Selection materials

Check of conditions when using hydraulic cylinders

Items	Contents
1. Set pressure (MPa)	Set pressure in hydraulic circuit
2. Load weight (kg)	Weight of objects to be moved, angle with gravity
3. Load driving conditions	Load installation, moving condition, presence of offset load
4. Required cylinder stroke (mm)	Cylinder stroke required for machines, cylinder excess stroke
5. Working speed (mm/s)	The maximum and working speed of cylinder inrush into cushion
6. Working frequency (number of time/time)	Working frequency
7. Working oil	Type of working oil used
8. Environmental conditions Note)	Temperature, dusts, vibration, cutting fluid splashing conditions, etc.

Note) Be sure to contact us before using or storing cylinders in places where are splashed with water and sea water, or are highly humid, since countermeasures against rusts and corrosion are required.

Hydraulic cylinder selection procedures

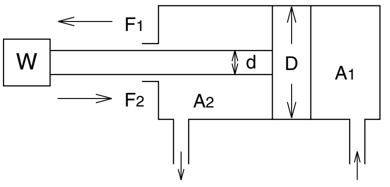
When selecting a hydraulic cylinder, the items below need to be decided.

Check	Selection items	Selection method	References
□1	Selection of cylinder bore	Select the appropriate cylinder bore depending on the required cylinder output, referring to the selection materials of a cylinder bore. Remember that the selected bore may need to be modified depending on the buckling of the piston rod or judgment result of inertia force absorption. Select based on the items which will require the maximum bore. Ex. 1) If the cylinder stroke is long, select the cylinder bore based on the buckling of the piston rod. Ex. 2) If the cylinder is used for conveyance, and the load is stopped with the cylinder cushion, select the cylinder bore based on the judgment result of inertia force absorption.	15 • 16
□2	Selection of cylinder series	Select the series based on the set pressure, cylinder bore, etc., referring to the type outline. At the same time, consider the specifications items.	Refer to the general catalogue of hydraulic equipment.
□3	Selection of mounting style	Select the mounting style based on the machines conditions, referring to the dimensional drawings of each series.	Refer to each series.
□4	Presence of boots and material selection (Selection of cylinder mounting length)	In the case of using cylinders in the places where are subjected to chips, sands, and dusts, boots need to be mounted to protect the piston rod. Select the material, referring to the selection materials of boots. Note 1) Since the boots have holes on their surfaces for expansion, the ingress of liquid, including cutting fluid (coolant), is inevitable. In such a case, use the cutting fluid proof type (70/140HW-8). Note 2) If the boots are equipped, the W (dimension WF) is long. Refer to the dimensional table.	24

□5	Judgment of piston rod buckling	Judge the usability, referring to the piston rod buckling materials. As a result, if the cylinder is inapplicable, modify any conditions shown below, and then, judge again. If it is still inapplicable, return to the 1) of the selection procedures, etc., and judge again. 1. Modify the mounting conditions. For example, if the load has no guide, attach the guide. 2. Decrease the set pressure. 3. Modify the cylinder bore or series, and widen the rod dia. (For the 70/140H-8 and 70/140HW-8, modify the rod type, and widen the rod dia..)	17 ~ 21
□6	Maximum absorbed energy of cylinder cushion	Judge the usability, referring to the chart of the maximum absorbed energy of cylinder cushion. If the cylinder is inapplicable, modify any conditions shown below, and then, judge again. If it is still inapplicable, return to the 1) of the selection procedures, etc., and judge again. 1. Decrease the set pressure. 2. Widen the cylinder bore, or modify the series (for example, change from the 35H-3 to the 70/140H-8). 3. Provide the deceleration circuit, and reduce the speed at the inrush into cushion until it is within the usable range. 4. Install external shock absorbers. Note 1) When using the cylinder without a cushion, decelerate until metallic noises due to the interference of the piston with the cover cannot be heard (approx. 50 mm/s or slower), or install the stopper outside. Note 2) If the cushioned cylinder is not used up to the stroke end, but it is stopped 5 mm or more before the stroke end, the cushioning effect becomes weaker.	26 ~ 33
□7	Selection of packing material	Select the material, referring to the packing material selection materials.	22 ~ 24
□8	Check of port dia. depending on cylinder speed	Check the cylinder port dia., referring to the relations diagrams of the cylinder speed, required oil amount, and pipe inside flow velocity.	25
□9	Check of notices on other selection	Check the notices on other selection.	35 ~ 39
□10	Selection of switches	Select the switches, referring to the switch selection procedures (refer to the switch specifications).	Refer to the switch specifications.

Selection of cylinder bore

The bore of a hydraulic cylinder depends on the required cylinder force.



- Push side cylinder force
  $F_1 = A_1 \times P \times \beta$ (N)
- Pull side cylinder force
  $F_2 = A_2 \times P \times \beta$ (N)

A_1 : push side piston pressurized area (mm²) $A_1 = \frac{\pi}{4} D^2$

A_2 : pull side piston pressurized area (mm²) $A_2 = \frac{\pi}{4} (D^2 - d^2)$

D : cylinder bore (mm) d: piston rod dia. (mm)

P : set pressure (MPa)

β : load rate

When deciding the actual cylinder output, the resistance in the cylinder slipping part and the pressure loss in piping and machines must be considered.
The load rate is the ratio of the actual force loaded onto the cylinder to the theoretical force (theoretical cylinder force) calculated from the circuit set pressure. The general set points are shown below.
For low speed working ..... 60 to 80%
For high speed working ..... 25 to 35%

The hydraulic cylinder theoretical output table is based on the calculation results of the formula above.

Pushed hydraulic cylinder theoretical output table (load rate 100%)

Unit : kN (1kN ≒102kgf)

Bore mm	Pressurized area mm²	Set pressure MPa							
		1.0	3.5	5.0	7.0	10.0	14.0	16.0	21.0
ϕ20	314	0.31	1.10	1.57	2.20	3.14	4.40	5.02	6.60
ϕ25	491	0.49	1.72	2.45	3.44	4.91	6.87	7.85	10.31
ϕ32	804	0.80	2.81	4.02	5.63	8.04	11.26	12.86	16.89
ϕ40	1257	1.26	4.40	6.28	8.80	12.57	17.59	20.11	26.39
ϕ50	1963	1.96	6.87	9.82	13.74	19.63	27.49	31.40	41.23
ϕ63	3117	3.12	10.91	15.59	21.82	31.17	43.64	49.87	65.46
ϕ80	5027	5.03	17.59	25.13	35.19	50.27	70.37	80.43	105.56
ϕ100	7854	7.85	27.49	39.27	54.98	78.54	109.96	125.66	164.93
ϕ125	12272	12.27	42.95	61.36	85.90	122.72	171.81	196.35	257.71
ϕ140	15394	15.39	53.88	76.97	107.76	153.94	215.51	246.30	323.27
ϕ150	17671	17.67	61.85	88.36	123.70	176.71	247.40	282.73	371.10
ϕ160	20106	20.11	70.37	100.53	140.74	201.06	281.49	321.69	422.23
ϕ180	25447	25.45	89.06	127.23	178.13	254.47	356.26	407.15	534.38
ϕ200	31416	31.42	109.96	157.08	219.91	314.16	439.82	502.65	659.73
ϕ224	39408	39.41	137.93	197.04	275.86	394.08	551.71	630.52	827.57
ϕ250	49087	49.09	171.81	245.44	343.61	490.87	687.22	785.39	1030.84

Notes)
- When deciding the actual cylinder output, consider the resistance in the cylinder slipping part and the pressure loss in piping and machines.
- Remember that the output at start may be decreased when the piston comes to a close contact status at the stroke end due to a load.

Pulled hydraulic cylinder theoretical output table (load rate 100%)

Unit : kN (1kN ≒102kgf)

Series type	Bore mm	Rod dia. mm	Pressurized area mm^2	Set pressure MPa							
				1.0	3.5	5.0	7.0	10.0	14.0	16.0	21.0
70/140H-8 Rod B 70/140P-8 Rod B 70/140HW-8 Rod B	ϕ32	ϕ18	550	0.55	1.92	2.75	3.85	5.50	7.70	–	–
	ϕ40	ϕ22.4	863	0.86	3.02	4.31	6.04	8.63	12.08	–	–
	ϕ50	ϕ28	1348	1.35	4.72	6.74	9.43	13.48	18.87	–	–
	ϕ63	ϕ35.5	2127	2.13	7.45	10.64	14.89	21.27	29.78	–	–
	ϕ80	ϕ45	3436	3.44	12.03	17.18	24.05	34.36	48.11	–	–
	ϕ100	ϕ56	5391	5.39	18.87	26.95	37.74	53.91	75.47	–	–
	ϕ125	ϕ71	8313	8.31	29.09	41.56	58.19	83.13	116.38	–	–
	ϕ140	ϕ80	10367	10.37	36.29	51.84	72.57	103.67	145.14	–	–
	ϕ150	ϕ85	11997	12.00	41.99	59.98	83.98	119.97	167.96	–	–
	ϕ160	ϕ90	13744	13.74	48.11	68.72	96.21	137.44	192.42	–	–
	ϕ180	ϕ100	17593	17.59	61.58	87.96	123.15	175.93	246.30	–	–
	ϕ200	ϕ112	21564	21.56	75.47	107.82	150.95	215.64	301.89	–	–
	ϕ224	ϕ125	27136	27.14	94.98	135.68	189.95	271.36	379.91	–	–
	ϕ250	ϕ140	33694	33.69	117.93	168.47	235.86	336.94	471.71	–	–
70/140H-8 Rod C 70/140P-8 Rod C	ϕ40	ϕ18	1002	1.00	3.51	5.01	7.02	10.02	14.03	–	–
	ϕ50	ϕ22.4	1569	1.57	5.49	7.85	10.99	15.69	21.97	–	–
	ϕ63	ϕ28	2501	2.50	8.76	12.51	17.51	25.01	35.02	–	–
	ϕ80	ϕ35.5	4037	4.04	14.13	20.18	28.26	40.37	56.51	–	–
	ϕ100	ϕ45	6264	6.26	21.92	31.32	43.84	62.64	87.69	–	–
	ϕ125	ϕ56	9809	9.81	34.33	49.04	68.66	98.09	137.32	–	–
	ϕ140	ϕ63	12277	12.28	42.97	61.38	85.94	122.77	171.87	–	–
	ϕ150	ϕ67	14146	14.15	49.51	70.73	99.02	141.46	198.04	–	–
	ϕ160	ϕ71	16147	16.15	56.51	80.74	113.03	161.47	226.06	–	–
	ϕ180	ϕ80	20420	20.42	71.47	102.10	142.94	204.20	285.88	–	–
	ϕ200	ϕ90	25054	25.05	87.69	125.27	175.38	250.54	350.76	–	–
	ϕ224	ϕ100	31554	31.55	110.44	157.77	220.88	315.54	441.76	–	–
	ϕ250	ϕ112	39235	39.24	137.32	196.18	274.65	392.35	549.29	–	–
70/140H-8 Rod A	ϕ40	ϕ28	641	0.64	2.24	3.20	4.49	6.41	8.97	–	–
	ϕ50	ϕ35.5	974	0.97	3.41	4.87	6.82	9.74	13.63	–	–
	ϕ63	ϕ45	1527	1.53	5.34	7.63	10.69	15.27	21.38	–	–
	ϕ80	ϕ56	2564	2.56	8.97	12.82	17.94	25.64	35.89	–	–
	ϕ100	ϕ71	3895	3.89	13.63	19.47	27.26	38.95	54.53	–	–
	ϕ125	ϕ90	5910	5.91	20.69	29.55	41.37	59.10	82.74	–	–
	ϕ140	ϕ100	7540	7.54	26.39	37.70	52.78	75.40	105.56	–	–
	ϕ150	ϕ100	9817	9.82	34.36	49.09	68.72	98.17	137.44	–	–
	ϕ160	ϕ112	10254	10.25	35.89	51.27	71.78	102.54	143.56	–	–
	ϕ180	ϕ125	13175	13.18	46.11	65.88	92.23	131.75	184.45	–	–
	ϕ200	ϕ140	16022	16.02	56.08	80.11	112.15	160.22	224.31	–	–
	ϕ224	ϕ160	19302	19.30	67.56	96.51	135.11	193.02	270.23	–	–
	ϕ250	ϕ180	23640	23.64	82.74	118.20	165.48	236.40	330.97	–	–

