

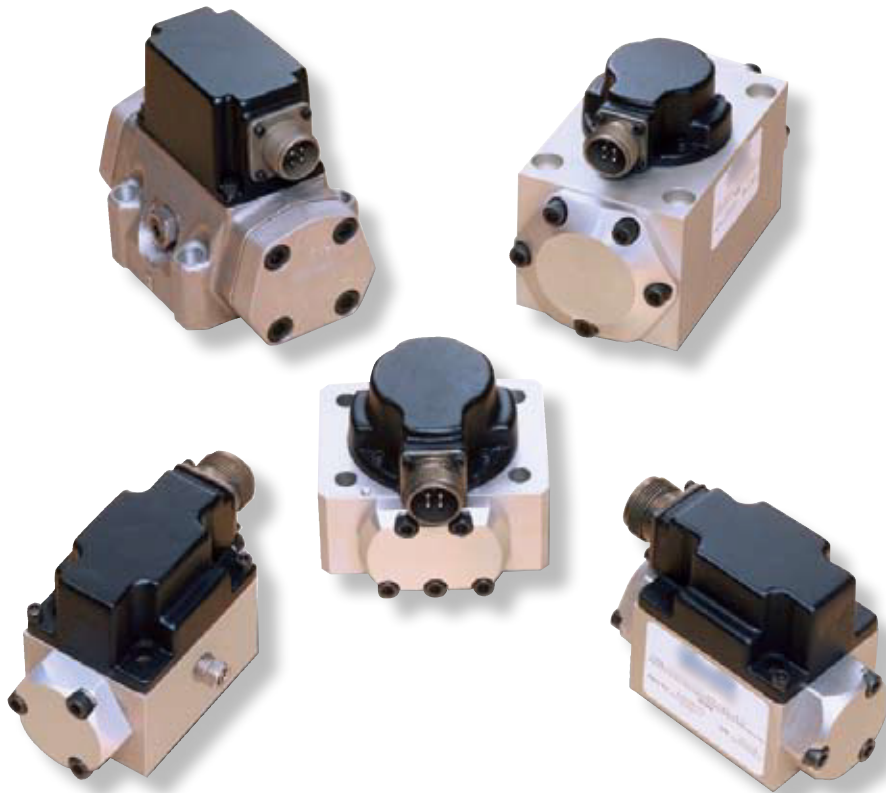
Vickers® by Danfoss  
SM4-20 Servo Valves  
Technical Information

Flows to  
76 l/min  
(20 USgpm) –

Pressures  
to 210 bar  
(3000 psi)

