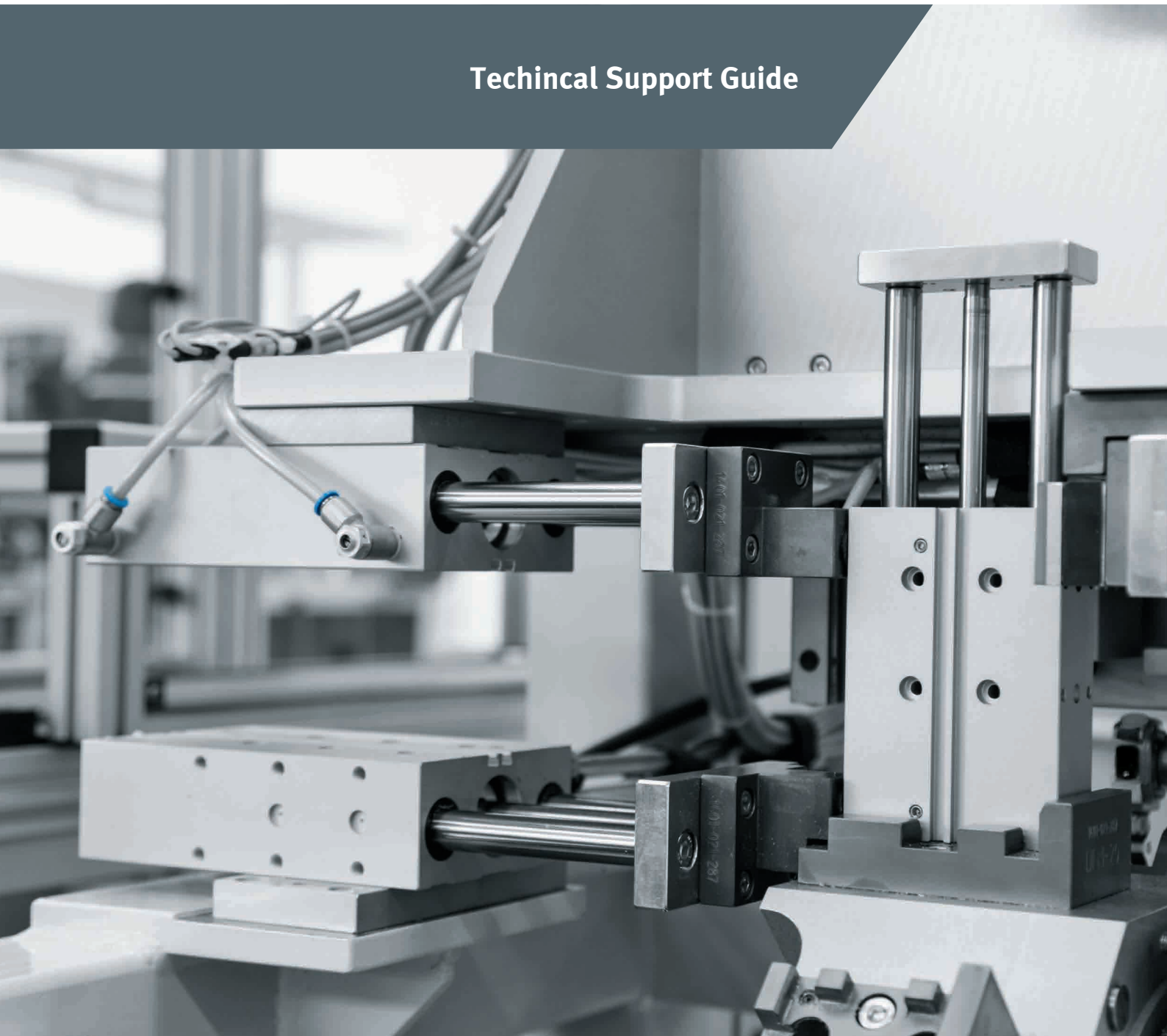


**FESTO**

**Technical Support Guide**



Your partner for factory and process automation

### Unit Conversion

Imperial to Metric			
inches (in)	x	25.400	= millimeters (mm)
feet (ft)	x	0.305	= meters (m)
yards (yds)	x	0.914	= meters (m)
miles (mi)	x	1.609	= kilometers (km)
sq. inch (in <sup>2</sup> )	x	6.451	= sq. centimeters (cm <sup>2</sup> )
sq. feet (ft <sup>2</sup> )	x	0.093	= sq. meters (m <sup>2</sup> )
sq. yards (yd <sup>2</sup> )	x	0.835	= sq. meters (m <sup>2</sup> )
cu. in (in <sup>3</sup> )	x	16.387	= cu. centimeters (cm <sup>3</sup> )
cu. ft (ft <sup>3</sup> )	x	0.028	= cu. meters (m <sup>3</sup> )
cu. yd (yd <sup>3</sup> )	x	0.764	= cu. meters (m <sup>3</sup> )
quart (qt)	x	0.946	= litres (l)
gallon (gal)	x	3.785	= litres (l)
ounce (oz)	x	28.349	= grams (g)
pound (lb)	x	0.453	= kilograms (kg)
horsepower (hp)	x	0.745	= kilowatts (kW)
feet per second (ft/s)	x	0.305	= meters per second (m/s)
ounce-force (ozf)	x	0.278	= newtons (N)
pound-force (lbf)	x	4.448	= newtons (N)
foot pounds (ft.lb)	x	1.355	= newton-meters (Nm)
foot pounds (ft.lb)	x	1.355	= joules (J)
in. pounds (in.lb)	x	0.112	= newton-meters (Nm)
