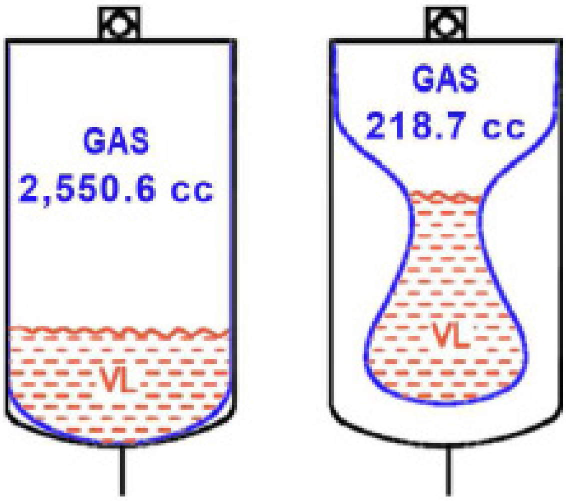
$$V_0 = 218.75 \times 11.66 = 2{,}550.62 \text{ c.c.}$$

This is in theory the total dampener volume necessary for this application; nevertheless, the ratio, V_0 / V_2 ratio cannot be higher than **4** (In bladder type dampeners. The value will be different in other design types of dampener. Please, consult ***HIDRACAR S.A.*** technical department for further details on the particular) in order not to wrinkle the bladder excessively, what could tear it prematurely. In our example, we have a ratio V_0 / V_2 of **2,550.62 / 218.75 = 11.65**, nearly **3** times higher than the value of **4** that we have just recommended.

To avoid exceeding this ratio of **4:1**, a certain amount of liquid must be introduced inside the bladder together with the gas (usually the same liquid of the circuit or any other unable to react with either the bladder material or with the circuit liquid). Again, in our example this volume of liquid which has to be introduced into the bladder, "V_L" (see figure), is calculated:

$$(2{,}550.62 + V_L) / 218.75 + V_L) \leq 4 \quad \text{and operating:} \quad V_L = 558.54 \text{ c.c.}$$

The total dampener volume needed will be: **2,550.62 + 558.54 = 3,109.16 c.c.**



WHEN TO INSTALL A PULSATION DAMPENER AT THE SUCTION INLET OF PISTON TYPE OR SIMILAR VOLUMETRIC OR DOSING PUMPS

As already said, volumetric pumps are used to dose with precision a constant volume of liquid. And therefore, the pump must get completely filled in every suction stroke piston displacement cycle.

When in the liquid inlet port of the pump the pressure can easily overcome the resistance of the suction valve spring that all pumps have (we can allow the pressure at the inlet port to exceed the resistance of the valve spring beyond 3 bar) and the section of the suction pipe is about twice the discharge section of the pump, it won't be necessary to install a pulsation dampener at the suction inlet.

If the static pressure of the liquid at the pump inlet is low (below the already mentioned 3 bar) the suction pipe is long enough, longer than 3 to 5 metres from the suction liquid supply tank to the pump inlet, and also the liquid has a low vapour tension at the working temperature then a phenomenon called "**cavitation**" could take place.

When this anomaly takes place, the pump could suction a mix of liquid and its vapour that, on being compressed during the pump discharge cycle, causes, because of the pump impulsion pressure, the condensation of the vapour and, in consequence, produces a reduction in volume. This effect, which can be detected by a soft explosion-like sound, reduces considerably the life of the pump, which also stops providing the required dosing.

In order to eliminate this problem it is necessary to prevent the pressure at the pump inlet port to be lower or close to the vapour tension of the liquid. And a condition for this, other than having enough pressure, is to avoid the suction pipe liquid column to be subjected to accelerations and decelerations caused by the operation of the pump.

It is precisely, **and exclusively to avoid these fluctuations in the liquid column** (accelerations and decelerations) at the suction pipe, **that a pulsation dampener is needed at the suction** of volumetric or dosing pumps.

