Accumulator Sizing Procedure (Conversion : kg/cm² —×0.0980665→ MPa ; MPa —×10.1972→ kg/cm²)

Terms of calculation

V_1 : Required accumulator gas volume (L)
V_W : Required oil discharge volume (L)
P_3 : Maximum working pressure (MPa・abs.)
P_2 : Minimum working pressure (MPa・abs.)
P_1 : Gas charging pressure (MPa・abs.)

For energy storage : $0.8P_2 \leqq P_1 \leqq 0.9P_2$
For shock dampening : $0.5P_X \leqq P_1 \leqq 0.8P_X$
For pulsation dampening : $0.5P_X \leqq P_1 \leqq 0.8P_X$

Decide P_1 taking the temperature change into account ⇒ page 95

P_a : Mean working pressure (MPa・abs.)

$$P_a = \frac{P_3 + P_2}{2}$$

P_X : Average circuit pressure (MPa・abs.)
P_m : Allowable maximum pressure of shock or pulsation (MPa・abs.)
e : Gas charging pressure ratio $= P_1 / P_2$
a : Working pressure ratio $= P_3 / P_2$
η : Gross efficiency of accumulator = 0.95
m : Polytropic exponent for oil charge time (See separate table showing various exponents)
n : Polytropic exponent for oil discharge time (See also separate table)
F : Oil discharge coefficient

$$F = \frac{a^{\frac{1}{n}} - 1}{a^{\frac{1}{m}}}$$

v : Velocity of oil flow (m/sec)
g : Gravitational acceleration = 9.8 (m/sec²)
d : Inside diameter of piping (mm)
L : Total piping length (m)
γ : Specific gravity of liquid (kg/m³)

Turbine oil ≒ 880
W.G. ≒ 1,100
Water ≒ 1,000

W : Weight of fluid in piping line (kg)

$$W = \frac{\pi \cdot d^2}{4} \cdot L \cdot \gamma \cdot 10^{-6}$$

q : Oil discharge volume per pump revolution (L/rev)
F_1 : Pump out-put coefficient

Pump type		Coefficient F_1
Simplex (Single cylinder)	Single acting	0.60
	Double acting	0.25
Duplex (Two cylinders)	Single acting	0.25
	Double acting	0.15
Triplex (Three cylinders)	Single acting	0.13
	Double acting	0.06

(When over triplex, F_1 shall be 0.06)

1. For Energy Storage (see Accumulator Sizing Calculation : Page 98)

$$V_1 = \frac{V_W}{e \cdot \eta \cdot F} \quad \cdots\cdots (1)$$

$$V_W = V_1 \cdot e \cdot \eta \cdot F \quad \cdots\cdots (2)$$

i) If larger "e" is taken, accumulator gas volume can be smaller.
ii) When "e", exceeds 0.9, bladder life will be shortened.
iii) If larger "a" is taken, accumulator gas volume can be smaller.
iv) If bladder compression ratio ($b = P_3 / P_1$) becomes to be larger, bladder life will be shortened.

Allowable Bladder Compression Ratio

Accumulator installation	$b = P_3 / P_1$
Vertical	4/1

v) "m", and "n" should be selected depending on "mean working pressure = $(P_3 + P_2) / 2$, and on oil charge / discharge time" selecting from the table as shown in the next page.
vi) When m > n (ex. m = 1.8, n = 1.6), calculation must be made taking m → n, ie. n = m. (In above example, m = n = 1.8)

2. For Shock Absorption (see Accumulator Sizing Calculation : Page 100)

$$V_1 = \frac{W \cdot v^2 \cdot (n-1) \cdot \left(\frac{P_X}{P_1}\right)^{\frac{1}{n}}}{203.94 \cdot g \cdot P_X \cdot \eta \left\{\left(\frac{P_m}{P_X}\right)^{\frac{n-1}{n}} - 1\right\}} \quad \cdots\cdots (3)$$

i) Select value of "n" to the figure at intersection of P_X and < 15 seconds in the table shown in the next page and put that value into the formula (3).
ii) "P_1 = 60% of P_X" shall be taken into calculation.