lb per foot (lb/ft)	x	14.59	= newton per meter (N/m)
cycles per sec (cps)	x	1.000	= hertz (Hz)

Metric to Imperial			
millimeters (mm)	x	0.039	= inches (in)
meters (m)	x	3.280	= feet (ft)
meters (m)	x	1.094	= yards (yds)
kilometers (km)	x	0.621	= miles (mi)
sq. centimeters (cm <sup>2</sup> )	x	0.155	= sq. inch (in <sup>2</sup> )
sq. meters (m <sup>2</sup> )	x	10.750	= sq. feet (ft <sup>2</sup> )
sq. meters (m <sup>2</sup> )	x	1.197	= sq. yards (yd <sup>2</sup> )
cu. centimeters (cm <sup>3</sup> )	x	0.061	= cu. in (in <sup>3</sup> )
cu. meters (m <sup>3</sup> )	x	35.245	= cu. ft (ft <sup>3</sup> )
cu. meters (m <sup>3</sup> )	x	1.310	= cu. yd (yd <sup>3</sup> )
litres (l)	x	1.056	= quart (qt)
litres (l)	x	0.264	= gallon (gal)
grams (g)	x	0.035	= ounce (oz)
kilograms (kg)	x	2.205	= pound (lb)
kilowatts (kW)	x	1.341	= horsepower (hp)
meters per second (m/s)	x	3.280	= feet per second (ft/s)
newtons (N)	x	3.597	= ounce-force (ozf)
newtons (N)	x	0.225	= pound-force (lbf)
newton-meters (Nm)	x	0.738	= foot pounds (ft.lb)
joules (J)	x	0.738	= foot pounds (ft.lb)
newton-meters (Nm)	x	8.850	= in. pounds (in.lb)
newton per meter (N/m)	x	0.068	= lb per foot (lb/ft)
hertz (Hz)	x	1.000	= cycles per sec (cps)

