TECHNICAL INFORMATION

TECHNICAL INFORMATION

The following pages contain important technical information on products found in this catalogue. There is a particular focus on Thermoplastic products that can help in determining the best suitable product for your application.

If you do not find the information you are looking for or would like further clarification, please contact Abdex directly.

IN THIS SECTION

CHEMICAL RESISTANCE TABLE
THERMOPLASTIC HOSE

RATINGS CODE
G Good to excellent. Little or no swelling, tensile or surface changes. Preferred choice.
L Marginal or conditional. Noticeable effects but not necessarily indicating lack of serviceability. Further testing suggested for specific application. Very long-term effects such as stiffening or potential for crazing should be evaluated.
P Poor or unsatisfactory. Not recommended without extensive and realistic testing.
- Indicates that this was not tested.

MATERIALS CODE FOR HOSE CORE TUBES
N Polyamide.
M Coextruded tube with Fluorpolymer inner liner.

MATERIALS CODE FOR HOSE COVER
N Polyamide.
U / HF Polyurethane.

NOTES ON THE CHEMICAL RESISTANCE TABLE
(1) The fluid resistance tables are simplified rating tabulations based on immersion tests at 24˚C. Higher temperatures tend to reduce ratings. Since final selection depends on pressure, fluid and ambient temperature and other factors not known to Abdex, no performance guarantee is expressed or implied. The indications do not imply any compliance with standards and regulations and do not refer to possible changes of colour, taste or smell. For food and drinking water specially approved materials have to be used. For fluids not listed or for advice on particular applications, please consult please consult Abdex.
(2) Hose applications for these fluids must take into account legal and insurance regulations. The chemical resistance indicated does not express or imply approval by certain institutions.
(3) Satisfactory at some concentrations and temperatures, unsatisfactory at others.
(4) For gas applications, the cover should be pin-pricked and the pressure must not be released quickly. Special safety guard accessories are to be used to prevent damage or personal injury in the event of failure.
(5) Chemical resistance does not imply low permeation rates. Please consult Abdex for a recommendation for your specific requirements.
(6) The indication of chemical resistance does not imply any special food compatibility; it refers only to the chemical resistance of the material.
(7) Chemical resistance does not imply acceptability for use in airless paint spray applications. These applications require a special, electrically conductive hose.

Chemical	N	U / HF	M
Acetone	G	P	L
Acetylene	-	-	-
Air (4)	G	G	G
Ammonium Chloride	P	G	G
Ammonium Hydroxyde	G	P	G
Anhydrous Ammonia	P	P	-
Aniline	P	P	G
Aromatic Hydrocarbons	G	L	-
Asphalt	G	G	L
Benzene	G	L	G
Butane (2) (4)	G	L	-
Calcium Chloride	-	G	G
Carbon Dioxide (4)	G	G	-
Carbon Monoxide (4)	-	G	-
Carbon Tetrachloride	G	P	G
Chlorinated Hydrocarbon Base Fluids	G	L	-
Chlorinated Petroleum Oil	G	L	-
Chlorinated Solvents	-	P	-
Chlorine, Gaseous, Dry	P	P	-

Chemical	N	U / HF	M
Chromic Acid	-	P	L
Citric Acid Solutions	G	L	G
Crude Petroleum Oil	G	G	-
Cyclohexan (2)	G	G	G
Diesel Fuel (2)	G	G	-
Diester Oils	G	P	-
Ethanol (6)	G	L	-
Ethers	G	P	G
Ethylene Glycol	G	L	G
Ethylene Oxide	G	L	-
Fatty Acids	G	-	G
Formaldehyde	L	P	G
Formic Acid J	P	P	G
Fuel Oil (2)	G	L	G
Gas (Oil) (2)	G	G	-
Gasoline	G	-	G
Glycerine	G	L	G
Glycols (to 135°F)	G	L	G
Grease (petroleum base)	G	G	--
Hexane (2)	G	G	G
Hydraulic Fluid (petroleum base)	G	G	L
Hydraulic Fluid phosphate ester base)	G	L	-
Hydraulic Fluid water base)	G	G	-
Hydraulic oil (petroleum base)	G	G	L
Hydrochloric Acid	L	P	G
Hydrofluoric Acid	P	P	G
Hydrolube (hydraulic fluid/water glycol base)	G	L	-
IRUS 902 (hydraulic fluid/water-oil emulsion)	G	G	-
Isooctane (2)	G	G	G
Kerosene (2)	G	L	G
Ketones	G	P	G
Lime (calcium oxide)	G	G	G
Lindol (hydraulic fluid/phosphate esters)	G	P	-
LP-Gas	-	-	-
Lubricating Oils (diester base)	G	P	-
Lubricating Oils (petroleum base)	G	G	G
Methane	-	-	-
Methanol	G	P	-
Methyl Alcohol (6)	G	P	G
Methyl Ethyl Ketone (MEK)	G	P	G
Methyl Ethyl Ketone Peroxide (MEKP)	L	P	-
Methyl Isobutyl Ketone (MIBK)	G	P	G
Methylen Chloride	L	P	G
Mineral Oil	G	G	G
Mineral Spirits	-	L	-
Motor Oils	G	G	G
Naphta	G	P	G
Natural Gas (4)	-	-	-
Nitric Acid	P	P	L
Nitrobenzene	G	P	G
Nitrogen, Gaseous (4) (5)	G	G	G