3. For Pulsation Dampening (see Accumulator Sizing Calculation : Page 99)

$$V_1 = \frac{q \cdot F_1 \cdot \left(\frac{P_X}{P_1}\right)^{\frac{1}{n}}}{1 - \left(\frac{P_X}{P_m}\right)^{\frac{1}{n}}} \quad \cdots\cdots (4)$$

i) Take value of "n" to the figure at intersection of P_X and < 15 seconds in the table shown in the next page and put that value into the formula (4).
ii) Take the value of P_1 to approx. 60% of P_X and put that in to the formula (4).

N_2 gas Polytropic Exponents for Accumulator (for oil charge : m, for oil discharge : n)

Average Pressure (MPa) \ Time		Oil "charge time (:Tm)" or "discharge time (:Tn)" Seconds								
		T<15	15≦T<30	30≦T<60	60≦T<120	120≦T<240	240≦T<480	480≦T<900	900≦T<1800	1800≦T
・Energy storage : P = Pa ・Shock absorption : P = Px ・Pulsation dampening : P = Px	P<2.0	1.42	1.38	1.34	1.29	1.24	1.19	1.15	1.10	1.05
	2.0≦P<3.5	1.46	1.41	1.37	1.32	1.27	1.22	1.16	1.11	1.06
	3.5≦P<5.0	1.50	1.45	1.40	1.35	1.30	1.24	1.19	1.13	1.07
	5.0≦P<6.5	1.54	1.50	1.44	1.39	1.33	1.27	1.22	1.16	1.10
	6.5≦P<8.0	1.59	1.54	1.49	1.43	1.37	1.31	1.25	1.19	1.12
	8.0≦P<9.5	1.64	1.59	1.53	1.47	1.41	1.35	1.28	1.22	1.15
	9.5≦P<11	1.69	1.64	1.58	1.52	1.45	1.39	1.32	1.26	1.18
	11≦P<12.5	1.74	1.69	1.62	1.56	1.50	1.43	1.36	1.29	1.22
	12.5≦P<14	1.80	1.74	1.67	1.61	1.54	1.47	1.40	1.33	1.25
	14≦P<15.5	1.85	1.79	1.72	1.66	1.59	1.51	1.44	1.37	1.29
	15.5≦P<17	1.90	1.84	1.77	1.70	1.63	1.56	1.48	1.41	1.32
	17≦P<18.5	1.96	1.90	1.83	1.75	1.68	1.60	1.53	1.45	1.36
	18.5≦P<20	2.01	1.95	1.88	1.80	1.73	1.65	1.57	1.49	1.40
	20≦P<21.5	2.07	2.00	1.93	1.85	1.78	1.70	1.61	1.53	1.44
	21.5≦P<23	2.12	2.06	1.98	1.90	1.83	1.74	1.66	1.58	1.48
	23≦P<24.5	2.18	2.11	2.03	1.96	1.87	1.79	1.70	1.62	1.52
	24.5≦P<26	2.24	2.17	2.09	2.01	1.92	1.84	1.75	1.66	1.56
	26≦P<27.5	2.29	2.22	2.14	2.06	1.97	1.89	1.79	1.71	1.60
	27.5≦P<29	2.35	2.28	2.19	2.11	2.02	1.93	1.84	1.75	1.64
	29≦P<30.5	2.40	2.33	2.25	2.16	2.07	1.98	1.89	1.79	1.68
	30.5≦P<32	2.46	2.39	2.30	2.21	2.12	2.03	1.93	1.84	1.72
	32≦P<33.5	2.52	2.44	2.36	2.27	2.18	2.08	1.98	1.88	1.76
	33.5≦P<35	2.58	2.50	2.41	2.32	2.23	2.13	2.03	1.93	1.81

※ When pressure exceeds 35MPa, please contact us or a distributor for the polytropic exponent.
The polytropic exponents are also obtainable from the following formula.