### Dimension Conversion

Inch	Decimal	mm	mm	Inch
1/32	0.0313	0.7938	1.0	0.03937
1/16	0.0625	1.5875	2.0	0.07874
3/32	0.0938	2.3813	3.0	0.11811
1/8	0.1250	3.1750	4.0	0.15748
5/32	0.1563	3.9688	5.0	0.19685
3/16	0.1875	4.7625	6.0	0.23622
7/32	0.2188	5.5563	7.0	0.27559
1/4	0.2500	6.3500	8.0	0.31496
9/32	0.2813	7.1438	9.0	0.35433
5/16	0.3125	7.9375	10.0	0.3937
11/32	0.3438	8.7313	11.0	0.43307
3/8	0.3750	9.5250	12.0	0.47244
13/32	0.4063	10.3188	13.0	0.51181
7/16	0.4375	11.1125	14.0	0.55118
15/32	0.4688	11.9063	15.0	0.59055
1/2	0.5000	12.7000	16.0	0.62992
17/32	0.5313	13.4938	17.0	0.66929
9/16	0.5625	14.2875	18.0	0.70866
19/32	0.5938	15.0813	19.0	0.74803
5/8	0.6250	15.8750	20.0	0.7874
21/32	0.6563	16.6688	21.0	0.82677
11/16	0.6875	17.4625	22.0	0.86614
23/32	0.7188	18.2563	23.0	0.90551
3/4	0.7500	19.0500	24.0	0.94488
25/32	0.7813	19.8438	25.0	0.98425
13/16	0.8125	20.6375		
27/32	0.8438	21.4313		
7/8	0.8750	22.2250		
29/32	0.9063	23.0188		
15/16	0.9375	23.8125		
31/32	0.9688	24.6063		
1	1.0000	25.4000		

**Note:**  
 1" = 25.4 mm  
 1mm = 0.03937"

### Pressure Conversion

psi	bar	MPa	kPa	bar	psi
1	0.0689	0.0069	6.90	1	14.5
5	0.3445	0.0345	34.48	2	29.0
10	0.6890	0.0690	68.95	3	43.5
15	1.0335	0.1035	103.43	4	58.1
20	1.3780	0.1380	137.90	5	72.6
25	1.7225	0.1725	172.38	6	87.1
30	2.0670	0.2070	206.85	7	101.6
35	2.4115	0.2415	241.33	8	116.1
40	2.7560	0.2760	275.80	9	130.6
45	3.1005	0.3105	310.28	10	145.1
50	3.4450	0.3450	344.75	11	159.7
55	3.7895	0.3795	379.23	12	174.2
60	4.1340	0.4140	413.70	13	188.7
65	4.4785	0.4485	448.18	14	203.2
70	4.8230	0.4830	482.65	15	217.7
75	5.1675	0.5175	517.13		
80	5.5120	0.5520	551.60		
85	5.8565	0.5865	586.08		
90	6.2010	0.6210	620.55		
95	6.5455	0.6555	655.03		
100	6.8900	0.6900	689.50		
150	10.3350	1.0350	1034.25		
200	13.7800	1.3800	1379.00		
250	17.2250	1.7250	1723.75		
300	20.6700	2.0700	2068.50		

**Note:**  
 1 psi = 0.0689 bar  
 1 bar = 14.5137 psi  
 1 psi = 0.0069 MPa  
 1 psi = 6.90 kPa



## Torque Conversion

kpm	Nm	lb.in	kpm	Nm	lb.in	kpm	Nm	lb.in	kpm	Nm	lb.in
0.01	0.10	0.87	2.50	24.53	217.78	6.00	58.86	522.66	9.50	93.20	827.55
0.05	0.49	4.36	3.00	29.43	261.33	6.50	63.77	566.22	10.00	98.10	871.10
0.10	0.98	8.71	3.50	34.34	304.89	7.00	68.67	609.77	12.00	117.72	1045.32
0.50	4.91	43.56	4.00	39.24	348.44	7.50	73.58	653.33	15.00	147.15	1306.65
1.00	9.81	87.11	4.50	44.15	392.00	8.00	78.48	696.88	20.00	196.20	1742.20
1.50	14.72	130.67	5.00	49.05	435.55	8.50	83.39	740.44	30.00	294.30	2613.30
2.00	19.62	174.22	5.50	53.96	479.11	9.00	88.29	783.99	40.00	392.40	3484.40