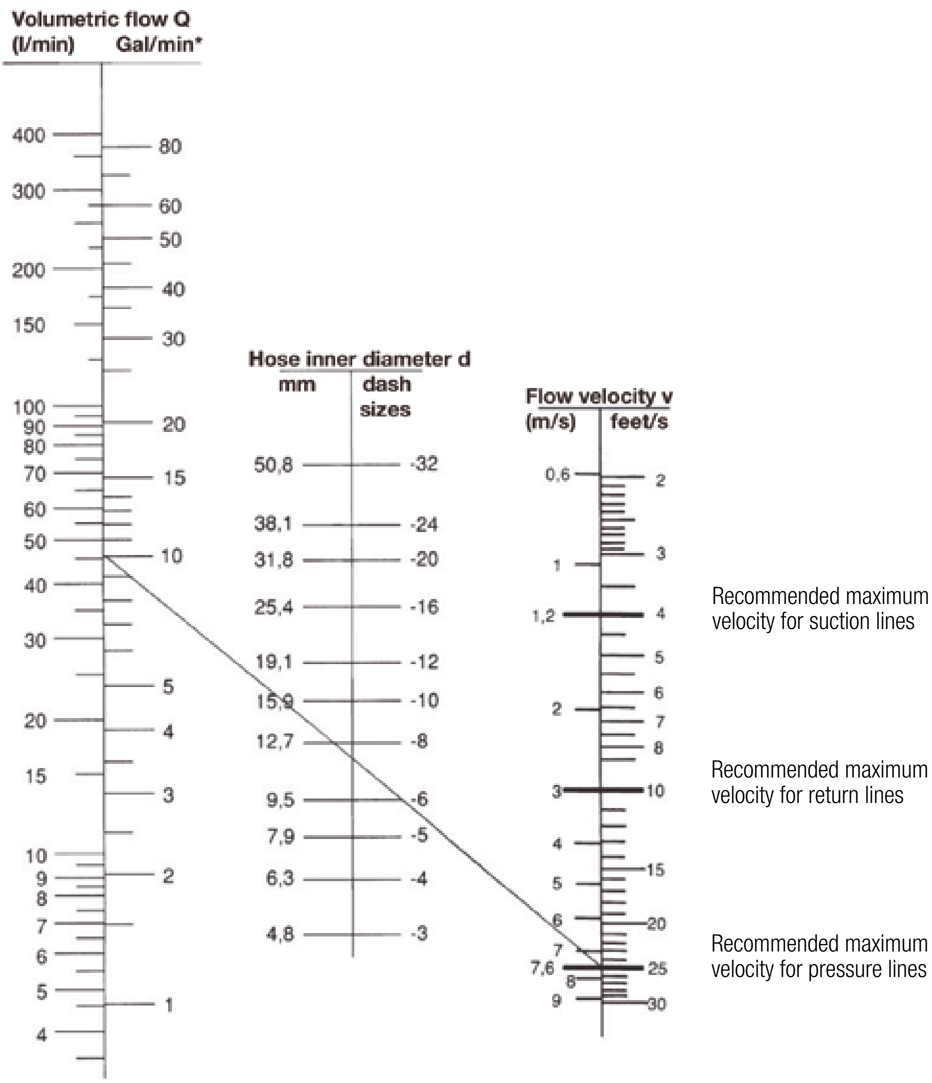
CHEMICAL RESISTANCE TABLE
THERMOPLASTIC HOSE

Chemical	N	U / HF	M
Nitrous Oxide	L	-	-
Oil (SAE)	G	G	-
Oxygen, Gaseous (4) (5) (6)	G	G	G
Pentane (2)	G	L	G
Perchloric Acid	P	P	L
Petroleum Ether	-	-	-
Petroleum Oils	G	G	-
Phenols	P	P	-
Phosphate Esters (above 135 °F)	G	P	-
Phosphate Esters (to 135 °F)	G	P	-
Propane (4) (5)	-	-	-
Propylen Glycol	-	G	G
Salt Water	-	-	G
Silicone Greases	G	G	-
Silicone Oils	G	G	-
Sodium Borate	G	G	G
Sodium Carbonate	-	-	-
Sodium Chloride Solutions	G	G	G
Sodium Hydroxide, 50%	P	P	G
Sodium Hypochloride	P	P	G
Steam	P	P	G
Straight Synthetic Oils (phosphate esters)	G	P	-
Sulphur Dioxide	L	L	G
Sulphur Hexafluoride Gas (4) (5)	G	G	-
Sulphuric Acid	P	P	-
Toluol, Toluene	G	L	G
Trichlorethylene	L	P	G
Ucon (hydraulic fluid/water glycol base	G	L	-
Water (above 60 °C) (6)	G	P	L
Water (to 60 °C) (6)	G	G	G
Water Glycols (above 60 °C)	L	P	-
Water Glycols (to 60 °C)	G	L	-
Water in oil Emulsions (above 60 °C)	L	P	-
Water in oil Emulsions (to 60 °C)	G	L	-
Xylene	G	P	G
Zinc Chloride	G	G	G

Flow capacities of Parker hose at recommended flow velocities
The chart below is provided as an aid in the determination of the correct hose size.
Suitable for hydraulic applications.
Example:
At 10 gallons per minute (gal/min), what is the proper hose size within the recommended velocity range for pressure lines?
Locate 10 gallons per minute in the left-hand column and 25 feet per second in the right-hand column (the maximum recommende velocity range for pressure lines).
Lay a straight line across these two points. The inside diameter shown in the centre column is above -6 so we have to use -8 (1/2″).
Fir suction hose, follow the same procedure except use recommended velocity range for intake lines in the right-hand column.