The pulsation dampener installed at the suction of the pump fulfills the same task as the one installed at the discharge: To keep the velocity of the liquid as constant as possible; and therefore, its pressure. If the low pressure of the liquid at the suction does not experiment any substantial drop, the possibility of reaching the vapour tension of the liquid will decrease and the main cause for the appearance of "**cavitation**" will be eliminated.

The pulsation dampener will not be able to avoid the "**cavitation**" phenomenon if all its determinants are present; and therefore it is convenient, when a risk exists, to install in order to prevent it an auxiliary centrifugal or similar pump, or else, to raise the liquid supply tank, or pressurize it, and this way increase the pressure at the inlet port of the dosing pump.

If all these recommendations can't be applied, there is the resort of installing the pulsation dampener to try to avoid the appearance of the "**cavitation**" effect. For this it is specially recommended that:

The size or volume of the dampener installed at the suction must be approximately twice as much as for the one installed at the discharge.

The size of the connection port of the dampener must be at least identical to the diameter of the suction pipe.

The dampener must be installed as close as possible to the pump liquid inlet port, with the least possible pipe length in between.

The gas charging or inflating pressure must be below atmospheric.

For further detail explaining about the above exposed, please, contact *HIDRACAR S.A.* technical department.

We have written this paper in the modest hope of helping any people interested in these devices to understand the applications of the hydro-pneumatic accumulators used as pulsation dampeners. If it results useful to anyone, we will feel satisfied and rewarded for the time and effort spent in the making.

7th rev., November 2013

Manuel Carcaré Gimeno
Technical Director & *HIDRACAR S.A.* founder

HIDRACAR S.A.

TECHNICAL AND PRACTICAL CONSIDERATIONS REGARDING PULSATION DAMPENERS INSTALLED AT THE SUCTION OR THE DISCHARGE OF DOSING PUMPS

As we already know, the volumetric or dosing pumps manage to supply a constant volume in time, but produce an oscillating and variable flow in pumps with a crankshaft movement.

As already exposed in our article *"Technical and practical considerations on the use of pulsation dampeners in circuits with volumetric or dosing pumps"*, this oscillating flow supply effect is more significant in the case of single-piston pumps; and it is in this type of pumps where the installation of a pulsation dampener becomes more useful and necessary, both at the discharge and the suction, if given the conditions exposed in the aforementioned article.

In some cases there is the tendency to install at the suction a dampener without a separator element between the pumped liquid and the atmospheric air inside the dampener. We understand that this solution creates a major problem that we will try to explain.

When the dampeners without separator are used at the discharge, the problem gets reduced in part.

Let's see which are the main problems of installing such a pulsation dampener at the suction of the pump:

I) It must be always mounted upright and must be filled with the pumped liquid at least to half of its volume, leaving the remaining volume for atmospheric air. This is a hazardous operation if the liquid is corrosive, as it must be performed on site.

II) The usual problem, but even more pronounced at the suction: The atmospheric air gets dissolved as time goes by, so it becomes necessary to proceed as in (I). But, ABOVE ALL, the dissolved air reduces the dosing of the liquid the pump is providing. The pump chamber gets full of liquid and dissolved air bubbles. These bubbles, which on entering the pump have a non-negligible size, as they could be slightly below the atmospheric pressure, when the pump starts the discharge and the pressure rises get compressed, what reduces the volume of the pump head and consequently an effect akin to CAVITATION happens (*).

(*): The volume freed by the reduction of the size of the air bubbles, is filled by the pumped liquid vapour and if this circumstance does not occur the problem gets worse.

III) Comparative analysis of volumes and costs of the dampeners with and without a separator between fluids (air / liquid):

DATA OF A HYPOTHETICAL CASE (simple-effect membrane pump)

Q = 5 L/min. at 100 r.p.m.
Pumping pressure: 4 bar-g
Suction pressure: 1 bar-g
Residual pulsation admitted at the discharge: +/- 6%
Residual pulsation admitted at the suction: +/- 3%

THEORETICAL CALCULATIONS ON THE VOLUME OF THE DAMPENER AT THE DISCHARGE

<u>With separator (bladder, membrane, bellows)</u>:

∂V = (5 / 100) / 2 = 0.025 litres ≡ 25 c.c. (this is the volume that gets in and out of the dampener in each pump cycle.