BC447083454306en-000101

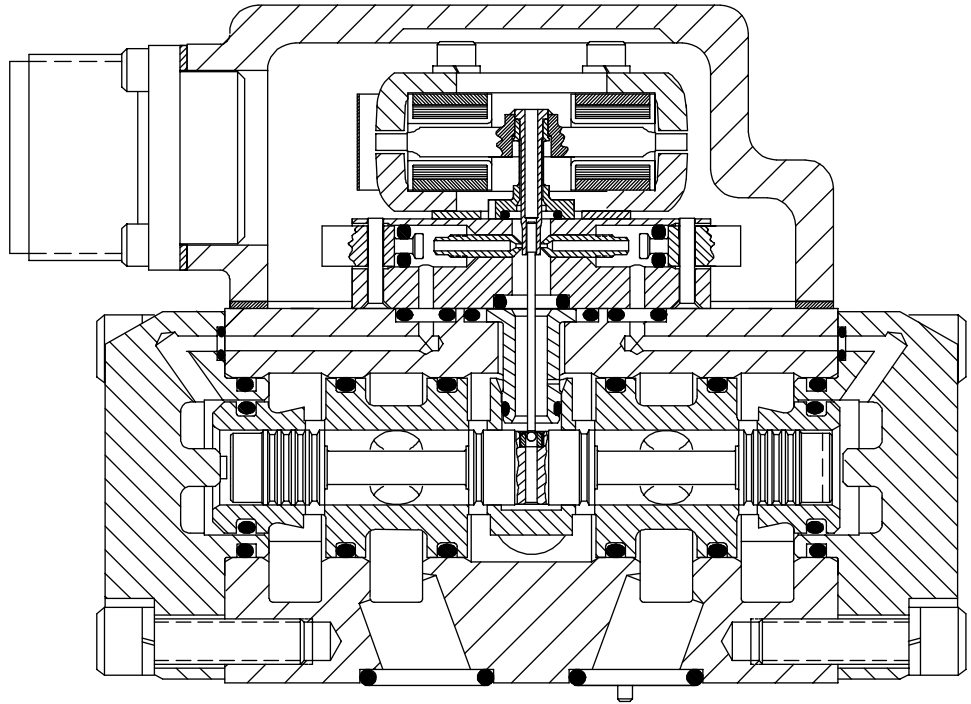
ENGINEERING  
TOMORROW



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Cross Section of  
Typical SM4-20  
Servovalve



# Introduction

Vickers by Danfoss SM4-20 servo valves can provide system closed loop control with exact positional accuracy, repeatable velocity profiles, and predictable force or torque regulation.

Typical applications include plastic injection molding and blow molding systems, test and simulation equipment, die casting machines, hydraulic press brakes, animation and entertainment equipment, oil exploration vehicles, and lumber machinery.

This model of the high performance SM4 series offers a wide range of rated flows from 3,8 to 76 l/min (1.0 to 20 US-gpm) at  $\Delta p$  of 70 bar (1000 psi).

The SM4 is a two-stage, modular design, flow control valve which can be manifold or subplate mounted. The

symmetrical, dual coil, quad air gap torque motor is integrally mounted to the first stage nozzle flapper pilot valve with six screws. The second stage utilizes a four-way sliding spool and sleeve arrangement with a mechanical null adjust. Spool position is fed back to the first stage by means of a cantilever spring. An integral 35 micron (absolute) filter reduces sensitivity to contamination of the first stage.

An SM4 servo valve, when used with a hydraulic cylinder, position transducer, and appropriate electronics, can provide infinite cylinder position control to within 0,025 mm (0.001 in) or better, depending on the components selected, length of stroke, and load characteristics.

When applied with servo hydraulic motors using tachometer feedback and appropriate electronics, the SM4 provides infinite proportional flow control for real-time velocity/acceleration profiles. The resulting closed loop system can be error corrected to within one-tenth of a revolution per minute. With appropriate pressure transducers or load cells in force control applications, the SM4 makes possible exact load pressure/force control. In addition, excellent system stability with pressure and load to  $\pm 1\%$  full scale can be achieved.

The field-proven design of the SM4-20 servo valve, combined with Vickers by Danfoss precision manufacturing techniques, provides you with the optimum in system control.

## Features and Benefits

- The wide range of SM4-20 flow capabilities allows selection of the valve size best suited for an application.
- The high strength aluminum alloy of the second stage valve body means lighter weight with rugged durability.
- The symmetrical, dual-coil, quad air gap, dry torque motor, with its extremely fast response to input signals, results in highly accurate control profiles.
- Higher frequency response is available on request to provide enhanced system bandwidth for critical performance requirements.
- An integral 35 micron (absolute) filter provides extra first stage contamination protection.
- The spool and sleeve are hardened stainless steel to minimize wear and erosion. The O-ring mounted sleeve eliminates spool binding and ensures smooth operation.
- Customized spool lap and sleeve porting are available to provide the specific flow control required for special applications.
- The SM4's symmetrical design provides inherently dependable metering of control flow with minimum null shifts. The result is more consistent machine operation.
- DuPont Viton® seals are standard.
- The flexibility of a standardized port circle and mounting pattern, with available adapter manifolds, makes Vickers by Danfoss SM4-20 servo valves a cost-effective choice for replacing existing servo valves and enhancing system performance.
- The SM4-20 features a simple interface to an available dual filter module that provides extra protection against pilot stage contamination.
- Flushing valves are available that can greatly reduce initial system contamination levels prior to SM4 installation.

# Operating Data

## Flow and Leakage

All data is typical, based on actual tests at 70 bar (1000 psi)  $\Delta p$ , 30 cST (141 SUS), and 49°C (120°F).