Where:
Q - flow in gallons per minute (gal/min and l/min)
V - velocity in feet per second (f/s and m/s)
d - hose inside diameter (mm and dash size)

Conversion factors:
gal/min x 4.546 = l/min
feet/s x 0.3948 = m/s



* gallons are UK gallons.

Recommended velocities are according to hydraulic fluids of maximum visosity 315 S.S.U at 38˚C working at room temperature within 18˚ and 68˚C.

GENERAL INFORMATION
HOW TO SELECT THE RIGHT HOSE

SIZE
ID
OD
Hose length (OAL or uncoupled length)
Tolerances

TEMPERATURE
Of material being conveyed (high, low, ambient)
Of outside exposure (high, low, ambient)
Intermittent?
Constant?
Sub-zero exposure?

APPLICATION(S)
Indoor and / or outdoor use
Intermittent or continuous use
Flexibility required (Min. bend radius)
Movement (static, vibrations, flexing)
External conditions: Abrasion
Oil
Solvents
Acid
Ozone
Electrical / static conductive
Oil resistance: Tube
Cover
Flame resistance
Non-contaminating materials
Hose currently in use
Current hose service life / failure description
Service life desired

MATERIAL(S) BEING CONVEYED
Solids (size, description)
Gaseous (volatility, inert)
Liquids (flammability, causticity, acid / alkaline, solution / concentration)
Chemical Names (generic)

PRESSURE(S)
Working pressure (including surges)
Burst pressure
Suction or vacuum requirements
Velocity
Impulse

ENDS & FITTINGS
Factory applied fittings: Type of threads
Male / Female
Reusable / Non-reusable
Material for fittings
Built-in fittings / ends: beaded
Flanged
Rubber-lined
Other
Cut to length
Crimp specs / crimper (hydraulics)

DELIVERY
Lead time
Quantity
Stock / non-stock
Special print
Special packaging

S
T
A
M
P
E
D

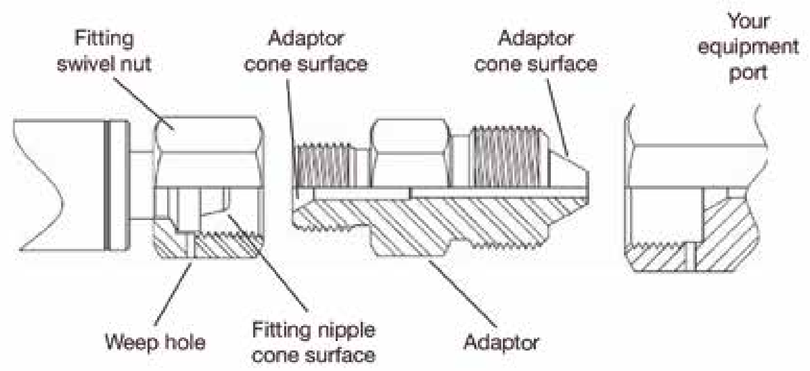
METRIC CONVERSION CHART

	English to Metric			Metric to English		
	To Convert From	To	Multiply	To Convert From	To	Multiply
Area	sq. in. (in²)	sq. mm. (mm²)	645.16	sq. mm (mm²)	sq. in. (in²)	0.00155
	sq. in. (in²)	sq. cm. (cm²)	6.4516			
	sq. ft. (ft²)	sq. metres (m²)	0.0929			
Density	Pounds / cubic foot (lb/ft)	Kilograms / Cubic metre (km/m³)	16.02	Kilograms / Cubic metre (kg/m³)	Pounds / Cubic foot (lb/ft)	0.0624
Energy	British Thermal Units (Btu) (1 J = Ws = 0.2388 cal)	Joules (J)	1055	Joules (J)	British Thermal Units (Btu)	0.000947
Force	Pounds - Force (lbf) (1N = 0.102 kgf)	Newtons (N)	4.448	Newtons (N)	Pounds - Force (lbf)	0.2248
Length	Inches (in)	Millimetres (mm)	25.4	Millimetres (mm)	Inches (in)	0.03937
	Feet (ft)	Metres (m)	0.3048	Metres (m)	Feet (ft)	3.281
	Miles (mi)	Kilometres (km)	1.609	Kilometres (km)	Miles (mi)	0.621
Mass (weight)	Ounces (oz.)	Grams (g)	28.35	Grams (g)	Ounces (oz.)	0.035
	Pounds - Mass (lb)	Kilograms (kg)	0.4536	Kilograms (kg)	Pounds - Mass (lb)	2.205
	Short tons (2000 lb) (tn)	Metre tons (1000 kg)	0.0972	Metric tonnes (1000 kg)	Short tons (2000 lb) (tn)	1.102
Power	Horsepower (550 ft. lb/s) (hp)	Kilowatts (kW)	0.7457	Kilowatts (kW)	Horsepower (550 ft. lb/s) (hp)	1.341
Pressure	Pounds / square / inch (psi)	Kilograms (f) / square cm (kg (f)/cm²)	0.0703	Kilograms (f) / square cm (kg (f)/cm²)	Pounds / square inch (psi)	14.22
	Pounds / square / inch (psi)	Kilopascals (kPa)	6.8948	Kilopascals (kPa)	Pounds / square inch (psi)	0.145
	Pounds / square / inch (psi)	Bars (100 kPa)	0.06895	Bars (1000 kPa)	Pounds / square inch (psi)	14.503
Stress	Pounds / square inch (psi) (1N/mm²=1MPa)	Megapascals (MPa)	0.006895	Megapascals (MPa)	Pounds / square inch (psi)	145.039
Temperature	Degrees Fahrenheit (˚F)	Degrees Celsius (˚C)	5/9 (after subtracting 32)	Degrees Celsius (˚C)	Degrees Fahrenheit (˚F)	9/5 (then add 32)
Torque or bending moment	Pounds - Force - Foot (lb-ft)	Newtons-metre (Nm)	1.3567	Newtons-metre (Nm)	Pounds - Force - Foot (lb-ft)	0.737
	Pounds - Force - Foot (lb-in)	Newtons-metre (Nm)	0.113	Newtons-metre (Nm)	Pounds - Force - Foot (lb-in)	8.85
Velocity	Feet / seconds (ft/s)	Metre / second (m/S)	03048	Metre / second (m/S)	Feet / seconds (ft/s)	3.2808
Viscosity	Dynamic (centipoise)	Pascal-second (Pas)	0.001	Pascal-second (Pas)	Dynamic (centipoise)	1000
	Kenematic-foot² / sec (ft²/s)	Metre² / sec (m²/s)	0.0929	Metre² / sec (m²/s)	Kenematic-foot² / sec (ft²/s)	10.7643
Volume	Cubic inch (in³)	Cubic centimetre (cm³) (millimetre)	16.3871	Cubic centimetre (cm³) (millimetre)	Cubic inch (in³)	0.061
	Quarts (qt)	Litres (1000 cm³)	0.9464	Litres (1000 cm³)	Quarts (qt)	1.057
	Gallons (gal)	Litres	3.7854	Litres	Gallons (gal)	0.2642