**Note:**

1.0 kpm = 9.81 Nm  
 1 Nm = 8.8810 lb.in  
 1.0 lb.in. = 0.1126 Nm

## Air Flow Conversion

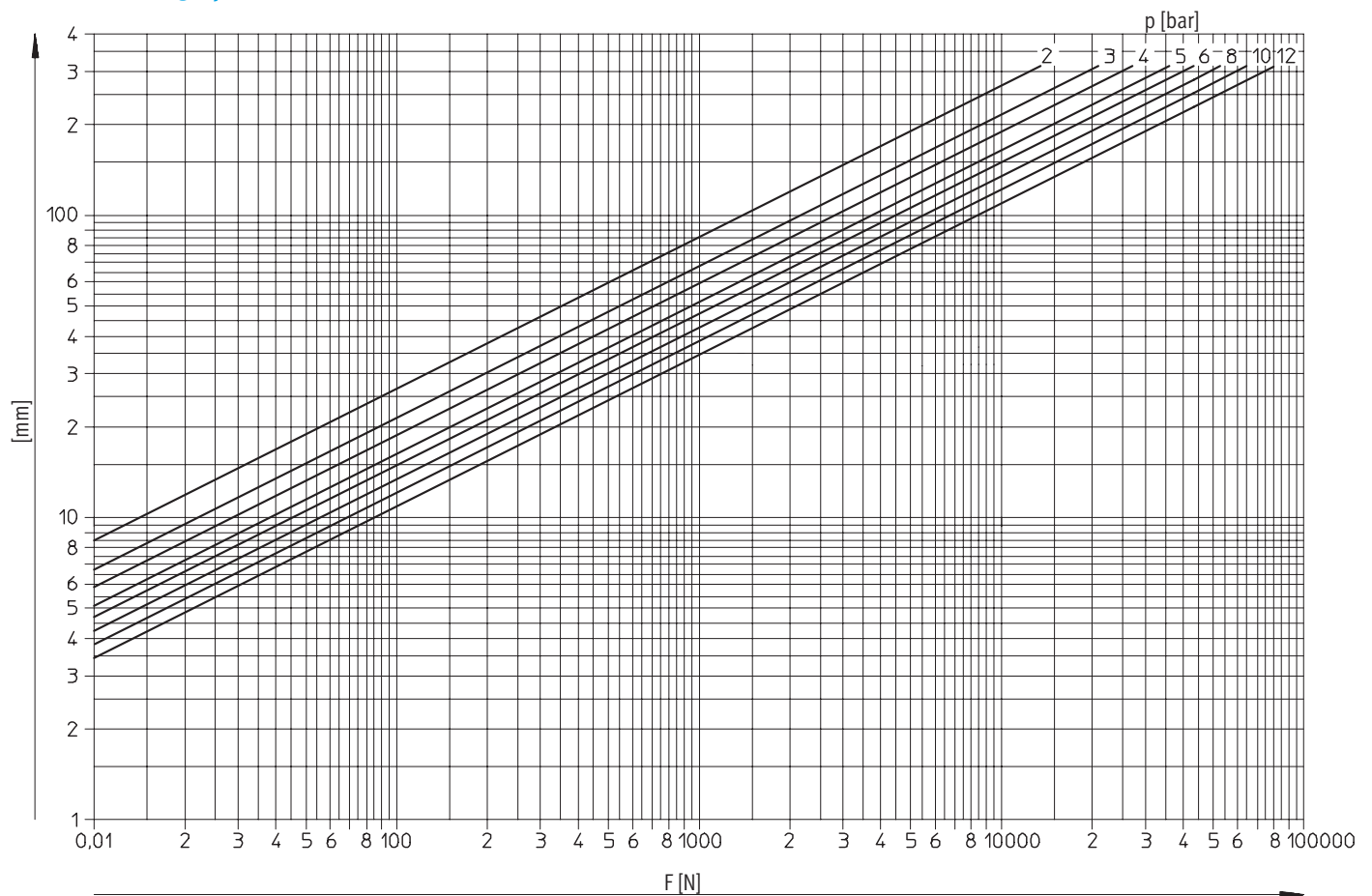
l/min	scfm	Cv	l/min	scfm	Cv	l/min	scfm	Cv	l/min	scfm	Cv
10	0.4	0.01	330	11.7	0.33	1000	35.3	1.00	5500	194.2	5.50
28	1.0	0.03	400	14.1	0.40	1200	42.4	1.20	6000	211.9	6.00
50	1.8	0.05	450	15.9	0.45	1500	53.0	1.50	6500	229.6	6.50
80	2.8	0.08	500	17.7	0.50	1750	61.8	1.75	7000	247.2	7.00
100	3.5	0.10	550	19.4	0.55	2000	70.6	2.00	7500	264.9	7.50
120	4.2	0.12	600	21.2	0.60	2500	88.3	2.50	8000	282.5	8.00
150	5.3	0.15	650	23.0	0.65	3000	105.9	3.00	8500	300.2	8.50
180	6.4	0.18	700	24.7	0.70	3500	123.6	3.50	9000	317.8	9.00
200	7.1	0.20	750	26.5	0.75	4000	141.3	4.00	9500	335.5	9.50
250	8.8	0.25	800	28.3	0.80	4500	158.9	4.50	10000	353.2	10.00
300	10.6	0.30	900	31.8	0.90	5000	176.6	5.00	10500	370.8	10.50