$\underline{V_0}$ = (∂V x P_2) / [0.85 x ($P_2 - P_1$)] = (25 x 4.24) / (0.85 x 0.48) ≈ $\underline{260}$ c.c. (this is the total volume of the dampener).

P_2 = Working pressure plus percentage of residual pulsation =
= 4 + (6 x 4 / 100) = 4.24 bar

P_1 = Working pressure minus percentage of residual pulsation =
= 4 – (6 x 4 / 100) = 3.76 bar

<u>Without separator</u>:

V_0 x 1 at = V_1 x P_1 = V_2 x P_2

V_2 = Volume of atmospheric air inside the dampener when compressed at P_2 pressure

P_0V_0 = 1 at x V_0 = P_1V_1 = P_2V_2;

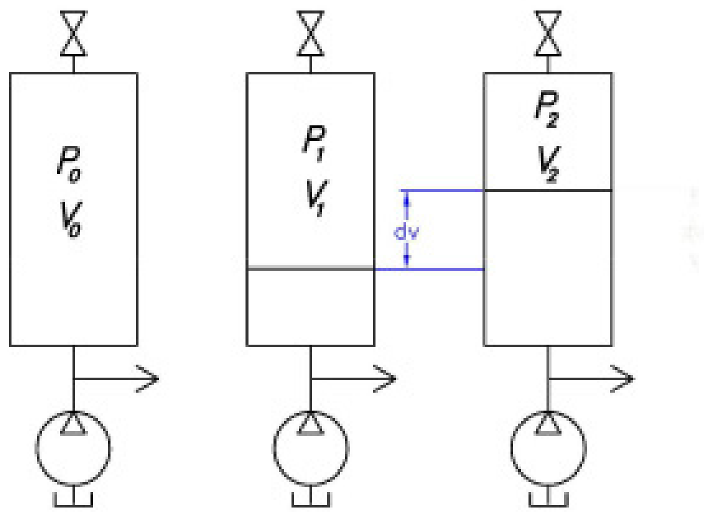
$V_1 - V_2 = \partial V$ = 25 c.c., V_1 = 25 + V_2;

P_1 x (25 + V_2) = P_2 x V_2;

(3.76 x 25) + 3.76 x V_2 = 4.24 x V_2;

V_2 x (4.24 – 3.76) = 3.76 x 50;

V_2 = 94 / 0.48 ≈ 196 c.c.



V_0 x 1 at = P_2 x 196 = 4.24 x 196;

V_0 = (4.24 x 196) / 0.85 ≈ 977 c.c.!!;

977 / 260 = 3.75 times the volume of the dampener without separator compared to the dampener with separator!!!

NOTE: The higher the working pressure, the bigger the size of the dampener without separator.

CALCULATIONS OF THE DAMPENER AT THE SUCTION

With separator:

$V'_0 = \partial V \times P'_2 / 0.85 \times (P'_2 - P'_1) = (25 \times 1.03) / (0.85 \times 0.06) = 505$ c.c.
$P'_2 = 1 + [(3 \times 1) / 100] = 1.03$
$P'_1 = 1 - [(3 \times 1) / 100] = 0.97$

Without separator:

$P'_1 \times (25 + V'_2) = P'_2 \times V'_2;$
$(0.97 \times 25) + 0.97 \times V'_2 = 1.03 \times V'_2;$
$0.06 \times V'_2 = 0.97 \times 25;$
$V'_2 = (0.97 \times 25) / 0.06 \approx 404$
$V'_0 \times 1$ at $= P'_2 \times 808;$
$V'_0 = (1.03 \times 404) / 0.85 = 490$ c.c.

The volume of the dampener must be at least twice the calculated value in order to get the initial level of the liquid as far from the dampener connecting port as possible. Therefore, this volume would be 490 x 2 = 980 c.c.

Summarizing:

The main drawback of not using pulsation dampeners with separator, either at the suction or the discharge, is the dissolving of the air inside the dampener into the liquid and the need for stopping the pump regularly to refill the dampener with atmospheric air; with the recurrent hazardous exposure in case of pumping corrosive chemicals.