Calculation Formula of Polytropic Exponents (NACOL Empirical Formula)

NACOL established an original formula to calculate the polytropic exponet, based upon the data of NACOL tests. With the calculation formula, it is possible to easily calculate the polytropic exponent as a function of pressure and time.

- m : Polytropic exponent for oil charge time.
- n : Polytropic exponent for oil discharge time.
- P : Pa (Mean working pressure) or Px (Rated accumulator circuit pressure) [MPa・abs.]
- T : Tm (Charging time) or Tn (Discharging time) [Sec.]
  (Note : When Tm or Tn is smaller than 8 seconds, take 8 for T. When Tm or Tn is larger than 1,800, take 1,800 for T)

$$m \text{ or } n = 0.00938 \times P \times (2.5 + \sqrt{3.7 - \log_{10} T}) + 1.34 - 0.2 \times \log_{10} T + \frac{18 \times \sqrt{0.45 + \log_{10} T}}{10.1972 \times P + 95}$$

NACOL Calculation Formula for Change of Gas Charging Pressure due to Change of Temperature

Based upon the data of NACOL tests and the theoretical formula of the real gas (formula of Fanderuworth), NACOL established a formula to calculate change of gas charging pressure due to change of temperature.

- P_1 : Gas pressure after temperature change (MPa. abs.)
- P_0 : Gas pressure before temperature change (MPa. abs.)
- T_0 : Original temperature before change (℃)
  [but, $-40 \leqq T_0 \leqq 110$℃]
- T_1 : Temperature after change (℃)

$$P_1 = \{ A \times (T_1 - T_0) + P_0 \times 10.1972 \} / 10.1972$$

$$A = 10.1972 \times B \times P_0 - C \times \left(1 - \frac{1}{0.2039 \times P_0 + 1}\right)$$

$$B = \{ 488 - \sqrt{2065 \times 10^2 - (T_0 - 170)^2} \} / 10^4$$

$$C = \{ 8233 - \sqrt{6794 \times 10^4 - (T_0 - 696)^2} \} / 10^2$$

Working conditions and system specifications

Di: Inside diameter of cylinder = ϕ 300 mm
S : Cylinder stroke = 380 mm
V : Required cylinder speed = 0.75 m/sec.
P_3: Maximum working pressure = 20 MPa
P_2: Minimum working pressure = 15 MPa
(Take pressure loss into account)
Q : Discharge volume from pump = 90 L/min.
(Working temperature = 10～90℃
Service fluid = Petroleum hydraulic oil)

＊ In calculation, the Absolute pressure (MPa・abs.) shall be used. So, convert Gauge pressure to Absolute pressure.

1) Obtain the required oil discharge volume (Vw) from above conditions.

$$V_W = \frac{\pi \cdot Di^2}{4} \cdot S \cdot 10^{-6}$$

$$= \frac{\pi \cdot 300^2}{4} \times 380 \times 10^{-6}$$

$$\fallingdotseq 26.9\ \mathrm{L}$$

2) Obtain gas precharge pressure (P_1) taking the change of temperature during operation into consideration.

i) Obtain Max. P_1 at maximum working temperature (90℃).

Max.P1 ＝0.9・P_2
＝0.9×15.1013MPa・abs
＝13.59MPa・abs

ii) Obtain MinP1 at minimum working temperature (10℃), following the "NACOL Calculation Formula for Change of Gas Charging Pressure due to Change of Temperature" shown on page 95.

