SAUER DANFOSS

Cartridge Valves Technical Information
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CARTRIDGE VALVE INTRODUCTION

Cartridge valves are compact and economical components that can be used for directional, pressure, or flow control in systems from 0.4 L/min [0.1 US gal/min] up to 400 l/min [100 gpm], and for pressures up to 350 bar [5000 psi]. By combining standard cartridge valves almost any hydraulic circuit can be easily created. Using cartridge valves in a custom manifold, a designer can create a hydraulic integrated circuit (HIC) that provides a compact package for hydraulic control with reduced plumbing, easier installation, easier service, and fewer leak points than traditional hydraulic systems.

Each valve has several key ratings, specifications, and settings:

- Each Sauer-Danfoss cartridge valve fits a Sauer-Danfoss standard **cavity**. These cavities are designed around SAE or metric standard o-ring straight thread ports. In many cases these cavities are interchangeable with cavities used by other manufacturers. See catalog sheets for details.

  The National Fluid Power Association (NFPA) and International Standards Organization (ISO) are developing a standard, NFPA T3.5.31M-19XX, that will define an industry-wide set of standard cavities. Sauer-Danfoss will manufacture cartridge valves for NFPA cavities upon formal approval of the standard.

- The **pressure rating** is based on NFPA fatigue test standards and a burst test at least 3:1 safety factor.

- The **flow rating** is based on the flow at a pressure drop of 7 bar [100 psi] for directional valves or a pressure rise or drop of 7 bar [100 psi] for pressure relief and reducing valves, with 32 mm^2/s (cSt) [151 SUS] fluid. Note that for many valves this flow can be exceeded if the penalties of higher pressure drop and the associated heat generation are acceptable. The exceptions to this are solenoid-operated spool-type directional valves and proportional flow control valves where the flow ratings indicate a performance limit.

- The **solenoid voltage** is a nominal value. All solenoid valves are designed to operate at 85% of nominal voltage with full rated flow and pressure and at an ambient temperature of 60 °C [140 °F].

- Pressure settings for check, relief, reducing, sequence, and motion control valves, commonly referred to as the **crack pressure**, are set at a flow rate of 0.95 L/min [0.25 gpm] through the valve.

- **Leakage** is generally measured at rated pressure limits or in the case of relief and motion control valves at 70-80% of crack pressure setting, with 32 mm^2/s (cSt) [151 SUS] fluid. See individual catalog sheets for details.

- **Temperature ratings** vary by model and options. Seal materials provide ranges of -40 °C to 100 °C [-40° F to 212 °F] (buna-n or polyurethane) or -26 °C to 204 °C [-15 °F to 400 °F] (viton). The recommended minimum fluid viscosity is 12 mm^2/s (cSt) [66 SUS] which will override the maximum seal temperature limit for most fluids. Solenoid valves are rated for 60 °C [140 °F] maximum *ambient* temperature for continuous duty. Consult factory for extreme applications.

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Fluid and filtration recommendations

FLUIDS

Ratings and performance data for cartridge valves are based on operating with premium hydraulic fluids containing oxidation, rust, and foam inhibitors.

These premium fluids include premium turbine oils, API CD engine oils per SAE J183, M2C33F or G automatic transmission fluids (ATF), Dexron II (ATF) meeting Allison C-3 or Caterpillar TO-2 requirements, and certain specialty agriculture tractor fluids. For further information see Sauer-Danfoss publication 520L0463, *Hydraulic Fluids and Lubricants*, and publication 520L0465, *Biodegradable Hydraulic Fluids Applications*.

CAUTION

Never mix hydraulic fluids.

Product performance will generally be within catalog limits with fluids meeting the recommended viscosity limits shown below.

Product can be operated at viscosities outside the recommended limits, however performance may be greatly degraded. Extreme conditions must be evaluated by the user to determine acceptibility of product performance.

Contact your Sauer-Danfoss representative for more information regarding fluids.

FILTRATION

It is imperative that only clean oil be used with cartridge valves to maintain valve operation and prevent premature wear. System filtration capable of controlling the fluid cleanliness to the limits shown below is required.

The selection of filters depends on a number of factors including the contamination ingression rate and the desired maintenance interval. Filters are selected to meet the below requirements using rating parameters of efficiency and capacity.