**Note:**

1.0 l/min = 0.0353 scfm  
 1.0 l/min = 0.001 Cv  
 1 scfm = 28 l/min  
 1 Cv = 1000 l/min



## Pressure/force graph



## Example on how to use this graph

Given:

- Load: 800 N
- System pressure: 6 bar

To be calculated:

- Required piston diameter
- Operating pressure to be set

## Procedure

From  $F = 800$  N go vertically upwards to the point of intersection with the 6 bar line. The next largest piston diameter, 50 mm, lies between the lines for 4 and 5 bar, which means that the operating pressure should be set to approx. 4.5 bar.

## Pressure/force table

Piston Diameter		bar	1	2	3	4	5	6	7	8	9	10
mm	Inch	psi	14.5	29.0	43.5	58.0	72.5	87.0	101.5	116.0	130.5	145.0
6	1/4"	N	2.5	5.1	7.6	10.2	12.7	15.3	17.8	20.4	22.9	25.4
		lbs.	0.6	1.1	1.7	2.3	2.8	3.4	4.0	4.6	5.1	5.7
8	5/16"	N	4.5	9.0	13.6	18.1	22.6	27.1	31.7	36.2	40.7	45.2
		lbs.	1.0	2.0	3.1	4.1	5.1	6.1	7.2	8.2	9.2	10.2
10	3/8"	N	7.1	14.1	21.2	28.3	35.3	42.4	49.5	56.5	63.6	70.7
		lbs.	1.6	3.2	4.8	6.4	8.0	9.6	11.2	12.8	14.4	16.0
12	1/2"	N	10.2	20.4	30.5	40.7	50.9	61	71.3	81.4	91.6	101
		lbs.	2.3	4.6	6.9	9.2	11.5	13.8	16.1	18.4	20.7	22.8
16	5/8"	N	18.1	36.2	54.3	72.4	90.5	109	127	145	163	181
		lbs.	4.1	8.2	12.3	16.4	20.5	24.6	28.7	32.8	36.9	40.9
20	3/4"	N	28.3	56.5	84.8	113	141	170	198	226	254	283
		lbs.	6	13	19	26	32	38	45	51	57	64
25	1"	N	44.2	88.4	133	177	221	265	309	353	398	442
		lbs.	10	20	30	40	50	60	70	80	90	100
32	1-1/4"	N	72.4	145	217	290	362	434	507	579	651	724
		lbs.	16	33	49	66	82	98	115	131	147	164
40	1-1/2"	N	113	226	339	452	565	679	792	905	1020	1130
		lbs.	26	51	77	102	128	154	179	205	231	255
50	2"	N	177	353	530	707	884	1060	1240	1410	1590	1770
		lbs.	40	80	120	160	200	240	280	319	360	400
63	2-1/2"	N	281	561	842	1120	1400	1680	1960	2240	2520	2810
		lbs.	64	127	190	253	317	380	443	506	570	635
80	3-1/4"	N	452	905	1360	1810	2260	2710	3170	3620	4070	4520
		lbs.	102	205	307	409	511	613	717	818	920	1022
100	4"	N	707	1410	2120	2830	3530	4240	4950	5650	6360	7070
		lbs.	160	319	479	640	798	959	1119	1277	1438	1599
125	5"	N	1100	2210	3310	4420	5520	6630	7730	8840	9940	11000
		lbs.	249	500	748	999	1248	1499	1748	1999	2247	2487
160	6"	N	1810	3620	5430	7240	9050	10900	12700	14500	16300	18100