Min.P1＝10.12MPa・abs

3) Next obtain gas precharge pressure ratio (e).

$$e = \frac{P_1}{P_2} = \frac{10.12}{(15+0.1013)}$$

$$\fallingdotseq 0.67$$

4) Select the polytropic exponent (m,n).

$$\text{Mean pressure (Pa)} = \frac{P_3 + P_2}{2} = \frac{20.1013+15.1013}{2}$$

$$\fallingdotseq 17.60\ \mathrm{MPa \cdot abs}$$

$$\text{Oil charge time (Tm)} = \frac{V_W}{Q} = \frac{26.9}{90/60}$$

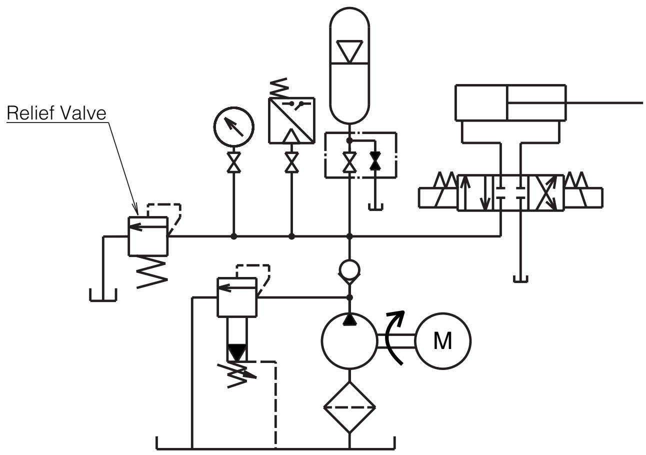
$$\fallingdotseq 17.9\ \mathrm{sec}$$

$$\text{Oil discharge time (Tn)} = \frac{S}{V}\ 10^{-3} = \frac{380}{0.75} \times 10^{-3}$$

$$\fallingdotseq 0.5\ \mathrm{sec}$$

From the table on page 59

m＝1.90 n＝1.96



5) Obtain the oil discharge coefficient (F).

$$F = \frac{a^{\frac{1}{n}} - 1}{a^{\frac{1}{m}}} = \frac{\left(\frac{20.1013}{15.1013}\right)^{\frac{1}{1.96}} - 1}{\left(\frac{20.1013}{15.1013}\right)^{\frac{1}{1.90}}}$$

$$\fallingdotseq 0.135$$

6) Calculate the required accumulator gas volume (V1).

$$V_1 = \frac{V_W}{e \cdot \eta \cdot F} = \frac{26.9}{0.67 \times 0.95 \times 0.135}$$

$$\fallingdotseq 313\ \mathrm{L}$$

7) Decide on the number of Accumulators.

Acc 60L: 313/60≒6pcs (N series)
Acc 160L: 313/160≒2pcs (N series)

8) Confirm that the oil discharge speed of the above two sizes of Accumulators is within the range of allowable oil discharge speed.

$$\text{Required oil discharge speed} = \frac{V_W}{T_n} \cdot 60 = \frac{26.9}{0.5} \times 60$$

$$\fallingdotseq 3.240\ \mathrm{L/min}$$

When using 60 L size standard type Accumulators in a quantity of 6 pcs.
600 L/min×6 = 3,600 L/min ≧ 3,240 L/min
(satisfying the above requirement)
When using 160 L size standard type Accumulators in a quantity of 2 pcs.
1,200 L/min×2 = 2,400 L/min ≦3,240 L/min
(not satisfying the above requirement)
When using 160 L size high flow type Accumulators in a quantity of 2 pcs.
2,400 L/min×2 = 4,800 L/min ≧3,240 L/min
(satisfying the above requirement)

9) Select the bladder compound.

Working temperature :10～90℃
System fluid : petroleum hydraulic oil } High temp. nitrile rubber (H)

10) From the above 1)～9), the following two types of Accumulators can be selected.

＊H-N21MP-L60-AAC …6 pcs
＊H-N21MP-160-AEC …2 pcs

Take the Accumulators installation space, cost, etc. into account and select the most suitable Accumulators.

Date:

Accumulator Sizing Program for Multiple Cylinders or Hydraulic Motors (Data Sheet)

(Please send this data sheet to NACOL .We are pleased to select the most suitable accumulator for you.)