But above all, in the application of the dampener without separator at the suction of the pump, the dissolving of air into the liquid can create cavitation and a deficient dosing.

The use of dampeners without separator, either at the suction or the discharge, will require dampeners with a bigger size than those needed if fitted with a separator.

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UNQUESTIONABLE BENEFITS OF INSTALLING A PULSATION DAMPENER AT THE DISCHARGE OF SINGLE-EFFECT DOSING PUMPS

As we have already seen, all single effect dosing pumps does not supply any flow during the filling or suction cycle of the pump. This means that at the end of such cycle, the pumping pressure has been reduced to "zero". The liquid column inside the discharge pipe has stopped.

On starting the course of discharge or the exiting of the liquid from the pump, the liquid column must overcome:

a) The inertia of the mass of the liquid that has stopped.

b) The resistances that are generated in the circuit against the movement of the liquid. These resistances are:

  I) Geometrical height.

  II) Head loss.

CONSEQUENTLY, the pressure at the outlet of the pump goes from "zero" to a pressure generated by resistances *a* and *b*.

This variation of pressure, from "zero" to a maximum value, creates the following problems:

- Fatigue of the material of the pump mechanisms, piping, filters, flow meters, threaded or flanged couplings, etc…
- Vibrations that end up producing leaking of the liquid at the couplings.
- The impossibility of getting a precise reading of the flow meter.

All this shows how necessary is the installation of a pulsation dampener to avoid all the problems that have been exposed. As the dampener procures a more constant flow in the pipe, it is possible to calculate more accurately its section and it always results in a diameter reduction. This alone already redeems in part the extra cost assumed on installing the dampener.

Let's see now how we can reduce to a certain extent the cost of the dampener.

As we already know, every time the size of the dampener must be calculated it is necessary to know the residual pulsation percentage that can be admitted or tolerated in the circuit. The final customer always tends to reduce this value when asked about, even though in most cases it is not necessary to adjust it to such tight values. In any case the pumping pressure must always be taken into account (it is not the same a wide percentage for a low pressure, say 6 bar than for a pressure of 200 bar or higher).

A simple illustration will make evident the reduction in the size of the dampener, just increasing slightly the percentage of residual pulsation:

If the pump head: 50 c.c.
The pumping pressure is: 6 bar
The initial residual pulsation is: +/- 4%
The size of the dampener will be:

$V_0 = (\partial V \times P_2) / 0,75 \times (P_2 – P_1) = (25 \times 6,24) / (0,75 \times 0,48) = 433,3$ c.c.
V_0 = Dampener size.
∂V = Volume of liquid the dampener will store and return = pump head / 2
$P_2 = 6 + (4 \times 6 / 100) = 6,24$ bar
$P_1 = 6 - (4 \times 6 / 100) = 5,76$ bar

If we take a pulsation % of +/- 8%

$P'_2 = 6 + (8 \times 6 / 100) = 6,48$ bar
$P'_1 = 6 - (8 \times 6 / 100) = 5,52$ bar
and $V'_0 = (25 \times 6,48) / (0,75 \times 0,96) = 225$ c.c.

We then see that if we change from a +/- 4% residual percentage to a +/- 8%, the size of the dampener has been reduced to approximately by half.

Pressures will fluctuate, with a 4%
+6,24; -5,76
and with a 8% residual pulsation
+6,48; -5,52
the fluctuation is just +/- 0,24 bar (difference between 6,48 - 6,24 = 0,24).

In a few words with a higher residual pulsation percentage (8%) the pressure fluctuation in the circuit is of just:
+6,48 bar; -5,52 bar

FINAL SUMMARY

In the single-effect dosing pump application, what is important is avoiding the fluctuation of the pump discharge pressure from "zero" to a maximum as it will eventually generate breakdowns in the circuit.

Therefore and unless the final customer wants to control with great precision the pressure fluctuation, ***HIDRACAR*** recommends, for these working pressure values (below 10 bar) to calculate the dampener size with a percentage of +/- 8% in order to avoid an important extra cost of the pump + dampener combo.

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