Filter efficiency may be measured using a Beta (β) ratio.* A filter with a β-ratio within the range of β_{10}=10 is typically required.

Since each system is unique, the filtration requirement for that system will be unique and must be determined by test in each case. It is essential that monitoring of prototypes and evaluation of components and performance throughout the test program be the final criteria for judging the adequacy of the filtration system. For further information see Sauer-Danfoss publication **520L467**, *Design Guidelines for Hydraulic Fluid Cleanliness Applications*.

Fluid specifications

Product	Cleanliness (per ISO 4406, 1999)	Recommended Viscosity limits mm²/sec (cSt) [SUS]	Absolute Viscosity limits mm²/sec (cSt) [SUS]
Proportional valves	18/17/13 or better	12-54 [66-250]	12-400 [66-1854]
Other spool valves	20/18/14 or better		
All other valves	20/19/14 or better		

* Filter β_x ratio is a measure of filter efficiency defined by ISO 4572. It is defined as the ratio of the number of particles greater than a given size (x) upstream of the filter to the number of particles greater than the same size downstream of the filter. The β_x ratio applies to a specific particle size, measured in microns.

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Standard pressure settings and adjustment options

STANDARD PRESSURE SETTINGS

The tables below detail coding for standard pressure settings. Use these tables for reference when filling in valve ordering options for valves with selectable pressure settings. Use the table on this page for valves that specify pressure in psi—typically those beginning with the letters CP. Use the table on the next page for valves that specify pressure in bar—typically those that do not begin with the letters CP.

Standard settings for valves set in psi

Crack Pressure (Code x 10 = psi)	Crack Pressure, psi [bar]
001	10 psi [0.69 bar]
002	20 psi [1.38 bar]
003	30 psi [2.07 bar]
004	40 psi [2.76 bar]
005	50 psi [3.45 bar]
006	60 psi [4.14 bar]
007	70 psi [4.83 bar]
008	80 psi [5.52 bar]
009	90 psi [6.21 bar]
010	100 psi [6.9 bar]
012	120 psi [8.28 bar]
014	140 psi [9.66 bar]
015	150 psi [10.34 bar]
016	160 psi [11.0 bar]
018	180 psi [12.4 bar]
020	200 psi [13.8 bar]
022	220 psi [15.2 bar]
024	240 psi [16.6 bar]
025	250 psi [17.2 bar]
026	260 psi [17.9 bar]
028	280 psi [19.3 bar]
030	300 psi [20.7 bar]
035	350 psi [24.1 bar]
040	400 psi [27.6 bar]
045	450 psi [31.0 bar]
050	500 psi [34.5 bar]
060	600 psi [41.4 bar]
070	700 psi [48.3 bar]
080	800 psi [55.2 bar]
090	900 psi [62.1 bar]
100	1000 psi [69.0 bar]
110	1100 psi [75.9 bar]
120	1200 psi [82.8 bar]
130	1300 psi [89.7 bar]
140	1400 psi [96.6 bar]

Crack Pressure (Code x 10 = psi)	Crack Pressure, psi [bar]
150	1500 psi [103 bar]
160	1600 psi [110 bar]
170	1700 psi [117 bar]
180	1800 psi [124 bar]
190	1900 psi [131 bar]
200	2000 psi [138 bar]
210	2100 psi [145 bar]
220	2200 psi [152 bar]
230	2300 psi [159 bar]
240	2400 psi [166 bar]
250	2500 psi [172 bar]
260	2600 psi [179 bar]
270	2700 psi [186 bar]
280	2800 psi [193 bar]
290	2900 psi [200 bar]
300	3000 psi [207 bar]
320	3200 psi [221 bar]
340	3400 psi [234 bar]
350	3500 psi [241 bar]
360	3600 psi [248 bar]
380	3800 psi [262 bar]
400	4000 psi [276 bar]
420	4200 psi [290 bar]
440	4400 psi [303 bar]
460	4600 psi [317 bar]
480	4800 psi [331 bar]
500	5000 psi [345 bar]
520	5200 psi [359 bar]
540	5400 psi [372 bar]
560	5600 psi [386 bar]
580	5800 psi [400 bar]
600	6000 psi [414 bar]
XXX	Pressure code stamped on valve; Pressure not set

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STANDARD PRESSURE SETTINGS (continued)