MODEL SERIES	MAXIMUM RATED FLOW $\pm 10\%$	MAXIMUM TOTAL NULL LEAKAGE	MAXIMUM PILOT FLOW AT 70 BAR (1000 PSI) $\Delta P$
	l/min (USgpm)	l/min (USgpm)	l/min (USgpm)
SM4-20	76 (20)	2,0 (0.52)	0,35 (0.092)

## PERFORMANCE

<b>Maximum Supply Pressure</b>		
bar (psi)	SM4-20:	210 (3000)*
<b>Minimum Supply Pressure</b>		
bar (psi)		14 (200)
<b>Proof Pressure</b>		At Supply Port: 150
% maximum supply pressure		At Return Port: 100
<b>Burst Pressure, Return Port Open</b>		
% maximum supply pressure		250
<b>Maximum Operating Temperature</b>		
°C (°F)		135 (275)
<b>Hysteresis Around Null</b>		
% of rated current		$\leq 3$
<b>Symmetry Error</b>		
% of rated current		<10
<b>Linearity Error</b>		
% of rated current		<10
<b>Threshold</b>		
% of rated current		$\leq 0.5$

\* SM4-20 (-50 design) features maximum supply pressure of 350 bar (5000 psi). See publication 662 for details.

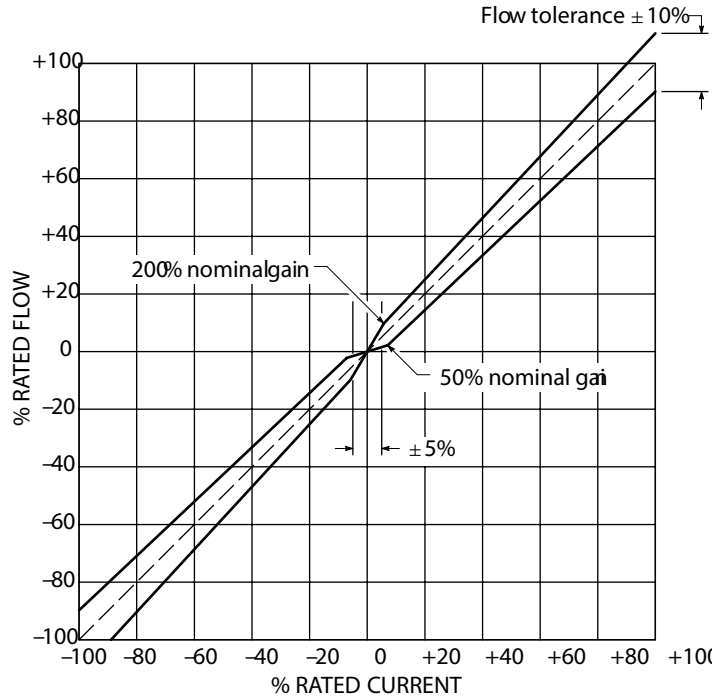
## RUGGEDNESS TEST RESULTS

<b>Vibration Test</b>	
5 Hz to 2000 Hz along each axis	No damage to components
<b>Shock Test</b>	
Up to 150g along all axes	No damage to components
<b>Endurance Test</b>	
To ISO 6404	No degradation in performance

# Operating Data

## Flow Gain

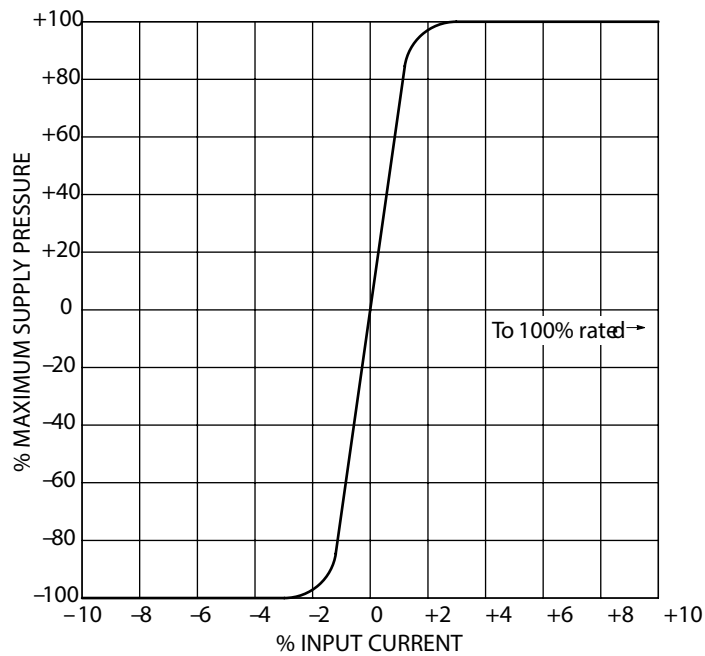
Normal region for standard models shown with typical no-load flow gain tolerances excluding hysteresis.