		lbs.	409	818	1228	1637	2046	2465	2871	3278	3685	4092
200	8"	N	2830	5650	8480	11300	14100	17000	19800	22600	25400	28300
		lbs.	640	1277	1917	2555	3188	3844	4477	5110	5743	6399
250	10"	N	4420	8840	13300	17700	22100	26500	30900	35300	39800	44200
		lbs.	999	1999	3007	4002	4997	5992	6987	7981	8999	9994
320	12-1/2"	N	7240	14500	21700	29000	36200	43400	50700	57900	65100	72400
		lbs.	1637	3278	4906	6557	8185	9813	11463	13091	14719	16370

**Note:**

Typical plant operating pressure at the machine level on average will be around the 90 psi (or 6 bar) range

**Corrosion Resistance Classes CRC to Festo standard FN 940070**

CRC	Corrosion stress description	
0	No corrosion stress	Applies to small, optically irrelevant standard parts such as threaded pins, circlips and clamping sleeves which are usually only available in a phosphated or burnished version (and possibly oiled) as well as to ball bearings (for components < CRC 3) and plain bearings.
1	Low corrosion stress	For dry indoor applications or transport and storage protection. Also applies to parts behind covers, in the non-visible interior area, and parts which are covered in the application (e.g. drive trunnions).
2	Moderate corrosion stress	Indoor applications in which condensation may occur. External visible parts with primarily decorative requirements for the surface and which are in direct contact with the ambient atmosphere typical for industrial applications.
3	High corrosion stress	Outdoor exposure under moderate corrosive conditions. External visible parts with primarily functional requirements for the surface and which are in direct contact with a normal industrial environment.
4	Particularly high corrosion stress	Outdoor exposure under extreme corrosive conditions. Parts exposed to aggressive media, for instance in the chemical or food industries. These applications may need to be supported by special tests ( also FN 940082) using appropriate media.

**NEMA / IP Definitions**

The National Electrical Manufacturer Association (NEMA) uses a standard rating system that defines the types of environments in which an electrical enclosure can be used, and frequently signifies a fixed enclosure’s ability to withstand certain environmental conditions.