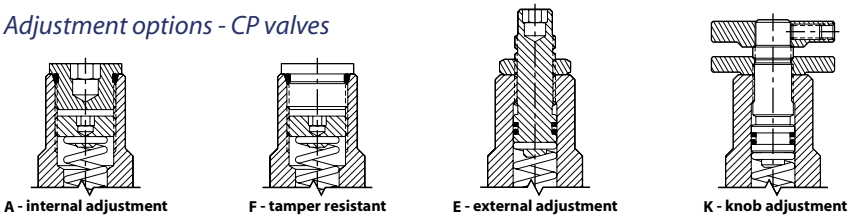
Standard settings for valves set in bar

Crack Pressure Code (bar)	Crack Pressure, bar [psi]
10	10 bar [145 psi]
15	15 bar [218 psi]
20	20 bar [290 psi]
25	25 bar [363 psi]
30	30 bar [435 psi]
35	35 bar [508 psi]
40	40 bar [580 psi]
45	45 bar [653 psi]
50	50 bar [725 psi]
55	55 bar [798 psi]
60	60 bar [870 psi]
65	65 bar [943 psi]
70	70 bar [1015 psi]
75	75 bar [1088 psi]
80	80 bar [1160 psi]
85	85 bar [1233 psi]
90	90 bar [1305 psi]
95	95 bar [1378 psi]
100	100 bar [1450 psi]
105	105 bar [1523 psi]
110	110 bar [1595 psi]
120	120 bar [1740 psi]
130	130 bar [1885 psi]

Crack Pressure Code (bar)	Crack Pressure, bar [psi]
140	140 bar [2030 psi]
150	150 bar [2175 psi]
160	160 bar [2320 psi]
170	170 bar [2465 psi]
180	180 bar [2610 psi]
190	190 bar [2755 psi]
200	200 bar [2900 psi]
210	210 bar [3045 psi]
220	220 bar [3190 psi]
230	230 bar [3335 psi]
240	240 bar [3480 psi]
250	250 bar [3625 psi]
260	260 bar [3770 psi]
270	270 bar [3915 psi]
280	280 bar [4060 psi]
290	290 bar [4205 psi]
300	300 bar [4350 psi]
310	310 bar [4495 psi]
320	320 bar [4640 psi]
330	330 bar [4785 psi]
340	340 bar [4930 psi]
350	350 bar [5075 psi]
XXX	Pressure code stamped on valve; Pressure not set

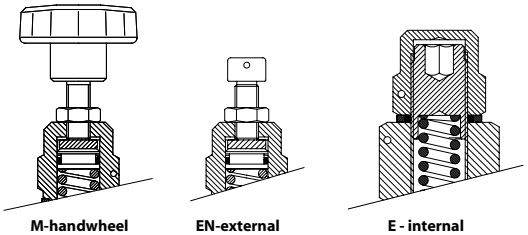
MECHANICAL VALVE ADJUSTMENT OPTIONS

Adjustment options - CP valves



A - internal adjustment | F - tamper resistant | E - external adjustment | K - knob adjustment

Adjustment options - other valves



M-handwheel | EN-external | E - internal

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Cartridge valve installation procedure

INSPECT THE VALVE BLOCK

Refer to specific pages within this catalog to ensure proper port identification for cartridge functions. Inspect the valve cavity to be sure it is free of burrs, chips or other contamination.

PREPARE CARTRIDGE FOR INSERTION INTO THE BLOCK

Check the cartridge to ensure it is free of external contamination, and the O-rings and back-up rings are intact. Dip the cartridge in clean oil to the top of the threads to lubricate the O-rings.

ASSEMBLY

Insert and screw the cartridge into its cavity by hand. It should turn easily up to the top O-ring. If it does not turn easily, the cavity has been machined improperly and the body should not be used.

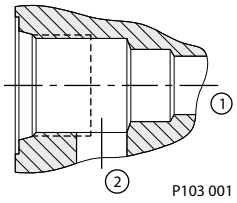
Torque all cartridges per specification shown on catalog sheet. Torque all coil nuts to 5-8 N•m [4-6 lbf•ft] unless otherwise specified.

TEST

Test the entire system to ensure that the cartridges are performing correctly and to check for leaks.