Notes)
- When deciding the actual cylinder output, consider the resistance in the cylinder slipping part and the pressure loss in piping and machines.
- Remember that the output at start may be decreased when the piston comes to a close contact status at the stroke end due to a load.

The hydraulic cylinder theoretical output table is based on the calculation results of the formula in page 15.

Calculation of cylinder buckling

1) Be sure to calculate the cylinder buckling.

2) In the case of using a hydraulic cylinder, the stress and buckling must be considered depending on the cylinder stroke.
The strength in the case that the piston rod is regarded as a long column, the buckling strength, cannot be enhanced by adopting highly tension-proof steel or heat treatment. The only way to improve the buckling strength of a cylinder is to widen the piston rod dia., and therefore, the selection of the piston rod is the very important point.
The buckling chart shown in the next page, based on the Euler's equation that is applicable to an upright long column, indicates the maximum safe L values against the piston rod dia. when the cylinder is used with the compressive load that is most frequently applied.

3) When buckling occurs to a cylinder, the cylinder rod may be bent, causing malfunctions or serious accidents.

Calculation method of cylinder buckling (use of buckling chart)

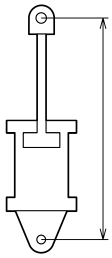
1. Find the L value (distance between the cylinder mounting position and load mounting position) with a cylinder fully extended.
2. Select any buckling chart depending on the mounting style, and find the maximum working load.

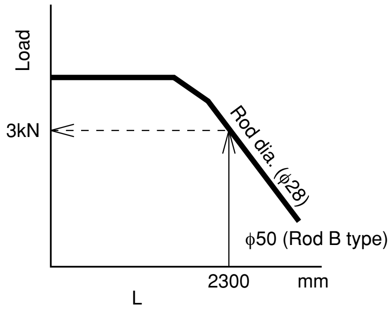
< Exercise >

Find the maximum working load for the 140H-8, ϕ50, rod B (rod dia. ϕ28), in case that the stroke is 1000 mm, CA type with the rod end eye.

< Answer >

1. Find the L value with the cylinder fully extended.
From the dimensional drawings in this catalogue, the L value can be calculated by the formula below.
L = 230 + 70 + 1000 + 1000 = 2300 mm
2. From the buckling chart of the both ends pin joints, the load can be found as below.
W = 3 kN (≒306 kgf)



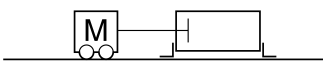


Notes on piston rod buckling

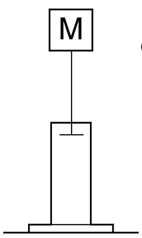
Prior to the calculation of the piston rod buckling, consider the cylinder stopping method. The stopping methods of a cylinder include the cylinder stopping method, in which a cylinder is stopped at the stroke end, and the external stopping method, in which a cylinder is stopped with the external stopper. The definition of load differs depending on the selection of the stopping method as shown below.

- **Definition of a load when the cylinder stopping method is selected**

In the case of ❷



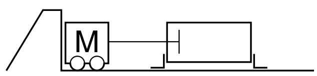
In the case of ❶

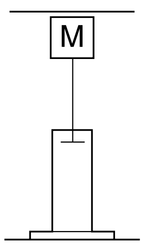


The state of stopping at the cylinder stroke end as shown in the figure.
For the load required for the buckling calculation, apply the formula below.

In the case of ❶ : load = M・g
In the case of ❷ : load = μ M・g
μ : frictional coefficient
g : gravity acceleration 9.8 m/s²
M : load weight (kg)

- **Definition of load when the external stopping method is selected**

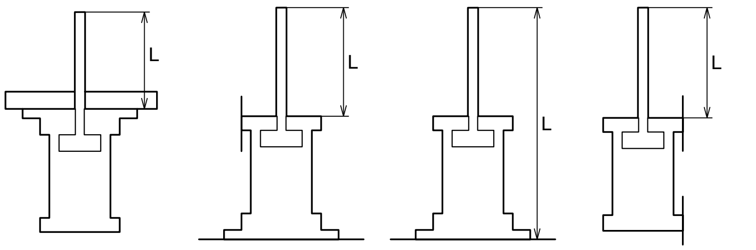




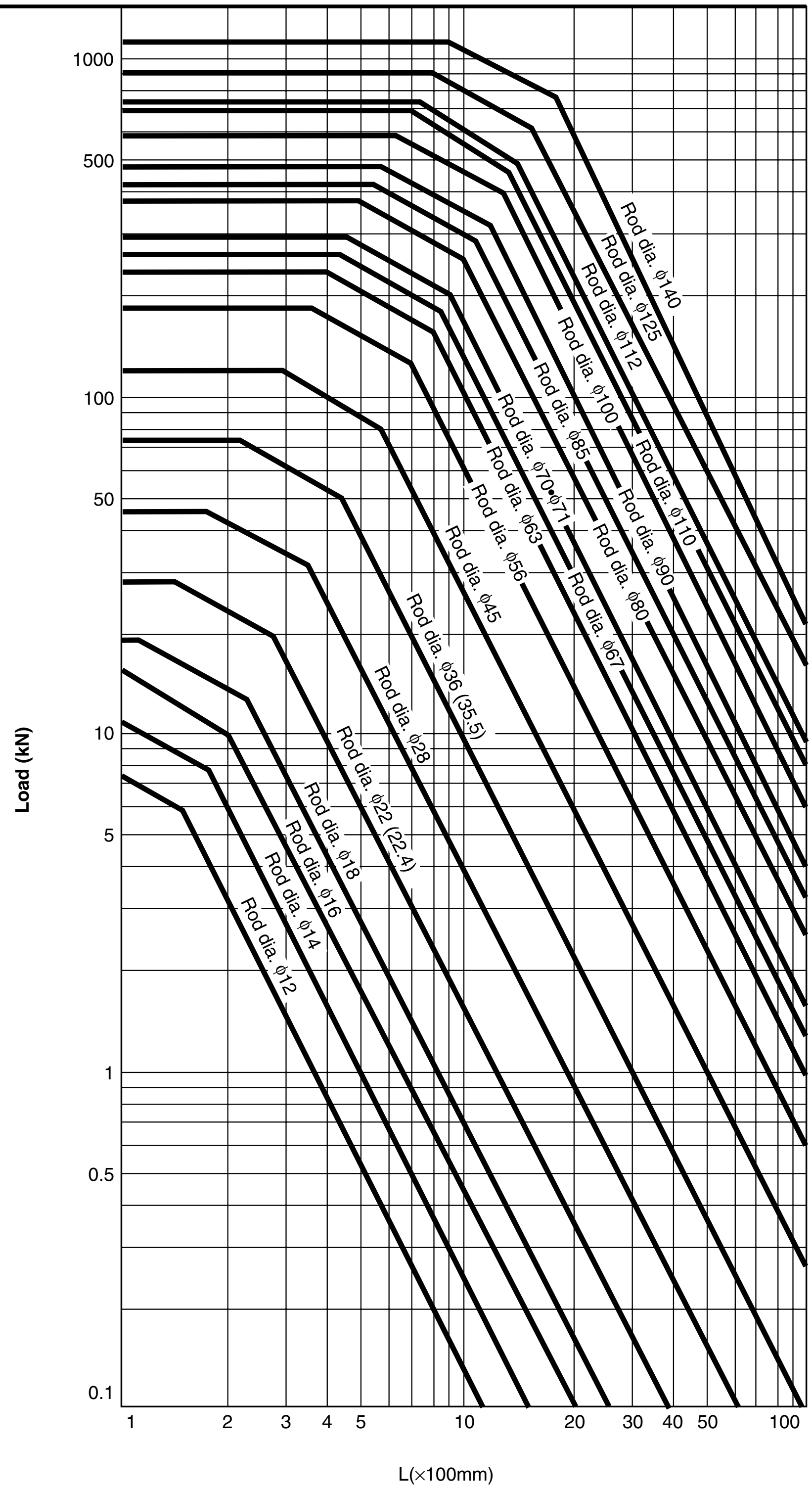
The state of halfway stopping with the external stopper as shown in the figure.
The load required for the buckling calculation in this case is not the M, but the cylinder theoretical output (relief set pressure MPa × piston area mm²).