## Pressure Gain

Change in load pressure drop with input current shown with no valve flow and closed control ports.

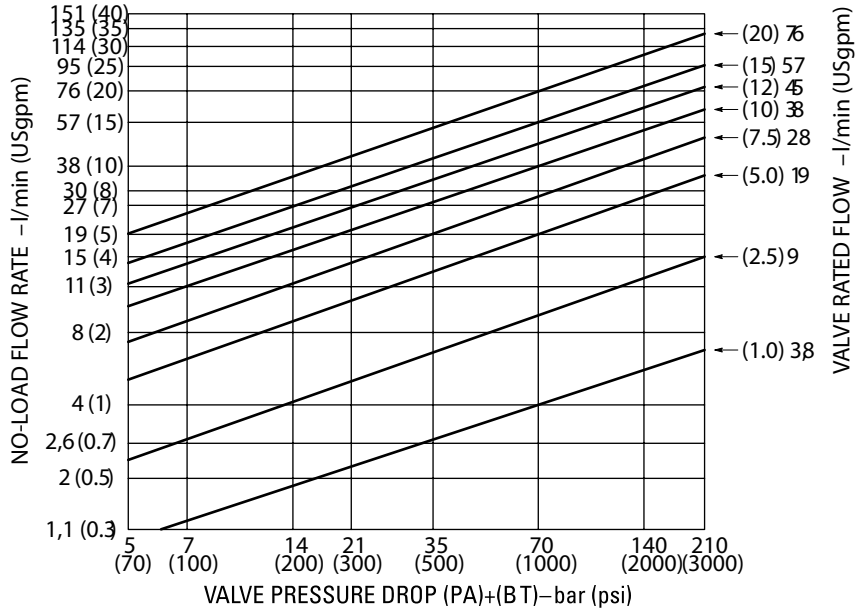
Pressure gain in the null region is  $>30\%$  of supply pressure per 1% of rated current.



# Operating Data

## Change in Rated Flow

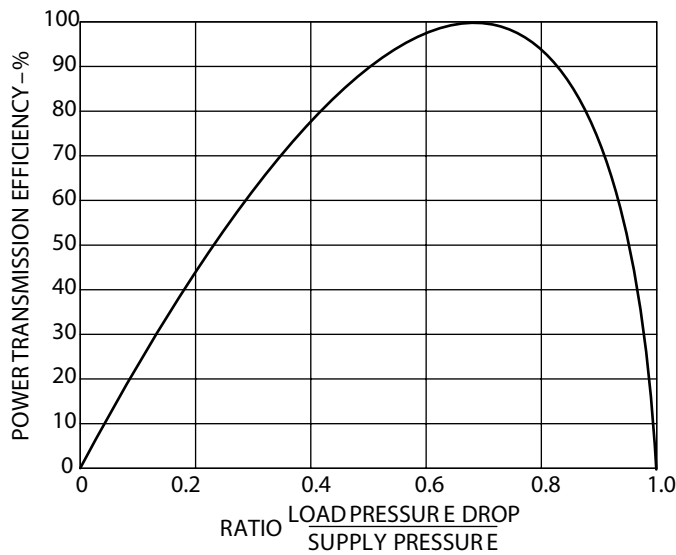
Rated flows at valve pressure drops from 5 bar (70 psi) to 210 bar (3000 psi) for eight of the available spools.