NEMA Rating	IP Equivalent	NEMA Definition	Digit 1 – IP Against Objects	Digit 2 – IP Against Liquids
1	IP10	Enclosures constructed for indoor use; to provide a degree of protection to personnel against incidental contact with the enclosed equipment and to provide a degree of protection against falling dirt	1 Protected against solid foreign objects of 5 cm (2 in) diameter and greater	0 Not protected
2	IP11	Enclosures constructed for indoor use; to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt, and to provide a degree of protection against dripping and light splashing of liquids	1 Protected against solid foreign objects of 5 cm (2 in) diameter and greater	1 Protected against vertically falling water drops
3	IP54	Enclosures constructed for indoor or outdoor use; to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt, rain, sleet, snow and windblown dust; and that will be undamaged by external formation of ice on the enclosure	5 Protected against dust; limited to ingress permitted (no harmful deposit)	4 Protected against water splashing from all directions; limited to ingress permitted
3R	IP14	Enclosures constructed for indoor or outdoor use; to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt, rain, sleet and snow; and that will be undamaged by external formation of ice on the enclosure	1 Protected against solid foreign objects of 5 cm (2 in) diameter and greater	4 Protected against water splashing from all directions; limited to ingress permitted
3S	IP54	Enclosures constructed for indoor or outdoor use; to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt, rain, sleet, snow and windblown dust; and in which the external mechanism(s) remain operable when ice laden	5 Protected against dust; limited to ingress permitted (no harmful deposit)	4 Protected against water splashing from all directions; limited to ingress permitted
4	IP56	Enclosures constructed for indoor or outdoor use; to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt, rain, sleet, snow, windblown dust, splashing water and hose-directed water; and that will be undamaged by external formation of ice on the enclosure	5 Protected against dust; limited to ingress permitted (no harmful deposit)	6 Protected against strong jets of water from all directions; limited to ingress permitted
4X	IP56	Enclosures constructed for indoor or outdoor use; to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt, rain, sleet, snow, windblown dust, splashing water and hose-directed water, and corrosion; and that will be undamaged by external formation of ice on the enclosure	5 Protected against dust; limited to ingress permitted (no harmful deposit)	6 Protected against strong jets of water from all directions; limited to ingress permitted
5	IP52	Enclosures constructed for indoor use; to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt; against settling airborne dust, lint, fibers and flyings; and to provide a degree of protection against dripping and light splashing of liquids	5 Protected against dust; limited to ingress permitted (no harmful deposit)	2 Protected against direct sprays of water up to 15° from the vertical
6	IP67	Enclosures constructed for indoor or outdoor use; to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt; against hose-directed water and the entry of water during occasional temporary submersion at a limited depth; and that will be undamaged by external formation of ice on the enclosure	6 Totally protected against entry of dust	7 Protected against effects of submersion from 15 cm (6 in) to 1 m (3 ft)
6P	IP68	Enclosures constructed for indoor or outdoor use; to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt; against hose-directed water and the entry of water during occasional prolonged submersion at a limited depth; and that will be undamaged by external formation of ice on the enclosure	6 Totally protected against entry of dust	8 Protected against the effects of occasional submersion in water, up to 10 m (33 ft)



## Purity classes for particles to ISO 8573-1:2010

Class	Maximum number of particles per m <sup>3</sup> as a function of particle size d		
	0.1 μm < d ≤ 0.5 μm	0.5 μm < d ≤ 1.0 μm	1.0 μm < d ≤ 5.0 μm
0	As stipulated by the user or supplier of the equipment, stricter requirements than class 1		
1	≤ 20,000	≤ 400	≤ 10
2	≤ 400,000	≤ 6000	≤ 100
3	Not specified	≤ 90,000	≤ 1000
4	Not specified	Not specified	≤ 10,000
5	Not specified	Not specified	≤ 100,000

Class	Mass concentration C <sub>p</sub> [mg/m <sup>3</sup> ]
6 <sup>1)</sup>	0 < C <sub>p</sub> ≤ 5
7 <sup>1)</sup>	5 < C <sub>p</sub> ≤ 10
x	C <sub>p</sub> > 10

1) Air cleaned using universal filters designed for particle sizes of 5 μm (class 6) and 40 μm (class 7) is normally used for the compressed air supply to industrial tools and pneumatic machines. These designs have been used for many years, before the latest systems for measuring particle sizes were developed, and have enabled satisfactory operation while minimising pressure (and therefore performance) losses. These filters are not 100% efficient; they offer an efficiency of at least 95% based on the specified particle size, i.e. for class 6, 95% of all particles of size 5 μm are filtered; for class 7, 95% of all particles of size 40 μm are filtered (measured as per ISO 12500-3).