Buckling chart by cylinder mounting style

Fixed cylinder, rod end free

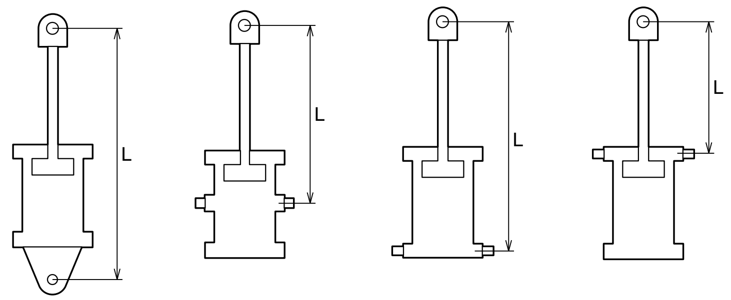


Buckling chart

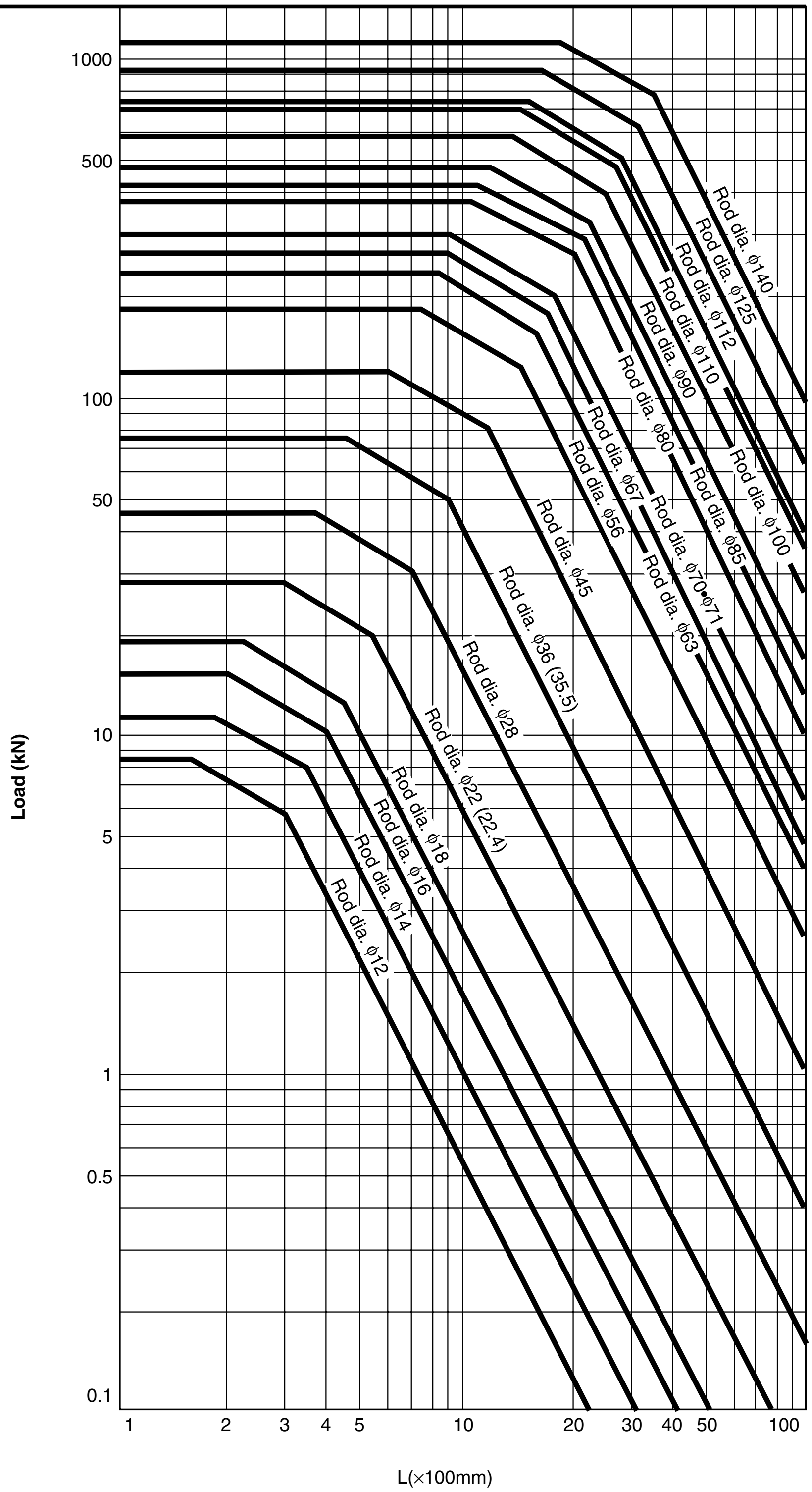


Buckling chart by cylinder mounting style

Both ends pin joints

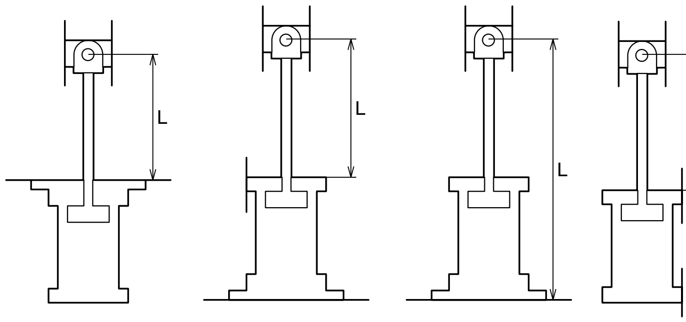


Buckling chart

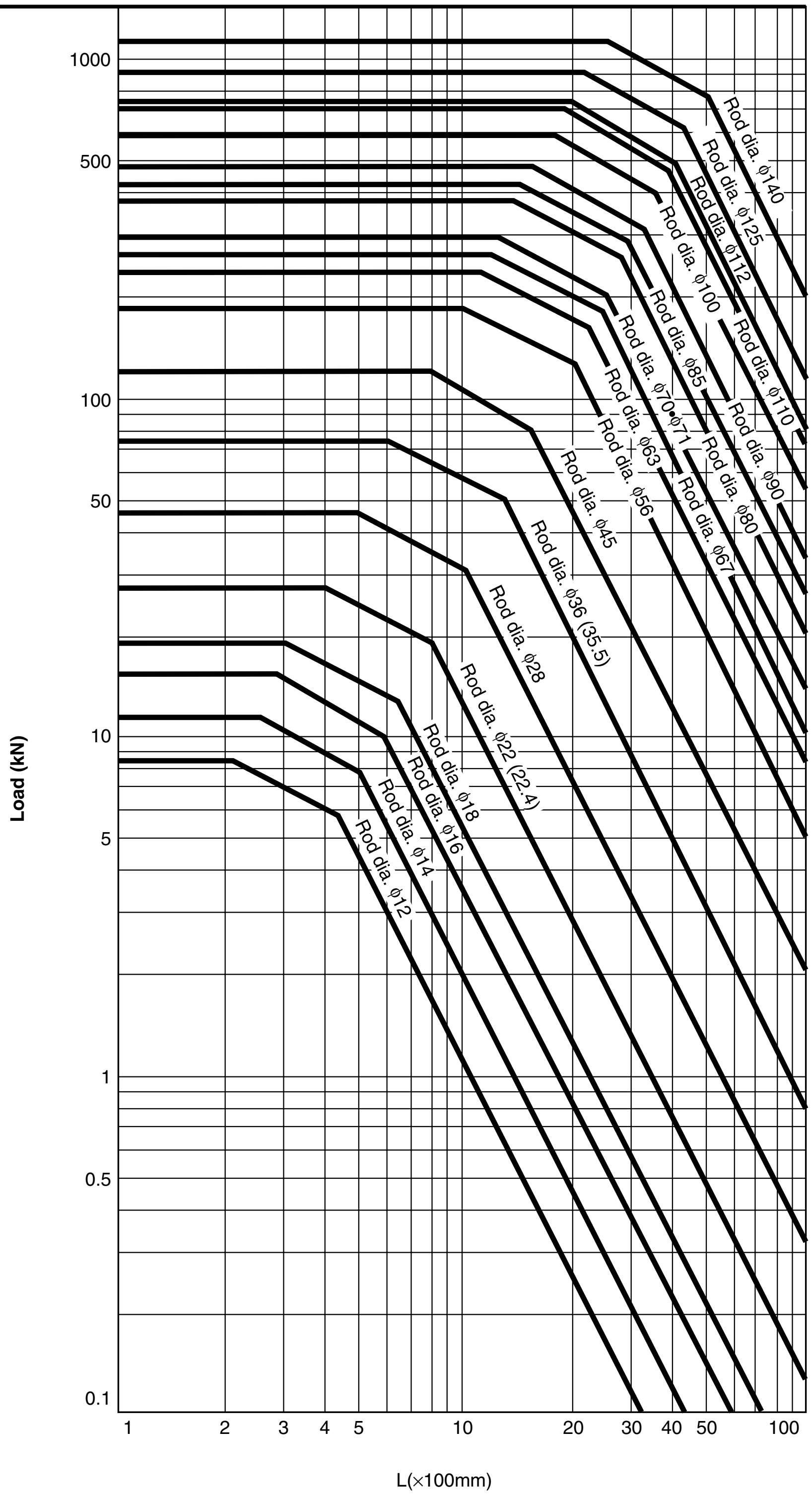


Buckling chart by cylinder mounting style

Fixed cylinder, rod end pin joint

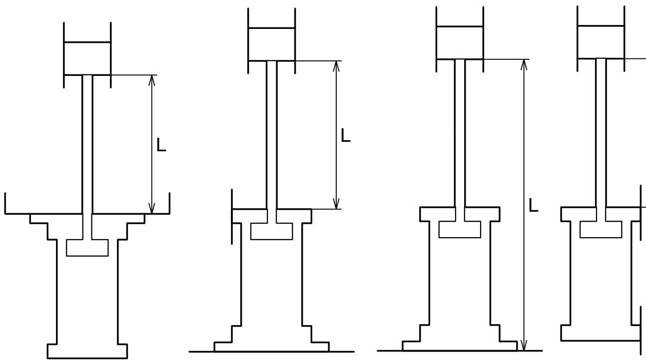


Buckling chart

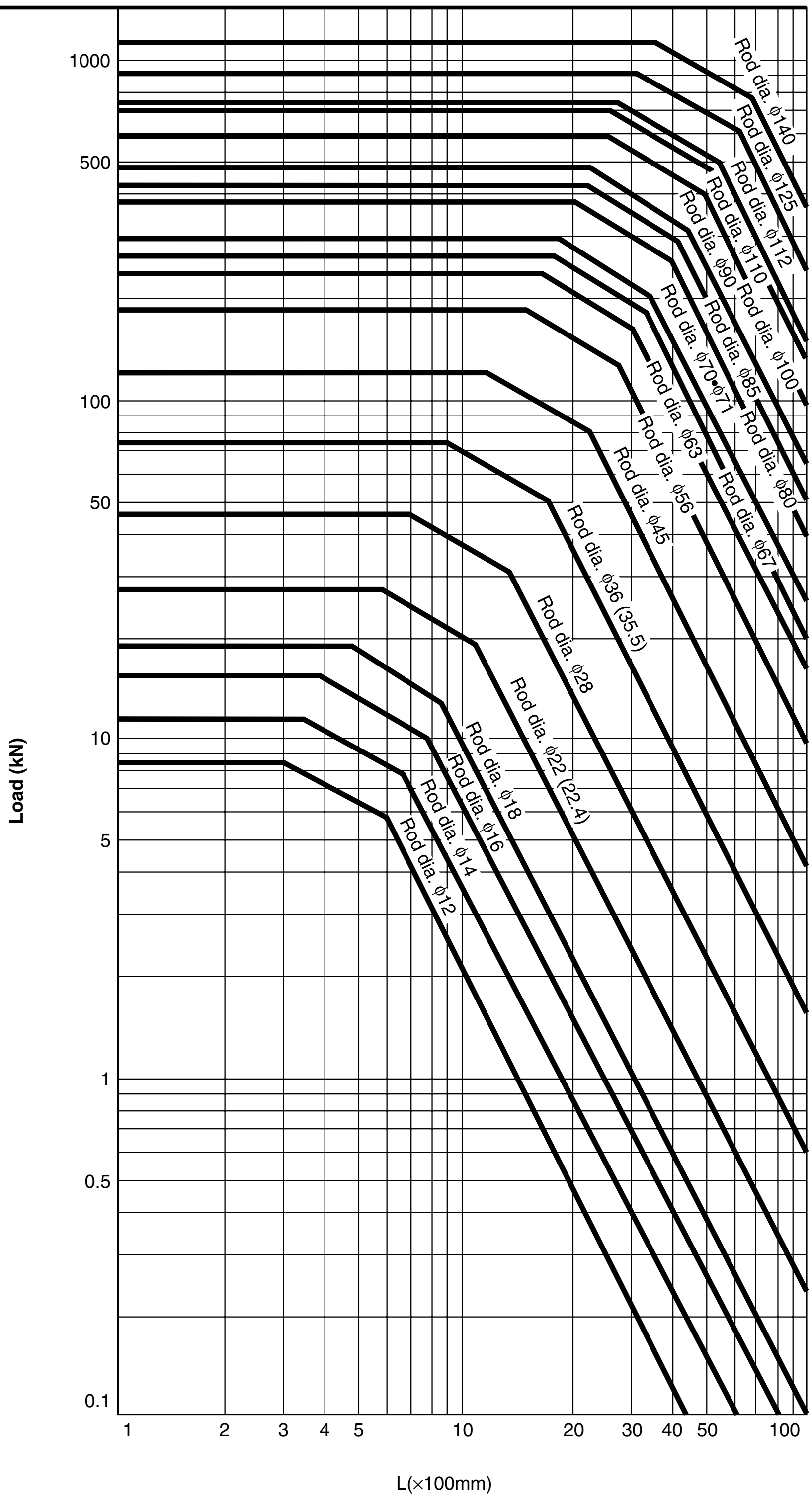


Buckling chart by cylinder mounting style

Fixed cylinder, rod end guide



Buckling char



Selection of packing material

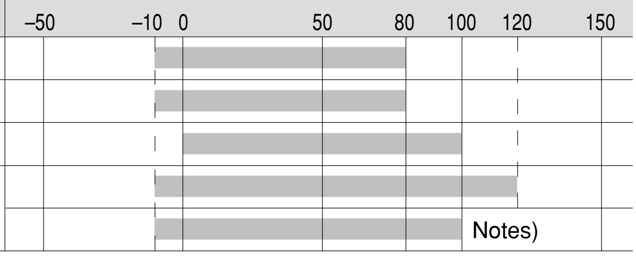
Prior to the selection of packing material, check the conditions below.

1. Oil temperature in a cylinder and ambient temperature
2. Type of working oil
3. In the case of use in the places where are splashed with cutting fluid (coolant), the type of cutting fluid
4. Use frequency

Notes)
- Select the packing material suitable for the working oil used. The wrong material selection may lead to the inferiority of packing material, causing the damaged packings.
- The recommended cleanliness level of the working oil used is the NAS grade 10 or higher.
- DO NOT mix different types of working oil. Otherwise, the mixed working oil may be changed in quality, posing the inferiority of the packings.
- In the case that working oil including water (water-glycol fluid, water in oil fluid, oil in water fluid, etc.) is used, and the cylinder tube is made of carbon steel for machine-structural use, it is recommended to plate the cylinder tube inside. When you request the plated cylinder tube, instruct us.

Adaptability of packing material to working oil and working temperature range of packing material

No.	Packing material	Applicable working oil					Oil temperature and ambient temperature (°C)
		Petroleum-based fluid	Water-glycol fluid	Phosphate ester fluid	W/O fluid	W/O fluid	
1	Nitrile rubber	○	○	×	○	○	
2	Urethane rubber	◎	×	×	△	△	
3	Fluoric rubber	○	×	○	○	○	
6	Hydrogenated nitrile rubber	○	◎	×	◎	◎	



Notes)
- The ◎ and ○-marked items are applicable, while the ×-marked items are inapplicable. For the △-marked items, contact us.
- In case that the priority is given to the abrasion resistance, adopt the packing material of the ◎-marked combinations.
- In case that hydrogenated nitrile rubber is adopted for the use of water-glycol fluid, water in oil fluid, oil in water fluid, the oil temperature must be ranged from –10 to +100°C.
- The temperature range in the table above indicates the working temperature range of packing material, and it is not the working temperature range of the cylinder. For the use of a cylinder at high temperature, contact us.

Criteria for selection of urethane rubber and nitrile rubber

The material of the packing for standard cylinders includes urethane rubber and nitrile rubber. When selecting the material, refer to the criteria for selection in the table below.

- Characteristics of urethane rubber
  Urethane rubber, having 2.5 times pull strength of nitrile rubber as shown in the table below, features the superior resistance against pressure and abrasion.
  However, urethane rubber may be changed in quality due to heat and inferiority in working oil in a long run (and the multiplier effect of oil temperature), and therefore, disassembly and inspection are required every year.