GENERAL ENGINEERING
RECOMMENDED TIGHTENING PROCEDURES

TIGHTENING PROCEDURES

	Connection	Thread Sizes	Tightening Torque	
			ft / lb	M / m
High Pressure	1/4	9/16 - 18	25	34
	3/8	3/4 - 16	50	69
	9/16	1 1/8 - 12	75	103
Medium Pressure	1/4	7/16 - 20	20	28
	3/8	9/16 - 20	30	41
	9/16	13/16 - 16	85	117
	3/4	3/4 NPSM	90	124
	1	1 3/8 - 12	125	173
Type “M” Swivel	A9	9/16 - 18	25 - 30	34 - 41
	A12	3/4 - 16	40 - 50	55 - 69
	A14	7/8 - 14	50 - 60	69 - 83
	A16	1 - 12	75 - 85	103 - 117
	A21	1 5/16 - 12	100 - 120	138 - 166



Leakage at swivel nut-to-adaptor joint
(Seen by leak at weep hole in swivel nut)
1. Reduce system pressure to zero.
2. Unscrew swivel nut and check cone surfaces of adaptor and hose insert.
3. If hose insert is damaged, return hose to Abdex for repair and retest.
4. If cone surfaces look good after cleaning, re-tighten swivel nut. Do not exceed 150% of reccomended torque.

Leakage at type “M” adaptor-to-port
(Seen by leak at weep hole in pressure port, or leak at threads for NPT adapters)
1. Reduce system pressure to zero.
2. Slacken hose swivel nut.
3. Tighten adaptor into port.
4. Re-tighten swivel nut.
Never use the swivel nut to tighten the adaptor into the port.

PERMABILITY COEFFICIENT

$$\text{Permability Coefficient} = \frac{V}{A \times T \times p}$$

Where:
V - volume of gas, in cm^3, which diffuses through a 1mm thickness.
A - area across which the gas diffuses, in m^2.
T - diffusion time, in days.
p - pressure difference across the plastic, in bar.

PERMABILITY COEFFICIENT PER DIN 53380

Material	Gas				
	N^2	0^2	CO^2	H^2	He
PTFE	50	150	1500	-	3500
PVDF	3	2	10	-	60
PA-6 XE 3289	1	4	10	100*	60*
PA-6 A 28 NZ	0.5	2	5	50*	30*
PA-12 L 2124	-	30	180	210	160
PA-12 P40 TL	-	-	105	-	-
PA-12 L 25W40	8	35	150	1000*	500*
PA-12 L 2140	-	12	71	-	130
PA-11 P 40 TL	-	-	55	130	-
PA-11 POLT	2	20	65	65	-
POM H 2320	5	10	130	35	40
POM 150 SA	2	4	20	-	-
PEE 4055	150	-	3000	-	1400
PEE 5556	120	-	1600	-	900
PEE 7246	-	-	-	-	300

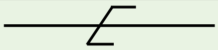
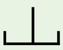
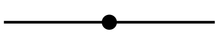
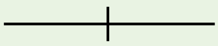
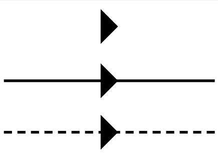
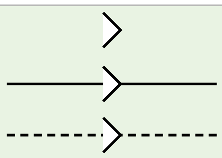
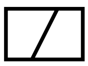
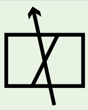
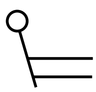
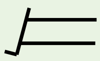
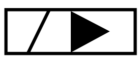
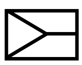
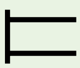
* Calculated value. Diffusion constants based on normal room temperature. Actual behaviour may vary considerably because of variations in processing the plastic.