To: NIPPON ACCUMULATOR CO., LTD.
Sales Department

From : (Your Company Name)
: (Your Dept. or Sect.)
: (Your Name)

FAX:
TEL:

Accumulator application (System Name)				
Customer's Specification	Type of Operating Oil			⟹ Suitable Bladder Compound
	Oil Temperature Ⓣ	℃	~	
	Cycle Time Ⓒ	sec		
	Max. Operating Pressure P_3	MPa		
	Min. Operating Pressure P_2	MPa		
	Pump discharging volume (Pump Q'ty) Ⓠ	L/min	(sets)	

【How to fill in the data】

A column: Fill in the each work step name from the first step of the first cycle till the first step of the second cycle.
(To fill in the first step of the second cycle is from the purpose to know the idle time between the first cycle and the second cycle.)
Note: When you fill in No.1 column to show an operation of the actuater, the computer treat this as Accumulators have been charged necessary oil volume beforehand.

B column: This column shall be filled in only when cylinder shall be actuated. Direction of the pressurization shall be shown by a mark ○ upon H or R (H : pressurization of the Head End side. R: Rod side pressurization) Then the columns ① thru ③ shall be filled in.

C column: This column ④ and ⑤ shall be filled in only when oil motor shall be actuated. (④ shall show displacement oil volume per one revolution)

D column: When you know the required oil volume, fill in that volume into this column ⑥. (when B or C column has already been filled in, it is not necessary to fill in this column)

E column: When you know the discharging volume of pump, fill in that volume into this column ⑦.
(when B or C or D column has already been filled in, it is unnecessary to fill in this column)

F column: Starting time and end time of each step shall be filled into ⑧ and ⑨ setting the Starting Time of the first step as Zero (0).

		B : Cylinder Spec.				C : Oil Motor Spec.		D : Required oil volume	E : Flow rate	F : Operation Time	
		Pressurized side. H:Head end side R:Cap end side	Tube. I.D.	Rod O.D.	Stroke	Displacement volume	Revolution			Starting Time	Ending Time
No.	A :Name of the each step		① ϕ Do mm	② ϕ d mm	③ S mm	④ q cc/rev	⑤ N rpm	⑥ L	⑦ L/min	⑧ sec	⑨ sec
1		H. R									
2		H. R									
3		H. R									
4		H. R									
5		H. R									
6		H. R									
7		H. R									
8		H. R									
9		H. R									
10		H. R									
11		H. R									
12		H. R									
13		H. R									
14		H. R									
15		H. R									
16		H. R									
17		H. R									
18		H. R									

NIPPON ACCUMULATOR CO., LTD. Sales Department will be happy to review your Accumulator requirements with any special Accumulator manufacturing codes or specifications.
We will review your specific requirements in detail to provide you with the most suitable and economical Accumulator.

NACOL
NIPPON ACCUMULATOR CO., LTD.
TEL : 8154 (367) 1252 FAX : 8154 (367) 1951
http://www.nacol.co.jp E-mail: sales@nacol.co.jp

Accumulator Sizing Program for Energy Storage Application

Date:

Customer Name:

Address

Accumulator application (Name of System)		
Max. Operating Temperature (T_H)	℃	Operating Oil	⟹ Suitable Bladder Compound
Min. Operating Temperature (T_L)	℃		

※ Note : In all calculations, the absolute pressure shall be used. (the absolute pressure = gauge pressure + 0.1013 MPa.)