- Characteristics of nitrile rubber
  The influences of heat and inferiority in working oil on nitrile rubber is less than those on urethane rubber. Since the pull strength of nitrile rubber is less than that of urethane rubber, nitrile rubber is rather inferior to urethane rubber in the resistance against pressure and abrasion. Therefore, in case that the use frequency is low under low pressures and disassembly and inspection are not performed for two or three years, it is recommended to adopt nitrile rubber.
- Characteristics of hydrogenated nitrile rubber
  When using in places where abrasion resistance more reliable than fluoric rubber is required at high temperature, and abrasion resistance more reliable than nitrile rubber is required at normal temperature, hydrogenated nitrile rubber is most suitable.

Table of packing selection criteria

Items \ Packing material	Nitrile rubber	Urethane rubber	Fluoric rubber	Hydrogenated nitrile rubber
Abrasion resistance	○	◎	○	◎
Life against inferiority of working oil	○	△	○	○
Life with high oil temperature	○	△	○	◎
Oil leak from rod	○ (JIS B type)	◎(JIS A type)	○ (JIS B type)	○ (JIS B type)
High use frequency under high pressure	○	◎	△	◎
Low use frequency under low pressure	◎	○	○	◎
Pull strength (reference value) (MPa)	17	47	15	30

Note) ◎, ○, and △- marks indicate the priority of selection in this order.

Criteria for selection in case that cutting fluid is splashed

Cutting fluid is in mist form or it is splashed several times a day.	If packing material is selected based on the adaptability of packing material to cutting fluid, normal cylinders are applicable.
Cutting fluid is splashed always or frequently.	In a normal cylinder, cutting fluid may enter the cylinder from the ground section. Therefore, select cutting fluid resistance type (70/140HW-8). For the use of a cylinder in the places where are splashed with nonaqueous cutting fluid of the type 2, contact us.

Adaptability of cutting fluid (coolant) and packing material

No.	Cutting fluid type / Chlorine in cutting oil / Packing material	Nonaqueous cutting fluid		Aqueous cutting fluid	
		Not included (type 1)	Included (type 2)	Not included (W1, type 2, No.1, 3)	Included (W1, type 2, No.2)
1	Nitrile rubber	×	×	△	×
2	Urethane rubber	×	×	×	×
3	Fluoric rubber	○	○	×	×
6	Hydrogenated nitrile rubber	○	×	○	○

Note) The ○-marked combinations are applicable, while the ×-marked combinations are inapplicable. For the △-marked combinations, they are applicable at 50°C or under.

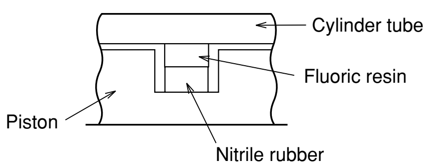
Packing material for each series

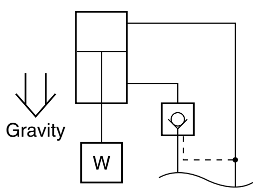
No.	Packing material	35Z-1	35H-3 35P-3	100Z-1	100H-2	70/140H-8 70/140P-8 (φ32~φ160)	70/140H-8R 70/140P-8R (φ32~φ140)	70/140H-8 (φ180~φ250)	70/140HW-8	160H-1	210C-1 210H-3	35S-1	HQS2 100S-1 160S-1 210S-1	HQSW2 100SW-1 160SW-1	70/140M-3
1	Nitrile rubber	○	○	○	○	○	○	○	×	○	○(with BUR)	×	×	×	△
2	Urethane rubber	×	×	×	○	○	○	×	×	○	○	×	×	×	○
3	Fluoric-containing rubber	×	○	×	×	○	○	○	×	×	○(with BUR)	×	○	×	△
6	Hydrogenated nitrile rubber	×	○	○	○	○	○	○	○	○	○(with BUR)	○	○	○	×
8	Slipper seal	×	○	×	×	○	×	×	×	×	×	×	×	×	×
	Combined seal	×	×	×	○	×	×	×	×	○	×	×	×	×	×

○-mark : standard
△-mark : semi-standard
×-mark : not available
The "BUR" in the column of the 210H-3 series in the table above is the abbreviation of the back-up ring.