GENERAL ENGINEERING
HYDRAULIC & PNEUMATIC SYMBOLS

HYDRAULIC & PNEUMATIC SYMBOLS

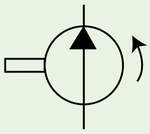
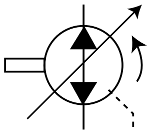
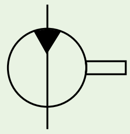
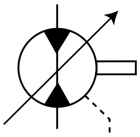
ISO 1219-1 covers graphic symbols for both hydraulic and pneumatic equipment. For circuit diagram layout rules see BS ISO 1219-2.
For port identification and operator marking see ISO 9461 (Hydraulic) or BS ISO 5599 (Pneumatic).

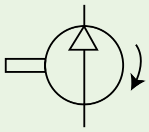
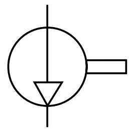
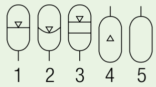
Graphic symbols for fluid power systems

	Supply lines, return lines, component enclosure, symbol enclosure
	Pilot (control) line, drain line, flushing line, bleed line
	Electrical control line
	Frame for several components
	Hose assembly
	Drain to tank
	Return to tank
	Connection of two fluid lines (indicated by the connection point ●)
	Two fluid lines crossing (no connection)
	Hydraulic source of energy
	Pneumatic source of energy
	Valve control - solenoid
	Valve control - Proportional solenoid
	Valve control - Lever
	Valve control - Pedal
	Valve control - Electro-hydraulic (pilot operated DCV)
	Valve control - Spring
	Valve control - Pneumatic spring
	Valve control - Manual override

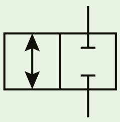
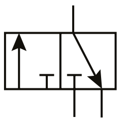
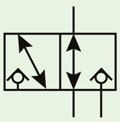
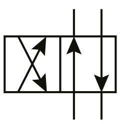
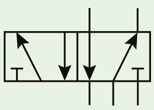
SYSTEMS OF UNITS & CONVERSIONS

Graphic symbols for fluid power systems

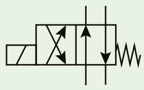
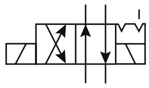
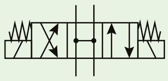
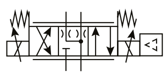
	Hydraulic pump Fixed displacement, one direction of rotation, one direction of flow, internal case drain
	Hydraulic pump Variable displacement, one direction of rotation, two directions of flow, external case drain
	Hydraulic motor Fixed displacement, one direction of rotation, internal case drain
	Hydraulic motor Variable displacement, bi-directional rotation, external case drain

	Compressor: clockwise rotation
	Air motor: one direction of rotation
	1. Diaphragm accumulator 2. Bladder accumulator 3. Piston accumulator 4. Back-up bottle, 5. Air reservoir [pressurised]

Directional control valves (DCV's)

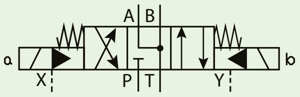
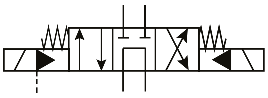
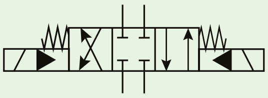
	2/2 Valve (2 ports, 2 positions)
	3/2 Valve (3 ports, 2 positions)
	3/2 Poppet valve (reversible flow, leak-free closure)
	4/2 Valve (4 ports, 2 positions)
	5/2 Valve (5 ports, 2 positions)

Direct operated (by solenoid) DCV's

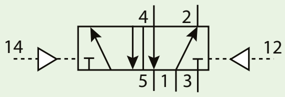
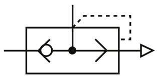
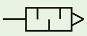
	4/2 "spring return" or "spring offset" DCV
	4/2 "detented" or "impulse" DCV
	4/3 spring centred DCV (open centre spool)
	"force controlled" or "non-feedback" proportional DCV (shown with integral amplifier)

GENERAL ENGINEERING
HYDRAULIC & PNEUMATIC SYMBOLS

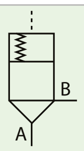
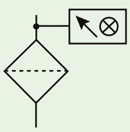
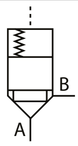
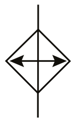
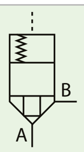
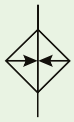
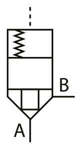
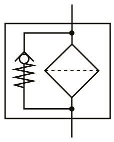
Port and solenoid identification for hydraulic valves according to ISO 9461
Electro-hydraulic (“pilot operated” or “two-stage”) DCV’s. Solenoid operated pilot stage (A and B).
Spring centred main stage (various spool configurations shown).

	External pilot supply (X), external pilot drain (Y)
	External pilot supply, internal pilot drain
	Internal pilot supply, internal pilot drain

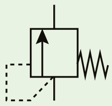
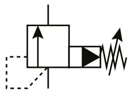
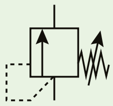
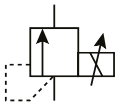
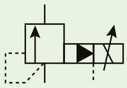
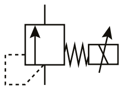
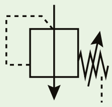
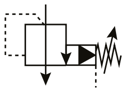
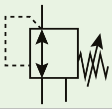
Port identification for pneumatic valves according to ISO 11727

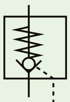
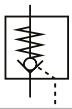
	Direct operated (by pneumatic pilot) 5/2 DCV
	Pneumatic quick-exhaust valve with possibility of connection to the exhaust port
	Pneumatic exhaust silencer with no possibility of connection to the outlet port

2/2 cartridge valves ("slip in valves" or "logic elements")