## Power Transmission Efficiency

Maximum power envelope expressed as a percentage with T port pressure equal to 0 bar.

Power transferred to the load is optimum when valve pressure drop is one third of supply pressure. Load pressure drop should be limited to 2/3 of supply pressure so the flow gain of the servovalve remains high enough to maintain control of the load. Overall hydraulic efficiency must be considered when sizing system heat exchangers.



# Operating Data

## Coil Resistance

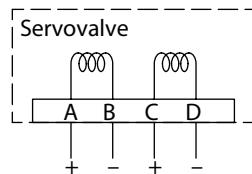
Select coil resistance and connections for compatible interface to servo electronics. Recommended coil resistance is shown in bold print.

	Nominal Resistance Per Coil at 21°C (70°F) Ohms	Rated Current mA	
		Single, Parallel, or Differential Connection	Series Connection
Standard coil resistance selection	20	200	100
	30	100	50
	80	40	20
	<b>200</b>	20	10
Optional coil resistance selection	80	50	25
	140	40	20
	200	15	7.5
	300	30	15
	1000	10	5
	1500	8	4

## Electrical Polarity for Control Flow Out of B Port

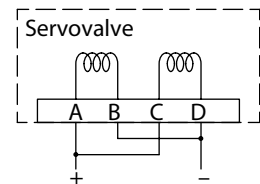
### Single:

A+, B-  
or  
C+, D-



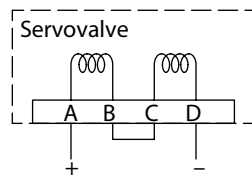
### Parallel:

A+, C+  
B-, D-  
Connect A and C  
Connect B and D



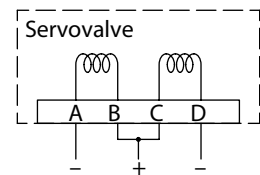
### Series:

A+, D-  
Connect B and C



### Differential:

A-, D-  
B+, C+  
Connect B and C  
BC-, current BA > CD  
BC+, current CD > BA



# Performance Curves

## Frequency Response

Frequency response is defined as the relationship of no-load control flow to input current with a sinusoidal current sweep at constant amplitude over a range of frequencies. It is expressed in frequency (Hz), amplitude ratio (dB), and phase angle (degrees).

As shown in the sample curve (below left), standard comparison points for servo-valve frequency response are those frequencies at which -3 dB amplitude ratio and 90° phase angle occur.

Vickers by Danfoss SM4 torque motors are magnetically stabilized for reliable servo valve performance at operating pressures from 14 to 210 bar (200 to 3000 psi).

## Calculating Frequency Response at System Pressure

$P_s$  = System pressure

$P_M$  = Maximum supply pressure of valve: 210 bar (3000 psi) for SM4-20 (-10 design)

$f_{PM}$  = Frequency (at 90° phase angle) at maximum supply pressure ( $P_M$ )

$f_{PS}$  = Frequency (at 90° phase angle) at system pressure ( $P_s$ )

1. Calculate the ratio of system pressure to maximum supply pressure:

$$\frac{P_s}{P_M}$$

2. Use the result of step 1 and the curve below to estimate

$$\frac{f_{PS}}{f_{PM}}$$

3. Use the applicable frequency response curve from page 7 to estimate  $f_{PM}$  (the maximum supply pressure frequency response at 90° phase angle) for the desired valve rated flow.

4. Multiply the values obtained in steps 2 and 3. The result is  $f_{PS}$  (system pressure frequency response at 90° phase angle).