Notes on selection of slipper seal

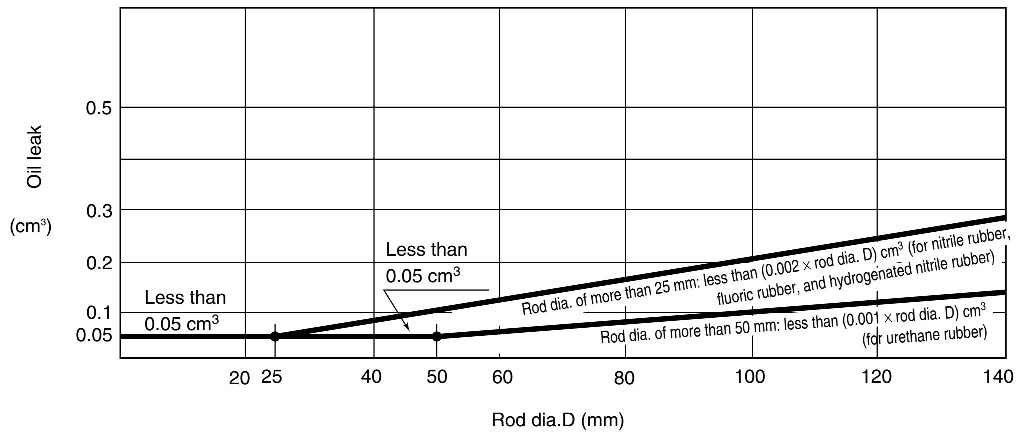
- Outline: This seal is a combination of fluoric resin of the slipping part and nitrile rubber of the back-up ring.
- Merits: Reliable working performance at a low speed compared to the U type packing.
  Ex.) The minimum speed of 70-140H-8 series
  U type packing: 8 mm/s
  Slipper seal: 1 mm/s
- Weak points: More internal leakage compared to the U type packing. In case that the piston position must be held while an external force is applied as shown in the right figure, it is recommended to use the U type packing.





Notes)
- For the applicable working oil temperature range and adaptability to working oil, refer to the materials related to nitrile rubber.
- Slipper seal is the registered trademark of Nippon Valqua Industries, Ltd.

Relation between external oil leak amount and rod dia.



The external oil leak is the total of oil leak from the wiper part of the piston rod with the piston moving distance of 100 m (according to JIS B8367).

Selection of boots

If hydraulic cylinders are used in the places under unfavorable conditions, where are subjected to wind, wind and rain, and dusts, the piston rod especially needs to be protected. When selecting the boots, consider the environment conditions and temperature.

Boots type and resistible temperature

Symbols	Name	Material	Resistible temperature
J	Nylon tarpaulin	Vinyl-coated nylon cloth	80°C
JN	Chloroprene	Nylon cloth coated with chloroprene	130°C
JK	Conex	Silicon-coated Conex cloth	200°C

Note) 1. If the boots are provided, the length of extended cylinder rod is changed.
Note) 2. Remember that the resistible temperatures in the table above are for the boots, not for the cylinder.
Note) 3. Conex is the registered trademark of Teijin Ltd.
Note) 4. Neoprene, the older name of chloroprene, is the registered trademark of Du Pont-Showa Denko Co., Ltd. Thus, we have adopted general name, chloroprene.

Check of port dia. depending on cylinder speed

Cylinder speed depends on the quantity of oil fed into a cylinder.

The cylinder speed V can be obtained from the following formula:

$$V = 1.67 \times 10^4 \times Qc/A$$

Qc : oil quantity supplied into cylinder (L/mm)
A : pressurized area of piston (mm^2)

The chart below shows the relation between the speed and the required flow rate for each size of standard hydraulic cylinders (cylinder inside) and that between the required flow rate and flow velocity in pipe for each port dia.

< Example >
In the case of the 70/140H-8 series with an 80 mm cylinder bore and 300 mm/s cylinder speed, is the standard port dia. applicable ? Also, find the flow velocity in pipe.

< Answer >
In the chart below, find the cross point of the straight line from the point of 300 mm/s cylinder speed and the slant line of 80 mm cylinder bore, and draw a straight line parallel with the lateral axis until it reaches the slant line of the port dia. 3/4 (the standard port dia. for the 70/140H-8 series with a cylinder bore of 80 mm).
From the cross point on the slant port dia. line, draw a straight line parallel with the longitudinal axis until it reaches the lateral axis. From the cross point, the corresponding flow velocity in pipe is 5.2 m/s.
Since the cross point, which is found based on the port dia., cylinder speed, and bore, is within the applicable working range, the standard port dia. is applicable.

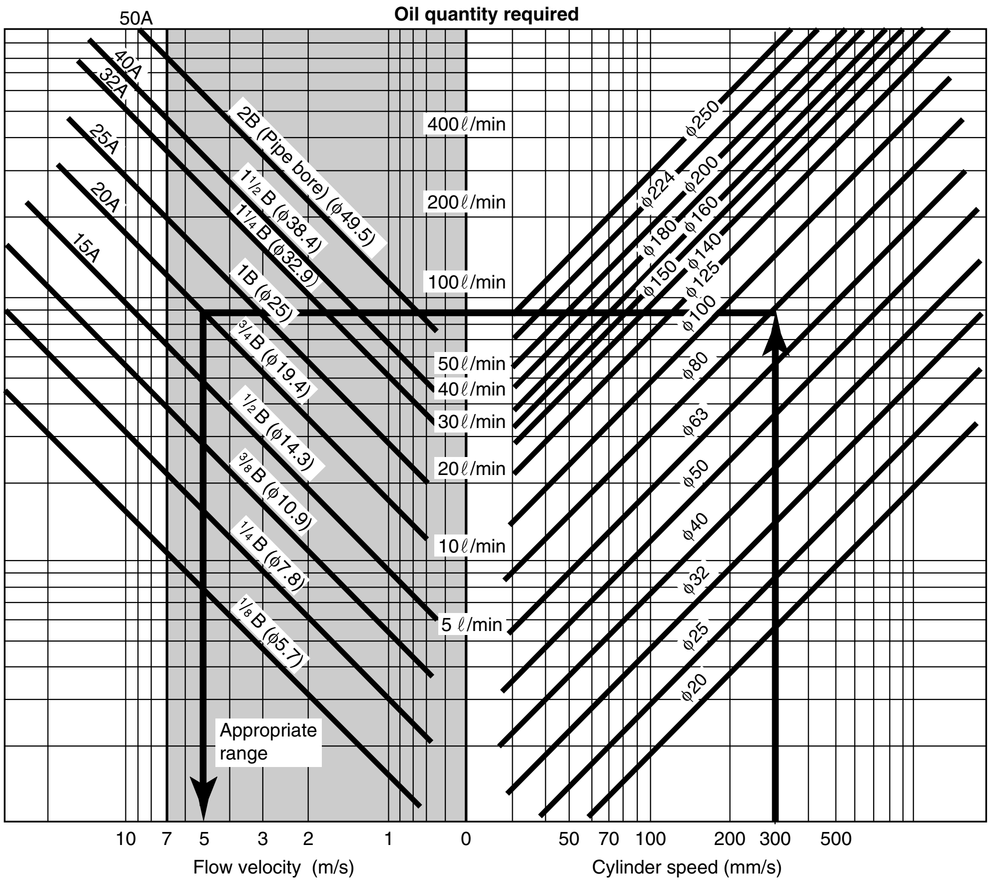


Chart of relation between cylinder speed, required flow rate, and flow velocity in pipe

Note)
The appropriate flow velocity in pipe for the appropriate range is 7 m/s or under. In general, if the flow velocity in pipe exceeds 7 m/s, the piping resistance and pressure loss are increased, causing less output during cylinder work and lower speed. To reduce pressure loss, adopt piping with larger dia. of one grade to the cylinder port. The flow velocity is calculated with steel tube for piping S ch80.

Standard port dia.

Bore (mm) / Series	Port dia.															
	20	25	32	40	50	63	80	100	125	140	150	160	180	200	224	250
70/140H-8	—	—	⅜	⅜	½	½	¾	¾	1	1	1	1	1¼	1½	1½	2
70/140P-8	—	—	—	⅜	½	½	¾	¾	—	—	—	—	—	—	—	—

Maximum energy absorbed of cylinder cushion

The conditions of absorbed energy allowable for the cylinder cushion can be obtained from the formula below.

Inertia energy of load at the inrush into cushion E_1	+	Energy generated by the external force applied to the cylinder at the inrush into cushion E_2	≦	Maximum energy absorbed of the cylinder cushion E_t

The procedures to find each item above are shown below.

Find the inertia energy of load at the inrush into cushion, E_1.

In the case of linear movement:

$E_1 = MV^2/2$ (J) M : load weight (kg)
V : load speed at the inrush into cushion (m/s)

In the case of rotation movement:

$E_1 = I\omega^2/2$ (J) I : inertia moment of load (kg · m^2)
ω : angular velocity of load at the inrush into cushion (rad/s)

Notes: If the cylinder speed is less than 0.08 m/s (80 mm/s), the cushioning effect is weakened.
Even if the cylinder speed is less than 0.08 m/s (80 mm/s), suppose it is 0.08 m/s to find the E_1.
In the case of rotation movement, even when the cylinder speed is 0.08 m/s or lower, similarly suppose it is 0.08 m/s, and calculate the angular velocity ω to find the E_1.

↓

Find the energy generated by the external force applied to the cylinder at the inrush into cushion, E_2.

The forces acting in the direction of the cylinder axis at the inrush into cushion are shown below.

- The force applied to the cylinder by the gravity of load
- The force applied by other cylinders
- The force applied to the cylinder by springs

Find the external force F, which is applied to the cylinder at the inrush into cushion, and the energy E_2 by using the "Chart of conversion of external force into energy at the inrush into cushion of 70/140H-8".
In case that such an external force is not applied, the following condition is satisfied: $E_2 = 0$.
For the selection of cushion, suppose that the frictional resistance of load is 0.