	Item	Symbol	Unit	Value	Remarks
Customer's specification	Required oil volume to be discharged from Accumulator	V_w	L		
	Max. working pressure	P_3	MPa・abs.		$P_3 \leqq 4 \times P_{1L}$
	Min. working pressure	P_2	MPa・abs.		P_2 is to be decided taking pressure loss (△P) into consideration
	Charged gas pressure at the highest temperature	P_{1H}	MPa・abs.		$P_{1H} = P_2 \times 0.9$ (at the highest operating temperature)
	Oil charge time	T_m	sec.		Time necessary to charge Vw into the Accumulator
	Oil discharge time	T_n	sec.		Time necessary to discharge Vw from the Accumulator
Applicable factors	Charged gas pressure at the lowest temperature	P_{1L}	MPa・abs.		Calculate from the FORMULA shown below
	Gas charging pressure ratio	e	―		When ($e = P_{1L} \div P_2$) > 0.9, bladder life will be shortened.
	Working pressure ratio	a	―		The higher we take a (= $P_3 \div P_2$), the larger the obtainable oil discharge amount.
	Mean Accumulator circuit pressure	P_a	MPa・abs.		$P_a = (P_3 + P_2) \div 2$
	Polytropic exponent at oil charge time	m	―		Intersecting point of Tm and Pa as given by the table of N_2 gas polytropic exponents. (see page 95)
	Polytropic exponent at oil discharge time	n	―		Intersecting point of Tn and Pa as given by the table of N_2 gas polytropic exponents. (see page 95)
	Accumulator gross efficiency	η	―	0.95	―
	Oil discharge coefficient	F	―		Obtained from the following formula.
	Accumulator gas capacity	V_1	L		Given from the following formula.
	Max. required oil velocity	Q	L/sec.		Q = Vw ÷ Tm or Tn ÷ pieces. Either Standard Type or High Flow type as selected from catalogue specifications.

(FORMULA)

$$C = \{8233 - \sqrt{6794 \times 10^4 - (T_H - 696)^2}\} / 10^2$$
$$= \{8233 - \sqrt{6794 \times 10^4 - (\boxed{T_H} - 696)^2}\} / 10^2$$

$$B = \{488 - \sqrt{2065 \times 10^2 - (T_H - 170)^2}\} / 10^4$$
$$= \{488 - \sqrt{2065 \times 10^2 - (\boxed{T_H} - 170)^2}\} / 10^4$$

$$A = 10.1972 \times B \times P_{1H} - C \times \left(1 - \frac{1}{0.2039 \times P_{1H} + 1}\right)$$
$$= 10.1972 \times \boxed{B} \times \boxed{P_{1H}} - \boxed{C} \times \left(1 - \frac{1}{0.2039 \times \boxed{P_{1H}} + 1}\right)$$

$$P_{1L} = \{A \times (T_L - T_H) + P_{1H} \times 10.1972\} / 10.1972$$
$$= \{\boxed{A} \times (\boxed{T_L} - \boxed{T_H}) + \boxed{P_{1H}} \times 10.1972\} / 10.1972$$

$$F = \frac{a^{\frac{1}{n}} - 1}{a^{\frac{1}{m}}} = \frac{(\quad a \quad)^{\frac{1}{(n)}} - 1}{(\quad a \quad)^{\frac{1}{(m)}}}$$

$$V_1 = \frac{V_w}{e \cdot \eta \cdot F} = \frac{(\quad V_w \quad)}{(\quad e \quad) \cdot 0.95 \cdot (\quad F \quad)}$$

Selected Accumulator model	Q'ty ／□-□□□□-□□□-□□□	Fittings	□Reduce Bush (　　) ・□Flange (　　)
Inspection certificate required by the customer	METI Japan・ASME・CE (Others　)	Remarks	

NIPPON ACCUMULATOR CO., LTD. Sales Department will be happy to review your Accumulator requirements with any special Accumulator manufacturing codes or specifications.
We will review your specific requirements in detail to provide you with the most suitable and economical Accumulator.

NACOL
NIPPON ACCUMULATOR CO., LTD.
TEL : 8154 (367) 1252　FAX : 8154 (367) 1951
http://www.nacol.co.jp　E-mail: sales@nacol.co.jp

Accumulator Sizing Program for Pulsation Dampening Application

Date:

Customer Name:

Address

Accumulator application (Name of System)		
Max. Operating Temperature (T_H)	℃	Operating Oil	⟹ Suitable Bladder Compound
Min. Operating Temperature (T_L)	℃		

※ Note : In all calculations, the absolute pressure shall be used. (Abs. pressure = gage press + 0.1013 MPa.)