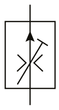
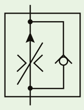
	Pressure control, normally closed, area ratio: 1		Filter with optical clogging indicator
	Directional control, area ratio: >0.5		Filter with bypass (the enclosure indicates that the component has two or more main functions that are connected to each other)
	Directional control, area ratio: <0.5		Cooler (with no indication of the cooling fluid flow path)
	Directional control, area ratio: <0.5 (with damping nose or throttle nose)		Heater (with no indication of the heat exchange fluid flow path)

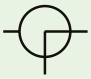
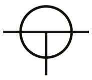
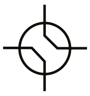
Abdex

	Direct operated ("single-stage") relief valve with adjustable spring
	Pilot operated ("two-stage") relief valve
	Direct operated sequence valve (external spring chamber drain)
	Direct operated proportional relief valve (solenoid acts directly on valve poppet)
	Pilot operated proportional relief valve (external pilot drain)
	Direct operated proportional relief valve (solenoid acts on valve poppet via spring - this type of valve is often equipped with a stroke transducer)
	Direct operated reducing valve
	Pilot operated reducing valve
	Direct operated 3-way reducing valve ("reducing/relieving" valve)

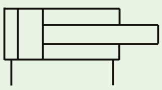
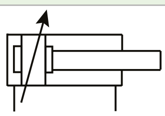
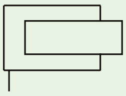
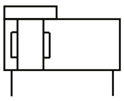
	Check valve without spring (symbol often used for valves with only a light spring)
	Check valve with spring (spring is drawn if its rating is significant)
	Pilot to open check valve ("PO check valve")
	Vented (or "4 port") pilot to open check valve
	Quick connect coupling (this symbol also used for pressure test points)

GENERAL ENGINEERING
HYDRAULIC & PNEUMATIC SYMBOLS

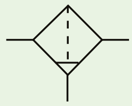
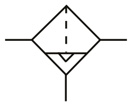
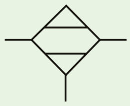
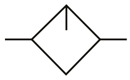
	Throttle valve with adjustable opening
	Pressure compensated and temperature (viscosity) compensated flow control valve with fixed setting
	Pressure compensated and temperature (viscosity) compensated flow control valve with adjustable setting and reverse flow check valve

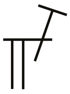
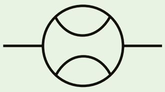
	Normally open isolation valve (ball valve, gate valve, globe valve etc. or a fully open needle valve)
	Normally closed isolation valve (ball valve, gate valve, globe valve etc. or a fully closed needle valve)
	3 way ball valve (“L” configuration)
	3 way ball valve (“T” configuration)
	3 way ball valve (“inverted T” configuration)
	4 way ball valve (“X” configuration)

Cylinders (linear actuators)

	Double-acting cylinder (single rod)
	Cylinder with adjustable cushions at each end of stroke
	Single-acting (“plunger”) cylinder
	“Rodless” cylinder [band type] with non-adjustable cushioning

Compressed air preparation

	Filter with separator with manual drain
	Filter with separator with automatic drain
	Air dryer
	Lubricator

	Permanent magnet
	Stroke transducer (as used on proportional valves with position feedback)
	Stroke limiter (adjustable)
	Stroke limiter (fixed setting)
	Flowmeter (type of output not shown)

GENERAL ENGINEERING
FORMULAE

PUMPS & MOTORS

Flow rate (L/min)	$Q = \frac{Dn}{1000}$
Shaft torque (Nm)	$T = \frac{Dp}{20\pi}$
Shaft power (kW)	$P_{SH} = \frac{Tn}{9549.3}$
Hydraulic power (kW)	$P_H = \frac{Qp}{600}$

CYLINDERS

Pressure (N/m²)	$\frac{F}{A}$
Flow rate (L/min)	$Q = 60 \times 10^3 \times Av$
Quick calculation	Power (kW) $P = \frac{\text{tonnes} \times \text{mm/sec}}{100}$

ABBREVIATIONS

F	Force (N)
A	Area (m²)
V	Velocity (m/s)
P	Pressure (bar)
D	Displacement (cm³/rev)
n	Shaft Speed (rev/min)
Øp	Pressure drop (bar)
Q	Flow Rate (L/min)
T	Shaft Torque (Nm)
P_{SH}	Shaft Power (kW)
P_H	Hydraulic Power (kW)

PRESSURE LOSS IN PIPES

Flow (L/min)	Tube bore size (mm)								
	5	7	10	13	16	21	25	30	36
1	0.69	0.22							
2	1.38	0.44							
3	2.07	0.66	0.17						
5	4.14	1.24	0.24						
7.5	6.55	1.72	0.31						
10		3.10	0.38	0.14					
15		5.38	0.69	0.21	0.08				
20			1.10	0.30	0.14				
30			2.21	0.69	0.25	0.04			
40				1.17	0.45	0.08	0.04		
50					0.59	0.12	0.07	0.03	
75					1.13	0.23	0.14	0.06	0.02
100						0.41	0.22	0.13	0.03
150							0.45	0.23	0.06
200								0.41	0.10
250									0.16

This chart gives the approximate pressure drop in smooth bore straight pipes, in bar per 3 m length. Bends and fittings will increase the above pressure losses and manufacturers should be consulted for more accurate figures.