↓

Find the maximum energy absorbed of the cylinder cushion, E_t.
Find it with the corresponding chart of the "Maximum energy absorbed".
Remember that the maximum energy absorbed of the cylinder moving forward (the ejected direction of the piston rod from the cylinder) and that of the cylinder moving backward are identical.

↓

Ensure that $E_1 + E_2$ is same as the maximum energy absorbed E_t, or smaller.

If the following condition is satisfied, the cylinder is applicable: $E_1 + E_2 \leqq E_t$.

If the following condition is satisfied, the cylinder is inapplicable: $E_1 + E_2 \geqq E_t$.
In such a case, perform the steps below, and then, select again.

- Decrease the inertia force of load.
- Decrease the external force applied to the cylinder.
- Lower the set pressure.
- Widen the cylinder bore.
- Install a shock absorber.
  When installing a shock absorber, refer to the "TAIYO Shock absorber general catalogue".
  DO NOT use the cylinder cushion together with a shock absorber. Otherwise, the inertia force of load may be applied to either of them due to the difference of cushioning characteristics.

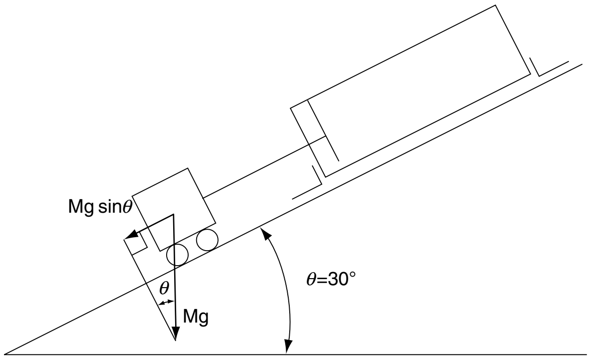
⚠CAUTION

Be sure to use cylinders within the range of the maximum energy absorbed of the cylinder cushion.
Otherwise, the cylinder or the peripheral devices may be damaged, leading to serious accidents.

Example of calculation for selection

< Example 1 >

Cylinder 70H-8 ϕ63
Set pressure P_1 = 5 MPa
Load weight M = 500 kg
Load speed V = 0.3 m/s (the speed at the inrush into cushion is 300 mm/s)
Load moving direction
Downward θ = 30° (there is no external force applied to the cylinder other than gravity)
Working direction
Forward (the direction of the piston rod ejected from the cylinder)
Gravitational acceleration g = 9.8 m/s^2



< Answer >

1. Find the inertia energy of load at the inrush into cushion, E_1.
   Inertia energy in the case of linear movement, E_1

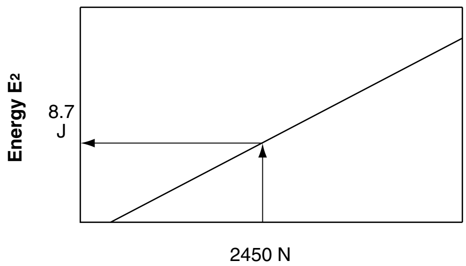
   $E_1 = MV^2/2 = 500 \times 0.3^2/2 = 22.5J$

2. Find the E_2, energy generated by the external force F, applied to the cylinder at the inrush into cushion.
   2.1 Find the external force F, applied in the direction of the cylinder axis at the inrush into cushion.

   $F = Mg\sin\theta = 500 \times 9.8 \times \sin 30° = 2450N$

   2.2 Convert the external force F, found in the step 2.1, into the energy E_2.
   In the "Chart of conversion of external force into energy at the inrush into cushion of 70/140H-8", find the cross point of the straight line from the point of 2450 N on the lateral axis F and the slant line shown in the chart. Then, draw a straight line from the cross point on the slant line parallel with the lateral axis until it reaches the longitudinal axis of the chart. The cross point 8.7 J, indicates the energy applied by the external force.

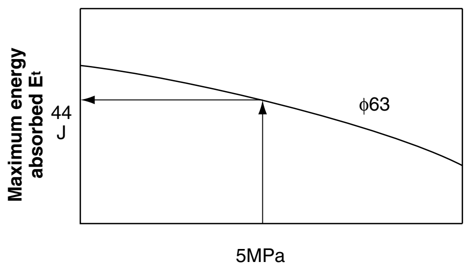
   $E_2 = 8.7J$



External force F applied during cushion stroke

3. Find the maximum energy absorbed of the cylinder, E_t.
   In the right chart, find the cross point of the straight line from the point of 5 MPa on the lateral axis, the set pressure of the "Maximum energy absorbed of cushion" of the 70H-8 and the curve of ϕ63. Then, draw a straight line from the cross point on the curve parallel with the lateral axis until it reaches the longitudinal axis of the chart. The cross point, 44 J, indicates the maximum energy absorbed.

   $E_t = 44J$



Set pressure P_1

4. Ensure that $E_1 + E_2$ is same as the maximum energy absorbed E_t, or smaller.

   $E_1 + E_2 = 22.5 + 8.7 = 31.2$ J
   where, $E_t = 44J$
   Therefore, the following condition is satisfied: $E_1 + E_2 \leqq E_t$.
   As a result, the cylinder is applicable.

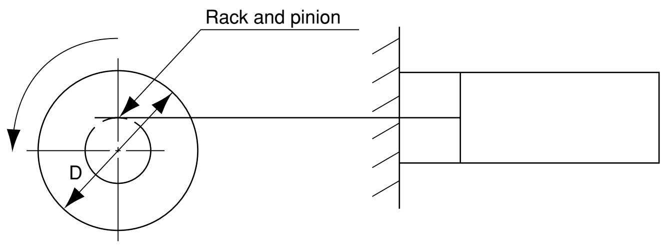
< Reference >

In case that the load moving direction is horizontal and there is no external force applied ($E_2 = 0$), from the set pressure, first find the maximum energy absorbed, E_t. Then, the allowable load weight and allowable load speed can be found.

To find the allowable load weight, M : $M = 2E_t/V^2$
To find the allowable load speed, V : $V = \sqrt{2E_t/M}$

< Example 2 >

Cylinder 70H-8 ϕ63
Set pressure P_1 = 5 MPa
Load weight M = 500 kg
Load dia. D = 0.7 m
Angular velocity of load
ω = 1.5 rad/s (angular speed at the inrush into cushion)
Load moving direction
Horizontal (without external force applied to the cylinder)
Working direction
Forward (the direction of the piston rod ejected from the cylinder)
The weight of the rack and pinion is so light that it can be ignored.



< Answer >

1. Find the inertia energy of a load at the inrush into cushion, E_1.
   1.1 Find the inertia moment of a load, I .

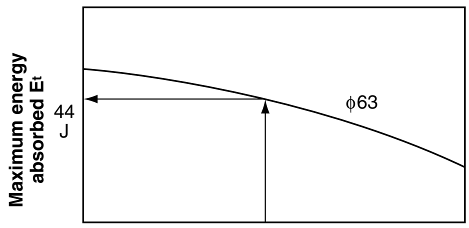
   From the inertia moment calculation table, the I can be calculated as below.
   $I = MD^2/8 = 500 \times 0.7^2/8 = 30.6\ (kg \cdot m^2)$

   1.2 Find the inertia energy of a load, E_1.
   $E_1 = I\omega^2/2 = 30.6 \times 1.5^2/2 = 34.4J$

2. Find the energy generated by the external force applied to the cylinder at the inrush into cushion, E_2.

   $E_2 = 0$, since there is no external force generated from the gravity of a load.

3. Find the maximum energy absorbed of the cylinder, E_t.
   In the right chart, find the cross point of the straight line from the point of 5 MPa on the lateral axis, the supply pressure of the "maximum energy absorbed of cushion" of the 70H-8 and the curve of ϕ63 bore. Then, draw a straight line from the cross point on the curve parallel with the lateral axis until it reaches the longitudinal axis of the chart. The cross point 44 J, indicates the maximum energy absorbed.
   $E_t = 44J$



4. Ensure that $E_1 + E_2$ is same as the maximum energy absorbed, E_t, or smaller.

   $E_1 + E_2 = 34.4 + 0 = 34.4$ J
   where, $E_t = 44J$
   Therefore, the following condition is satisfied: $E_1 + E_2 \leqq E_t$.
   As a result, the cylinder is applicable.

Note: Even if the cylinder speed is less than 0.08 m/s (80 mm/s), suppose it is 0.08 m/s, and find the angular velocity for calculation.

< Reference >

In case of the rotation movement, of which load moving direction is horizontal, without an external force ($E_2 = 0$), from the set pressure, first find the maximum energy absorbed, E_t. Then, the allowable inertia moment and allowable load angular velocity can be found.

To find the allowable load inertia moment, I : $I = 2E_t/\omega^2$
To find the allowable load angular velocity, ω : $\omega = \sqrt{2E_t/I}$