**Example:** A standard performance SM4-20 valve with a flow of 38 l/min (10 USgpm) is to be used at 165 bar (2400 psi).

1. Calculate the ratio of system pressure to maximum supply pressure:

$$\frac{P_s}{P_M} = \frac{2400 \text{ psi}}{3000 \text{ psi}} = 0.8$$

2. Use the result of step 1 and the curve below right to estimate

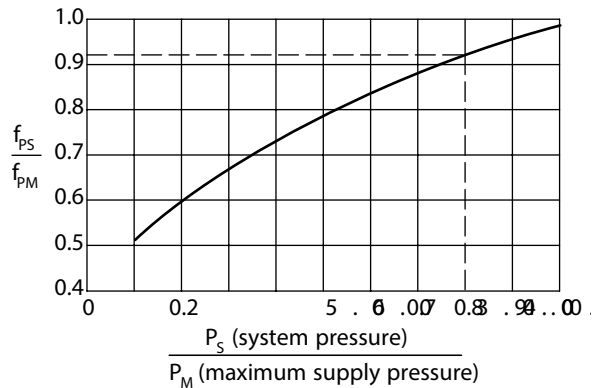
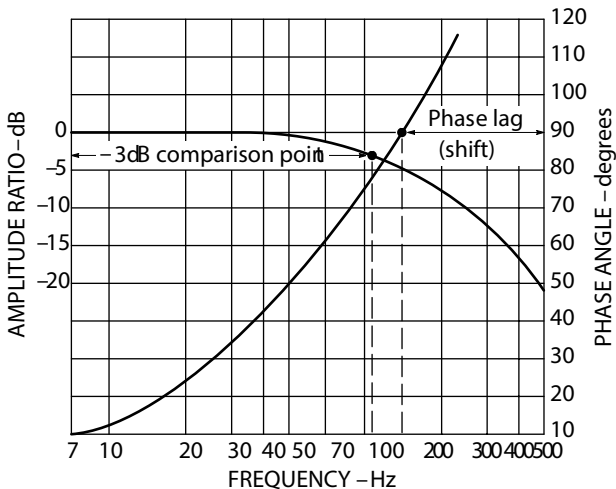
$$\frac{f_{PS}}{f_{PM}} = 0.92$$

3. Use the frequency response curve from page 7 to estimate  $f_{PM}$ .

$$f_{PM} = 100 \text{ Hz}$$

4. Multiply the values obtained in steps 2 and 3. The result is  $f_{PS}$  (system pressure frequency response at 90° phase angle).

$$f_{PS} = 0.92 \times 100 \text{ Hz} = 92 \text{ Hz}$$





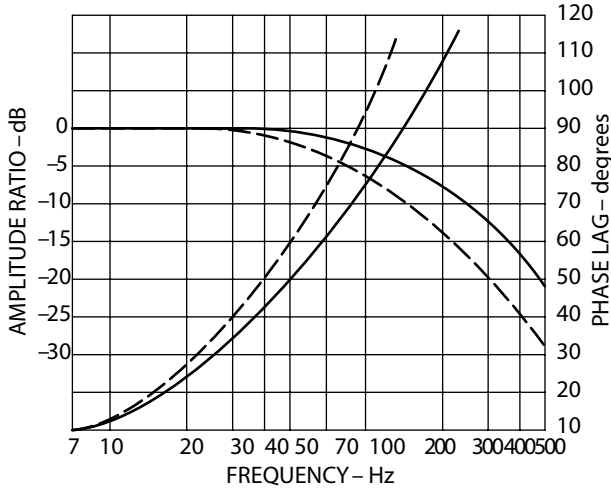
# Performance Curves

## Typical Frequency Response Curves

SM4-20 (-10 design) shown at 210 bar (3000 psi)

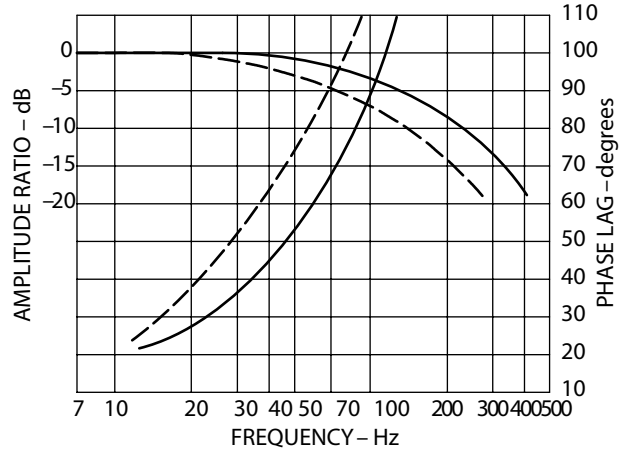
3,8 l/min (1.0 USgpm)  
 9 l/min (2.5 USgpm)  
 19 l/min (5.0 USgpm)  
 28 l/min (7.5 USgpm)