CAVITY PORT IDENTIFICATION

Cavity 2 way



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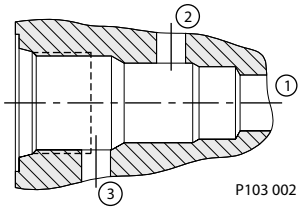
Cavity 3 way



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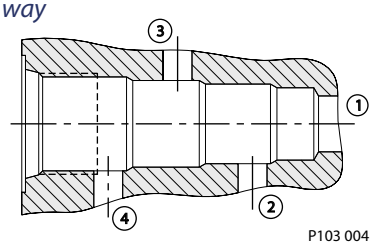
Cavity 4 way



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Cartridge Valves Technical Information
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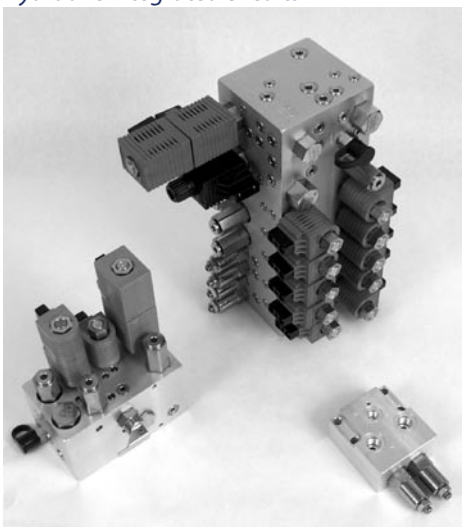
Hydraulic integrated circuits

DESCRIPTION

Cartridge valves can be installed in custom designed manifolds to create a **H**ydraulic **I**ntegrated **C**ircuit (**HIC**). HICs provide many advantages over traditional hydraulic control systems:

Hydraulic integrated circuits



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- HICs are compact packages that simplify machine plumbing.
- Costs for fittings, tubes, hoses, and seals are dramatically reduced.
- Installation costs are dramatically reduced.
- Leak points are eliminated.
- Service time and costs are dramatically reduced. Components can be replaced without disturbing machine plumbing.
- HICs can be centralized on a machine or strategically located. Using a custom HIC provides the designer unlimited flexibility to optimize machines for assembly, plumbing, wiring, service, and weight distribution.

Sauer-Danfoss designs and manufactures the highest quality custom HICs in the world.

DESIGN CAPABILITIES

A custom HIC can be designed to your circuit requirements. Contact your Sauer-Danfoss representative for circuit design consultation.

State of the art CAD design

F102 019

- Manifolds are designed using the most advanced 3-D solid modeling CAD software.
- Advanced quality planning concepts are used throughout the design stage including product and process failure mode and effects analysis and design for manufacturability. A pre-production approval process is followed and initial sample inspection reports are used for first production pieces. Statistical process control is used to control critical features. Control plans and gauge reliability and repeatability programs are used to ensure continued quality.
- Industry-leading rapid prototyping is available to support your test program requirements. Most prototype manifolds can be delivered to meet your schedule requirements.

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PRODUCTION CAPABILITIES

- Manifolds are machined from 6061-T6 or 2011 aluminum (for pressures to 210 bar [3,000 psi]), 7075-T6 aluminum (pressures to 240 bar [3,500 psi]), or ductile iron (pressures to 480 bar [7,000 psi]).
- State-of-the art flexible CNC machining centers are used to maintain the highest quality standards.
- All manifolds go through extensive deburring and cleaning operations.

Machining a manifold

F102 001

- Aluminum manifolds can be finished with clear or color anodizing on request for added cleanliness, enhanced corrosion resistance, and improved appearance.
- Steel and ductile iron manifolds are zinc plated.

Clear plastic training aid

P103 228

- All HICs are 100% tested on automated computerized test stands. Performance requirements and test specifications are often unique for each custom HIC and are agreed to by Sauer-Danfoss and the customer prior to production.
- HICs can be supplied with hydraulic fittings installed on request.
- HICs can be supplied with custom electrical wire harnesses on request. These can be designed for HICs with two or more solenoids to provide the end-user with a one-point electrical connection to reduce assembly time and eliminate potential wiring mistakes.
- All HICs are identified with a Sauer-Danfoss part number and manufacturing date code. HICs can be identified with customer specified part numbers, logos, etc., on request.