Customer's specification	Symbol	Unit	Value	Remarks
Regular circuit pressure	P_x	MPa・abs.		
Max. allowable pulsation pressure	P_m	MPa・abs.		$P_m = P_X + \alpha$
Gas charging pressure	P_1	MPa・abs.		$P_1 = P_X \times 0.6$ (at ℃)
Polytropic exponent	n	−		Intersectional point from Px and T < 15 given by the table of N_2 gas polytropic exponents. (see page 95)
Discharging volume of pump	Q	L/min		Pump sort { Piston (Simplex, Duplex, or more), (single, double) acting; ☐ Vane ☐ Gear; ☐ Others ( )
Revolution of pump	N	rpm		
Discharging volume of pump per one revolution	q	L/rev		$q = Q \div N$
Discharge coefficient of pump	F_1			See the table below (When pump is larger than triplex, vane or gear pump, F1 should be 0.06)
Accumulator capacity	V_1	L		Given from the following formula.

$$V_1 = \frac{q \cdot F_1 \cdot \left(\frac{P_X}{P_1}\right)^{\frac{1}{n}}}{1 - \left(\frac{P_X}{P_m}\right)^{\frac{1}{n}}} = \frac{(\ q\ )\cdot(\ F_1\ )\cdot\left(\frac{(\ P_X\ )}{(\ P_1\ )}\right)^{\frac{1}{(\ n\ )}}}{1 - \left(\frac{(\ P_X\ )}{(\ P_m\ )}\right)^{\frac{1}{(\ n\ )}}} = \_\_\_\_\ L$$

Pump sort		F_1
single	single	0. 60
	double	0. 25
duplex	single	0. 25
	double	0. 15
triplex	single	0. 13
	double	0. 06

Selected Accumulator model	Q'ty ／☐☐-☐☐☐☐-☐☐☐-☐☐☐	Fittings	☐Reduce Bush ( )・☐Flange ( )
Inspection certificate required by the customer	METI Japan・ASME・CE(Others)	Remarks	

NIPPON ACCUMULATOR CO., LTD. Sales Department will be happy to review your Accumulator requirements with any special Accumulator manufacturing codes or specifications.
We will review your specific requirements in detail to provide you with the most suitable and economical Accumulator.

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http://www.nacol.co.jp E-mail: sales@nacol.co.jp

Accumulator Sizing Program for Shock Absorbing Application

Date:

Customer Name:

Address

Accumulator application (Name of System)				
Max. Operating Temperature	T_H	℃	Operating Oil	⟹ Suitable Bladder Compound
Min. Operating Temperature	T_L	℃		

※ Note : In all calculations, the absolute pressure shall be used. (the absolute pressure = gauge pressure + 0.1013 MPa.)

Customer's specification	Regular circuit pressure	P_x	MPa・abs.		
	Max. allowable shock pressure	P_m	MPa・abs.		$Pm = P_X + \alpha$
	Gas charging pressure	P_1	MPa・abs.		$P_1 = P_X \times 0.6$ (at ℃)
	Polytropic exponent	n	—		Intersectional point from Px and T＜15 given by the table of N_2 gas polytropic exponents. (see page 95)
	Pipe length	L	m		
	Inside diameter of pipe	d	㎜		
	Discharging volume of pump	Q	L/min		
	Flow velocity	v	m/sec		ⓥ = pump discharge volume ÷ square measure of pipe cross section.
	Acceleration of gravity	g	m/sec^2	9.8	
	Specific weight of fluid	γ	kg/m^3		Turbine oil ≒ 880, W.G. ≒ 1,100, Water ≒ 1,000
	Accumulator gross efficiency	η	—	0.95	
	Weight of fluid inside the line	W	kg		Given from the following formula
	Accumulator capacity	V_1	L		Given from the following formula