PRESSURE DROP THROUGH PIPES

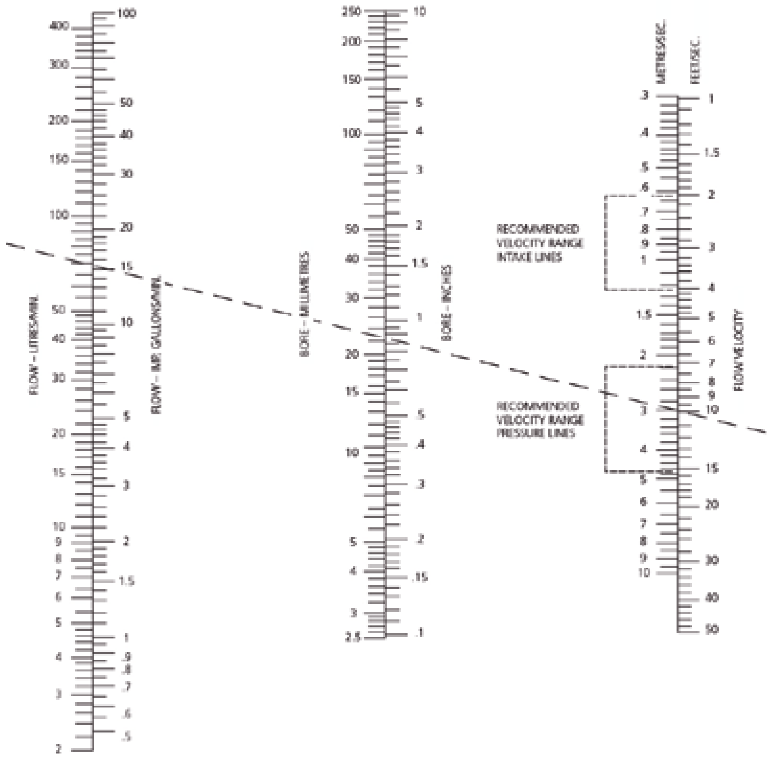
Øp	Pressure drop (bar)
Q	Free air flow (m^3/s) = l/s x 10^{-3}
L	Pipe length (m)
d	Internal pipe diameter (m)
p	Pressure (bar)

VELOCITY THROUGH PIPES

v	Flow velocity (m/s)
p	Initial pressure (bar)
d	Internal pipe diameter (mm)

If the free air flow is known, the minimum inside diameter to keep velocity below 6 m/s, can be found from:
For normal installations, where the pressure is about 7 bar gauge, this can be simplified to:
d (mm) should be greater than 5 × Q

PRESSURE DROP IN PIPES & HOSES



Nomogram for determining pipe sizes in relation to flow rates and recommended velocity ranges.

Based on the formula:

$$\text{Velocity of fluid in pipe (m/s)} = \frac{\text{Flow rate (l/min)} \times 21.22}{\text{d2}}$$

d = Bore of pipe (mm)

Recommended velocity ranges based on oils having a maximum viscosity grade of 70 cSt at 38˚C and operating between 18˚C and 51˚C.

Note: For pipe runs greater than 10 m pipe size should be increased correspondingly. Intake line should never exceed 1m in length.

GENERAL ENGINEERING
FORMULAE

HYDRAULIC FLUIDS, SEALS & CONTAMINATION CONTROL

ISO Classification of hydraulic fluids – BS ISO 6743-4

HH Non-inhibited refined mineral oils
HL Refined mineral oils with improved anti-rust and anti-oxidation properties
HM Oils of HL type with improved anti-wear properties
HV Oils of HM type with improved viscosity/temperature properties HFAE Oil-in-water emulsions
HFAS Chemical solutions in water
HFB Water-in-oil emulsions
HFC Water polymer solutions
HFDR Synthetic fluids containing no water and consisting of phosphate esters
HFDU Synthetic fluids containing no water and of other composition

Environmentally acceptable hydraulic fluids

HETG Tryglycerides
HEPG Polyglycols
HEES Synthetic esters
HEPR Polyalphaolefins

Viscosity classification of hydraulic fluids – ISO 3448 (BS 4231)

Each viscosity grade is designated by the nearest whole number to its mid-point kinematic viscosity in centistokes at 40 °C. It is abbreviated ISO VG. Common viscosity grades of hydraulic fluids are VG 22, 32, 46 and 68.

Thus HM32 is a mineral oil with improved anti-rust, anti- oxidation and anti-wear properties having a viscosity of approximately 32 centistokes at 40 °C.

SEALS

Seal Material	Recommended for:
Acrylonitrile butadiene (NBR)	Air, oil, water, water/glycol
Polyurethane (AU)	Oil
Polyurethane (EU)	Air, oil, water
Fluorocarbon rubber (FKM)	Air, oil, water, phosphate esters (except alkyl phosphates)
Ethylene propylene diene* (EPDM)	Air, water, water/glycol, phosphate esters
Polytetrafluoroethylene - virgin, bronze-filled, glass-filled, carbon-filled (PTFE)	Air, oil, water, water/glycol, phosphate esters
Thermoplastic polyester elastomer	Oil, water
Ultra high molecular weight polyethylene (UHMWPE)	Oil, water, water/glycol

*EPDM is not recommended for mineral oil as it will swell rapidly.

FLUID & HYDRAULIC CLEANLINESS

Cleanliness control

The presence of particulate contamination (dirt) is the single most important factor governing the life and reliability of fluid power systems. Operating with clean fluids is essential to achieve modern performance and reliability requirements.

Target cleanliness level (TCL) for a hydraulic system

The TCL is the operational cleanliness of the system and the level that should be achieved and maintained by the cleanliness control measures designed for that system.

The TCL should be selected at the design stage and used to define the cleanliness through the production and commissioning processes. The method for selecting the TCL described is based upon both the sensitivity of the system to particulate contamination and the life and reliability required by the user.