Inertia moment calculation table

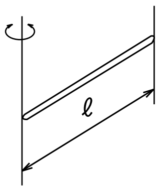
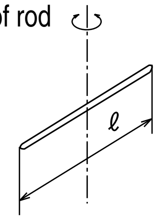
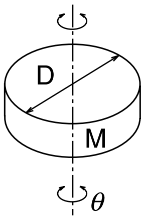
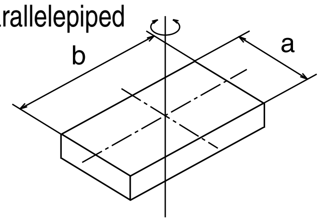
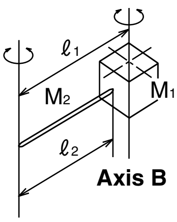
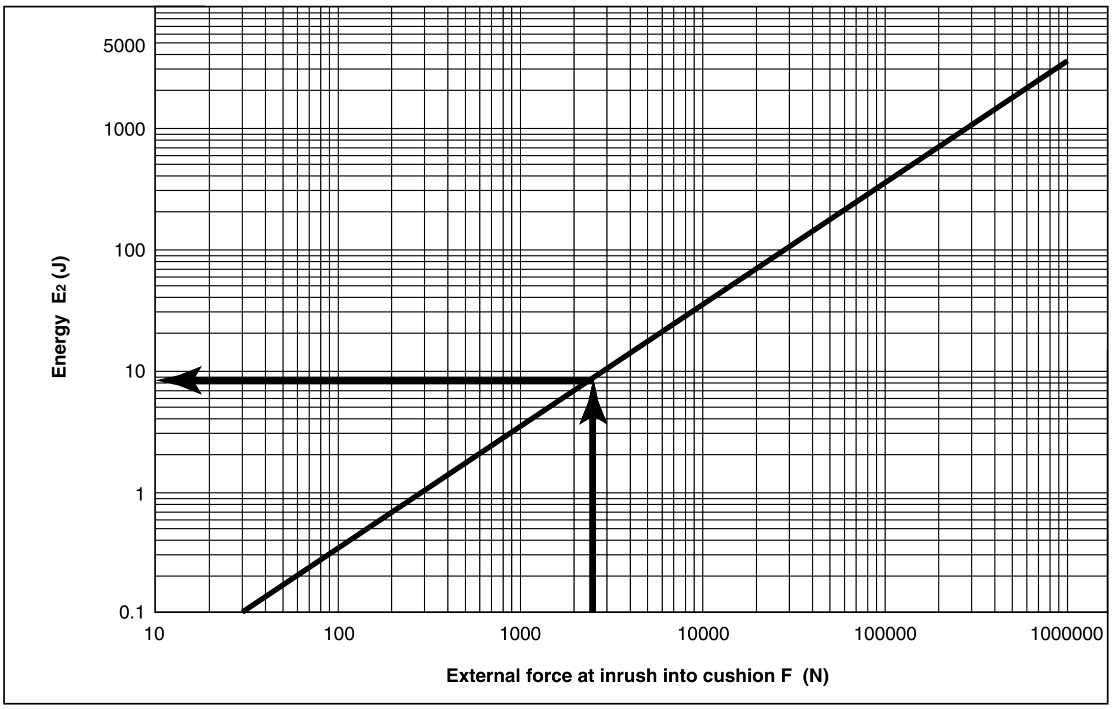
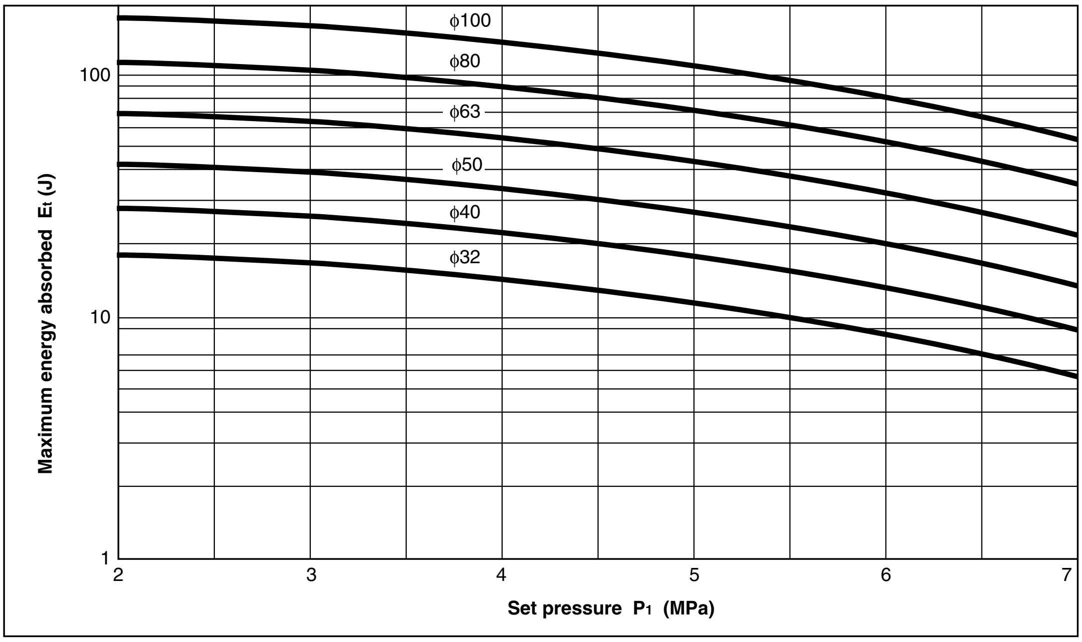
Outline	I : Inertia moment	Outline	I : Inertia moment
● In the case of the axis at rod end 	$I = \frac{M\ell^2}{3}$	● In the case of the axis in the middle of rod  Note) The axis passes through the center of gravity.	$I = \frac{M\ell^2}{12}$
● In the case of a cylinder (including a disk)  Note) The axis passes through the center of gravity.	$I = \frac{MD^2}{8}$	● In the case of a rectangular parallelepiped  Note) The axis passes through the center of gravity.	$I = \frac{M}{12}(a^2+b^2)$
● In the case of an arm (rotated around the axis A)  M_1 : Weight of a weight M_2 : Weight of an arm ℓ_1 : Distance from the axis A to the center of a weight ℓ_2 : Arm length	$I = M_1\ell_1^2 + I_1 + \frac{M_2\ell_2^2}{3}$ I_1 : The inertia moment of a weight when the axis passing through the center of the gravity of the weight (axis B) is the center.	$I\ (I_1)$: Inertia moment kg • m² M (M_1, M_2) : Weight kg ℓ, a, b : Length m D : Diameter m	

Chart of conversion of external force into energy at inrush into cushion of 70/140H-8