$$W = \frac{\pi \cdot d^2}{4} \cdot L \cdot \gamma \cdot 10^{-6}$$

$$= \frac{\pi \cdot (\ d\ )^2}{4} \cdot (\ L\ ) \cdot (\ \gamma\ ) \cdot 10^{-6}$$

$$V_1 = \frac{W \cdot v^2 \cdot (n-1) \cdot \left(\frac{P_X}{P_1}\right)^{\frac{1}{n}}}{203.94 \cdot g \cdot P_X \cdot \eta \left\{\left(\frac{P_m}{P_X}\right)^{\frac{n-1}{n}} - 1\right\}}$$

$$= \frac{(\ W\ ) \cdot (\ v\ )^2 \cdot ((\ n\ ) - 1) \cdot \left(\frac{(\ P_X\ )}{(\ P_1\ )}\right)^{\frac{1}{(\ n\ )}}}{1998.6 \cdot (\ P_X\ ) \cdot 0.95 \left\{\left(\frac{(\ P_m\ )}{(\ P_X\ )}\right)^{\frac{(\ n\ )-1}{(\ n\ )}} - 1\right\}} = \_\_\_\_\_ L$$

Selected Accumulator model	Q'ty ／□□-□□□□-□□□-□□□	Fittings	□Reduce Bush (　　)・□Flange (　　)
Inspection certificate required by the customer	METI Japan ASME・CE (Others)	Remarks	

NIPPON ACCUMULATOR CO., LTD. Sales Department will be happy to review your Accumulator requirements with any special Accumulator manufacturing codes or specifications.
We will review your specific requirements in detail to provide you with the most suitable and economical Accumulator.

NACOL
NIPPON ACCUMULATOR CO., LTD.
TEL : 8154 (367) 1252 FAX : 8154 (367) 1951
http://www.nacol.co.jp E-mail: sales@nacol.co.jp

Sizing Program for Dynaclean

Date:

Customer Name:

Address

Accumulator application (Name of System)				
Max. Operating Temperature	T_H	℃	Operating Oil	⟹ Suitable Bladder Compound ________
Min. Operating Temperature	T_L	℃		

Customer's specification	Max. oil volume in the oil tank	V	L		
	Max.change amount of oil volume	V_O	L		
	Air volume in the oil tank	V_A	L		
	Thermal expansion coefficient of the system fluid (at normal temp.)	α	—		See the table below
Applicable factors	Oil volume of thermal swell	O_H	L		Given from the following formula
	Air volume of thermal expansion	A_H	L		Given from the following formula
	Max. air volume into / out of Dynaclean	V_W	L		Given from the following formula
	Capacity of Dynaclean	V_1	L		Given from the following formula

$$O_H = V \cdot \alpha (T_H - T_L) = (V) \cdot (\alpha) \cdot \left((T_H) - (T_L)\right) = \_\_\_\_\_\_\ L$$

$$A_H = V_A \left(\frac{T_H + 273}{T_L + 273} - 1\right) = (V_A) \cdot \left(\frac{(T_H) + 273}{(T_L) + 273} - 1\right) = \_\_\_\_\_\_\ L$$

$$V_W = V_O + O_H + A_H = (V_O) + (O_H) + (A_H) = \_\_\_\_\_\_\ L$$

$$V_1 = \frac{V_W}{0.55} = \frac{(V_W)}{0.55} = \_\_\_\_\_\_\ L$$

Table of specific gravity-thermal expansion coeffient

Specific gravity	Thermal expansion coefficient
0.867～0.874	0.00077
0.875～0.882	0.00076
0.883～0.891	0.00075
0.892～0.902	0.00074
0.903～0.912	0.00073
0.913～0.923	0.00072
0.924～0.937	0.00071
0.938～0.951	0.00070
0.952～0.964	0.00069
0.965～0.975	0.00068
0.976～0.986	0.00067
0.987～1.000	0.00066
1.001～1.075	0.00063

Selected Accumulator model	Q'ty	／□□-□□□□□-□□□-□□□	Remarks	

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