Design and cleanliness
Filtration Standards
A wide range of standards are available to test a filter's capability to perform under various system conditions, namely:-

Parameter	
Collapse/Burst Resistance	BS ISO 2941
Fabrication Integrity	BS ISO 2942
Fluid Compatibility	BS ISO 2943
End Load Strength	BS ISO 3723
Flow Fatigue Test	BS ISO 3724
Flow/Pressure Loss	BS ISO 3968
Pressure Fatigue (Housings)	BS ISO 10771-1
Filter Qualification Programme	BS ISO 10770
Testing differential pressure devices	BS ISO 16860
Filtration Performance	BS ISO 16889
Flow fatigue using high viscosity fluid	BS ISO 23181

Degree of filtration – BS ISO 16889
This ISO standard describes the "Multi-pass" method for evaluating the filtration performance of a hydraulic filter element. The element is subject to a constant circulation of oil during which fresh contaminant (ISO Medium Test Dust) is injected into the rig. The contaminant that is not removed by the element under test is re-circulated, thereby simulating service conditions. The test continues until the element is 'blocked'.

The measure of the filter's ability to remove contaminant is determined by the analysis of fluid samples extracted from upstream and downstream of the filter and expressed as the Filtration Ratio ßx(c), thus:- for the sizes measured.

BS ISO 16889 specifies a number of ratings to define the element's performance over a wide size range and gives the µm(c) rating at ß(c) values of 2, 10, 75, 100, 200 and 1000.

The test also gives a measure of the element's ability to retain quantities of ISO Medium Test Dust.

Cleanliness of components
Components should be cleaned to a level that is commensurate with the system TCL. Guidelines on how to achieve and measure component cleanliness are provided in BS ISO/TR 10949 and BS ISO 18413.

Flushing
Flushing is a process designed to remove dirt introduced into the system during manufacture, assembly and initial operation. It is also used when significant maintenance is undertaken. The requirements are summarised below:-

- A turbulent flow regime to pick up the particles from the walls of components and transport them to the flushing filter
- The Reynolds Number (Re) defines the flow condition and should be greater than 4,000 thus:-
  $Re = 21{,}200 \times Q/(v \times d)$
  or
  $Q > 0.189 \times v \times d$ (l/min) to achieve $Re \geq 4{,}000$

Q = Flow rate (L/min)
v = Viscosity (mm/s)
d = Pipe diameter (mm)

- A 'fine' filter to capture transported particles quickly and effectively

Taking fluid Samples
Fluid samples are extracted from the hydraulic system to determine the operating cleanliness level and whether the TCL is being achieved. To ensure that the data is representative, care must be taken with this process and pre-cleaned sample bottles are essential.

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Measuring fluid cleanliness
The size range of interest in Fluid Power is generally from 2 to 100 µm. A range of instruments and techniques are available to measure the numbers or concentration of particles in either the hydraulic fluid or the component. These are:-

Measurement	
Gravimetric analysis (weight) (only suitable for 'dirty' systems or components)	ISO 4405
Optical Microscope and Image Analysis	BS ISO 4407
Automatic Particle Counting (APC)	BS ISO 11500
Filter/Mesh Blockage	BS ISO 21018 Part 3
Comparison Slide Method 05/44	BS 8465 and DEF STAN
Calibration of APCs (bottle analysis)	BS ISO 11171
Calibration of on-line APCs	BS ISO 11943

BS ISO 21018-1 gives guidance on both how to select the most suitable technique and monitor, and on the use of online instruments.

Reporting fluid cleanliness
A convenient and preferred method of reporting the data from the above techniques is to convert the particle numbers into broad codes, as described in BS ISO 4406. The interval between each code is effectively a doubling of contamination.

The code is constructed from the combination of three range numbers selected from the following table to describe the numbers of particles at that size.

Changes to certain ISO standards have resulted in differences in the labelling of sizes used in different techniques. These are described in BS ISO/TR 16386. For Automatic Particle Counters (APCs) the sizes are 4/6/14 µm(c), e.g. ISO 17/15/12 (note that 'µm(c)' refers to APCs calibrated to BS ISO 11171 or 11943). If the APC cannot count at the 4 µm(c) size, a hyphen ("-") is used in place of the first code to signify this. Likewise, if the technique used does not include this size or it is not applicable, the other two sizes 6 and 14 µm (monitors) or 5 and 15 µm (microscopic techniques) are used. A typical code is ISO -/15/12. The last two sizes in both code formats are roughly comparable with each other.

Cleanliness management
Essential points:
- The system should be correctly designed to achieve and maintain the TCL.
- Inspect filters regularly for signs of blockage and replace when indicating blockage.
- Filter oil into the system.
- Monitor the fluid cleanliness on a regular basis.
- Promptly implement corrective actions if the TCL is exceeded to limit damage to components.
- Have specifications for both fluid cleanliness (TCL) and filters.
- Educate personnel involved with the process on the need and benefits of cleanliness.

Number of particles per millilitre		
More than	Up to and including	Scale number
40000	80000	23
20000	40000	22
10000	20000	21
5000	10000	20
2500	5000	19
1300	2500	18
640	1300	17
320	640	16
160	320	15
80	160	14
40	80	13
20	40	12
10	20	11
5	10	10
2.5	5	9
1.3	2.5	8
0.64	1.3	7
0.32	0.64	6
0.16	0.32	5
0.08	0.16	4
0.04	0.08	3
0.02	0.04	2
0.01	0.02	1