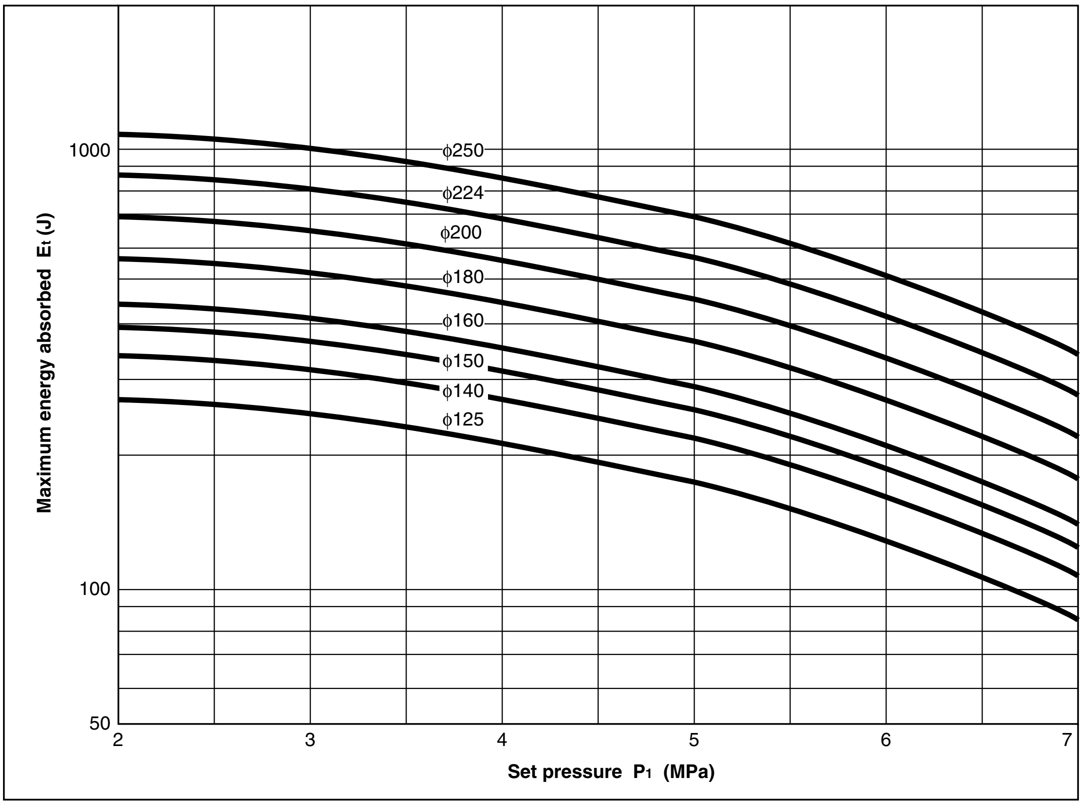


70H-8 Maximum energy absorbed common to rod A, B, C

Bore ϕ32 - ϕ100

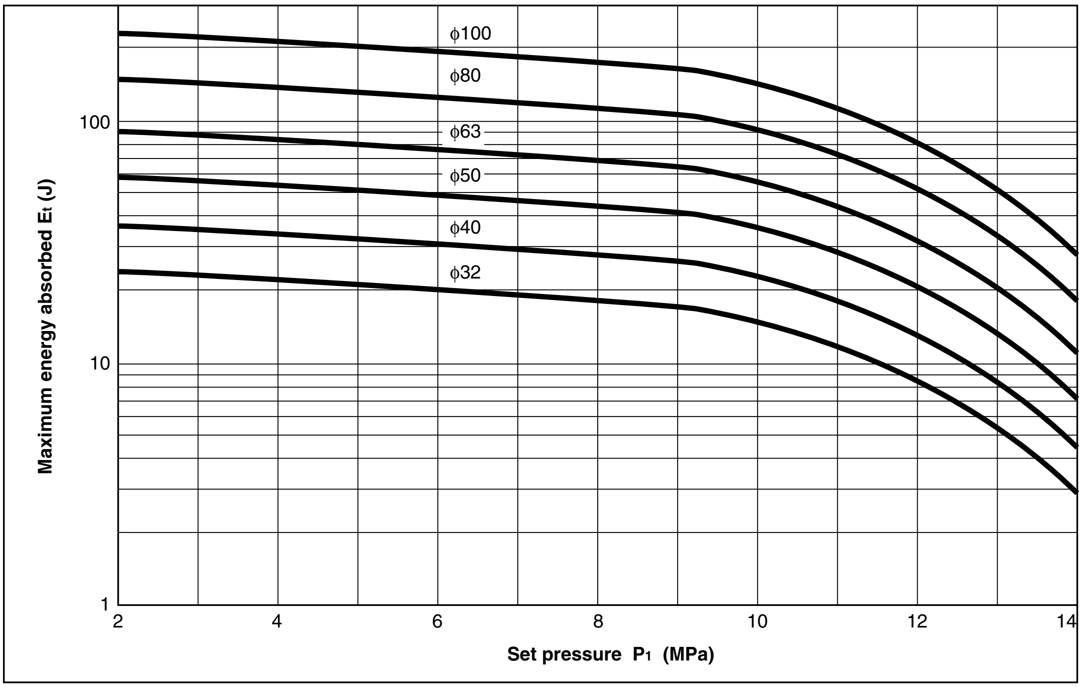


Bore ϕ125 - ϕ250

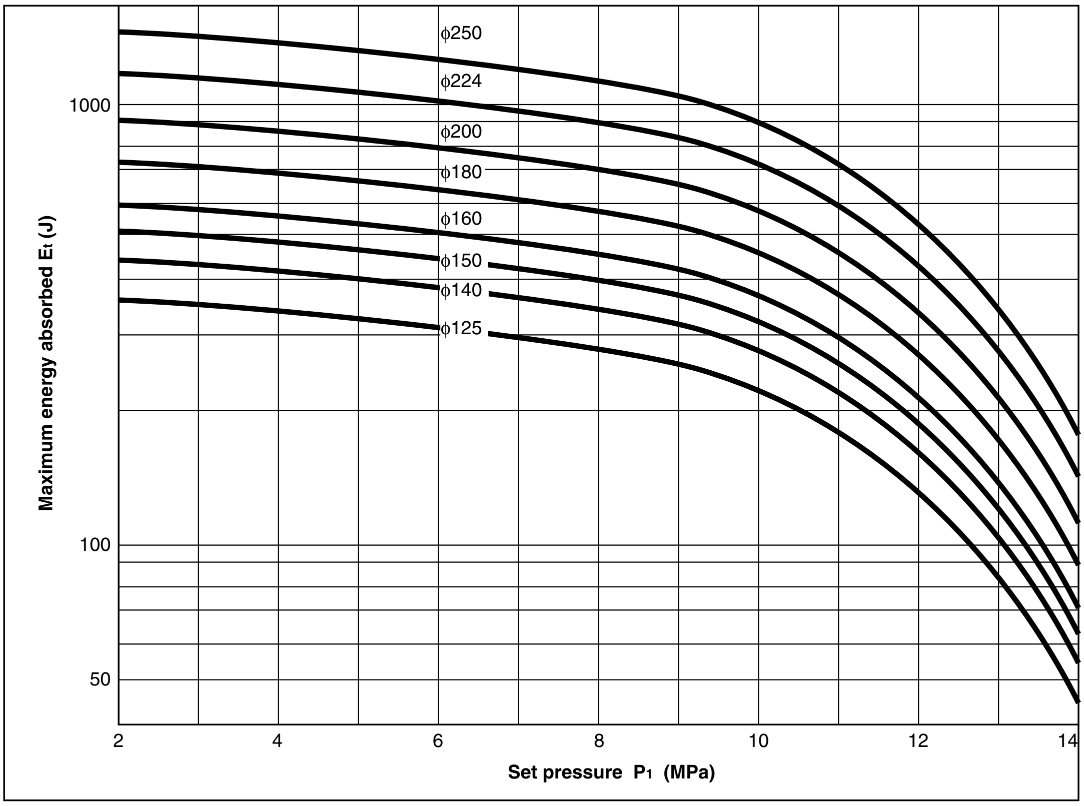


140H-8 Maximum energy absorbed of rod B

Bore ϕ32 - ϕ100

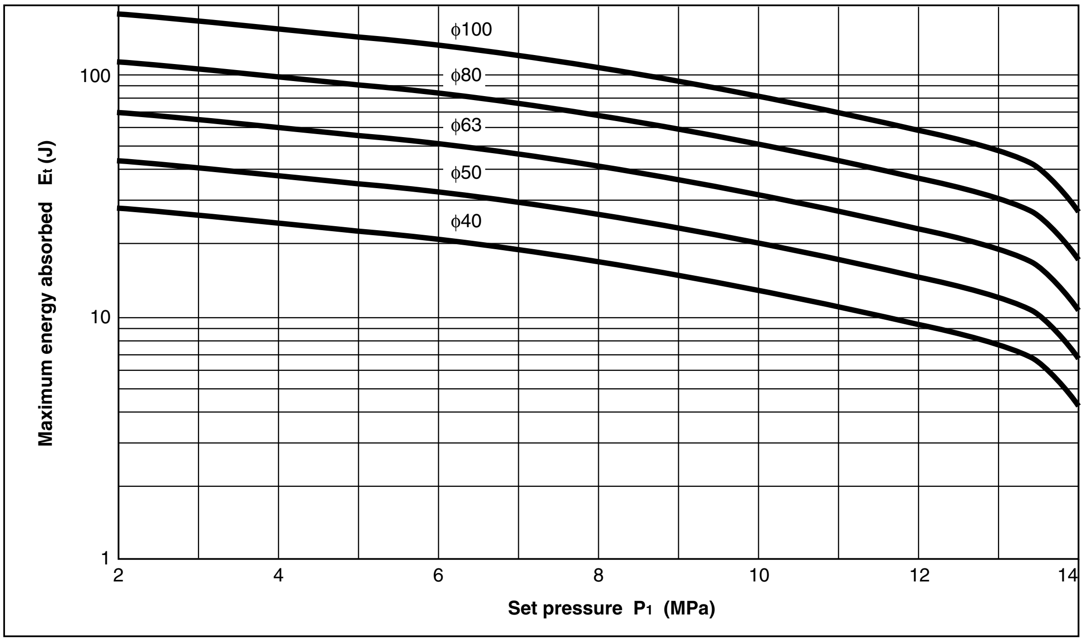


Bore ϕ125 - ϕ250

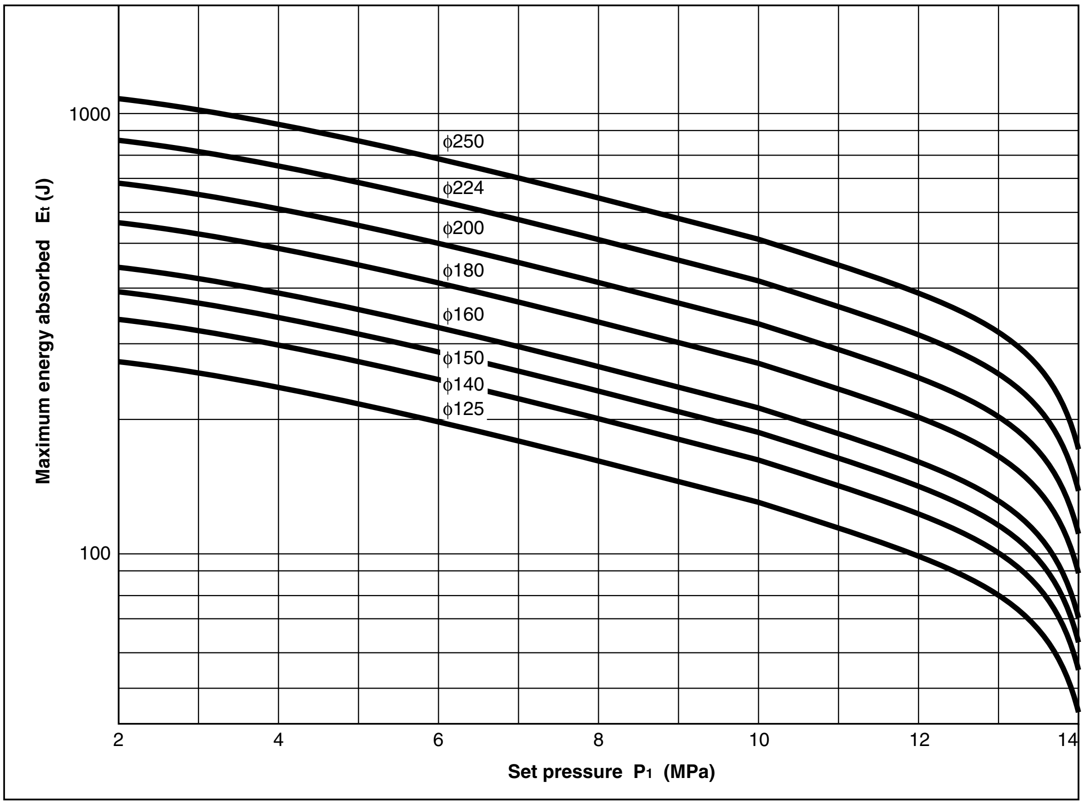


140H-8 Maximum energy absorbed of rod C

Bore ϕ40 - ϕ100

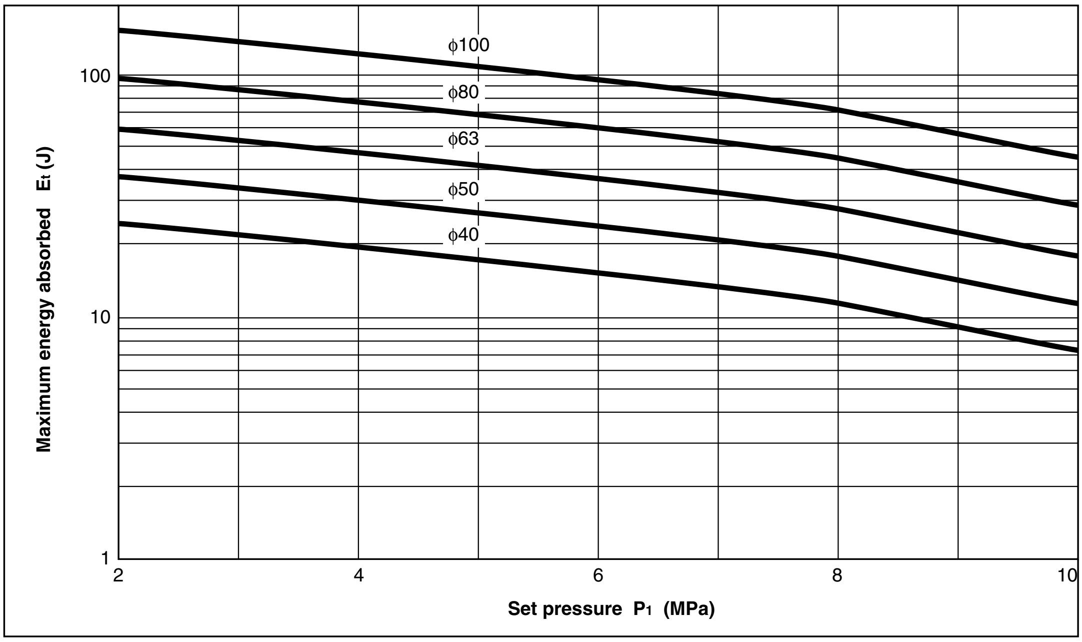


Bore ϕ125 - ϕ250



140H-8 Maximum energy absorbed of rod A

Bore ϕ40 - ϕ100



Bore ϕ125 - ϕ160