## Purity classes for humidity and liquid water to ISO 8573-1:2010

Class	Pressure dew point [°C]
0	As stipulated by the user or supplier of the equipment, stricter requirements than class 1
1	≤ -70
2	≤ -40
3	≤ -20
4	≤ +3
5	≤ +7
6	≤ +10

Class	Concentration of liquid water C <sub>w</sub> [g/m <sup>3</sup> ]
7	C <sub>w</sub> ≤ 0.5
8	0.5 < C <sub>w</sub> ≤ 5
9	5 < C <sub>w</sub> ≤ 10
x	C <sub>w</sub> > 10

## Purity classes for total oil content to ISO 8573-1:2010

Class	Total concentration of oil (liquid, aerosol and vapour) [mg/m <sup>3</sup> ]
0	As stipulated by the user or supplier of the equipment, stricter requirements than class 1
1	≤ 0.01
2	≤ 0.1
3	≤ 1
4	≤ 5
x	> 5

## Compressed air quality in use

Designation to ISO 8573-1:2010  
[particle:water:oil]

The class that can be achieved with compressed air preparation depends on the

quality of the compressed air downstream of the compressor. The specifications

apply to typical compressed air systems (this list is not exhaustive).

Central air preparation		Air distribution	Decentralised air preparation		Typical applications
Component	Class	Class	Component	Class <sup>3)</sup>	
Compressor	[-:-:-]	[-:-:-]	Water separators	[-:7:4]	All applications where the compressed air must be virtually free from condensate. No defined particle filtering.
Compressor + pre-filter + air dryer	[7:4:4] <sup>1)</sup>	[-:4:-] <sup>2)</sup>	Filter, 40 µm	[7:4:4]	Operating medium for valves, cylinders, secondary packaging (standard)
			Filter, 5 µm	[6:4:4]	Servopneumatic positioning using proportional directional control valves, compressed air tools
			Filter, 5 + 1 µm	[5:4:3]	Applications with a residual oil content < 0.5 mg/m <sup>3</sup> , textile industry, pneumatic spinning machines, paper industry
			Filter, 5 + 1 + 0.01 µm	[1:4:2]	Applications with a residual oil content < 0.01 mg/m <sup>3</sup> , e.g. air bearings, painting, powder coating
			Filter, 5 + 1 + 0.01 µm + activated carbon filter	[1:4:1]	Applications with a residual oil content < 0.003 mg/m <sup>3</sup> , reduction of oil vapours and odours, optical instruments, sealing air for precision glass scales/lasers, primary packaging
			Filter, 5 + 1 + 0.01 µm + activated carbon filter + membrane air dryer	[1:3:1]	Semiconductor industry, pharmaceutical products
			Filter, 5 + 1 µm + adsorption dryer	[2:2:2]	Applications in the low-temperature range, dry process air, powder transportation, food production [1:2:1]

1) Much higher classes are possible with suitable air preparation downstream of the compressor.

2) Pipe systems can increase the particle content of the compressed air (chips, rust, etc.), liquid oil can accumulate in some lines of the compressed air distribution system. Specifications apply at normal room temperature. If parts in the compressed air system are subject to lower temperatures, the humidity class must be chosen so that the pressure dew point is 10 K below the minimum expected temperature.

3) Class to ISO 8573-1:2010 at room temperature (20°C).

## Port designations of pneumatic components to ISO 5599

	Using ISO 5599 numbers (5/2-way and 5/3-way valves)	Using letters <sup>1)</sup>
Supply port	1	P
Working ports	2	B
	4	A
Exhaust ports	3	S
	5	R
Pilot ports (signal)	10 <sup>2)</sup>	Z <sup>2)</sup>
	12	Y
	14	Z
Leakage lines		L

1) Still frequently used

2) Clears the output signal