— ±40% rated current  
 - - - ±100% rated current



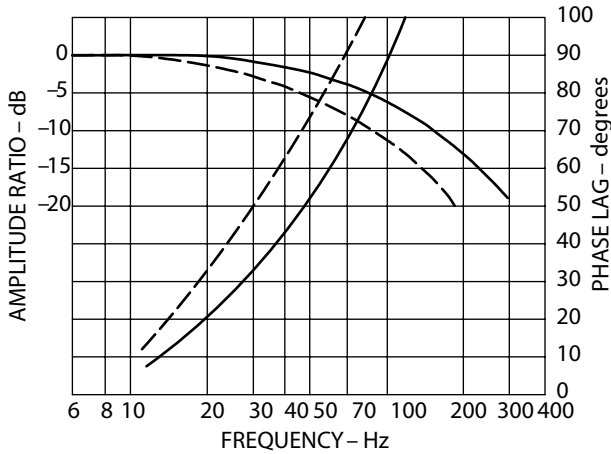
38 l/min (10 USgpm)

— ±40% rated current  
 - - - ±100% rated current



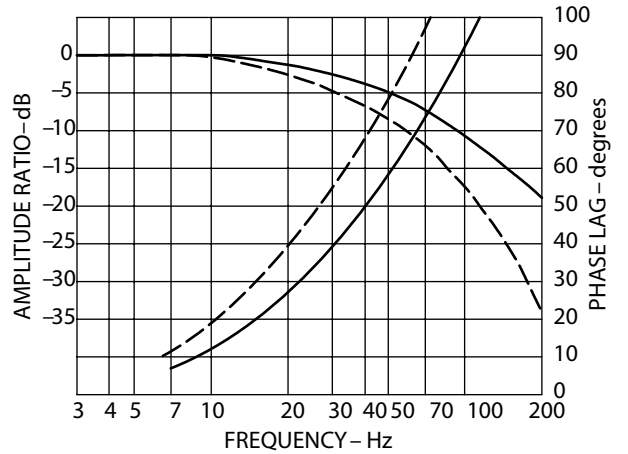
47 l/min (12.5 USgpm)

— ±40% rated current  
 - - - ±100% rated current



57 l/min (15 USgpm)  
 76 l/min (20 USgpm)

— ±40% rated current  
 - - - ±100% rated current

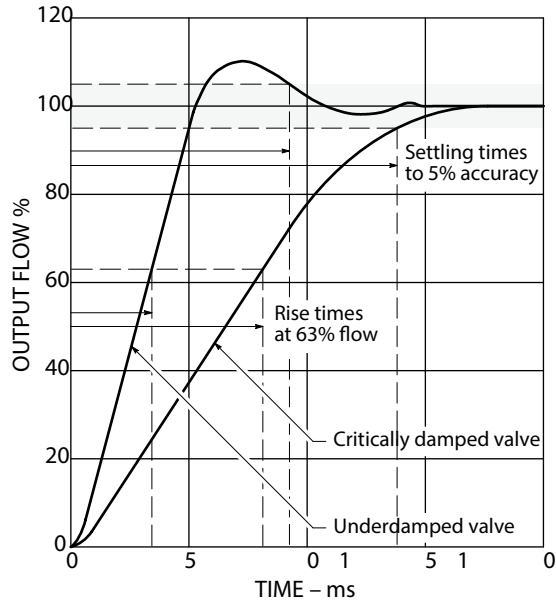


# Performance Curves

## Step Response

Step response is defined as the typical rise time needed to achieve a given percentage of control flow output. Settling time is the time needed for transient flow fluctuations to diminish to within a given accuracy range. Both are expressed in milliseconds (ms).

The example at right shows the step response curves for a critically damped valve and an underdamped valve. Rise times are illustrated for 63% of control flow output, and settling times are shown at  $100 \pm 5\%$  of control flow output.

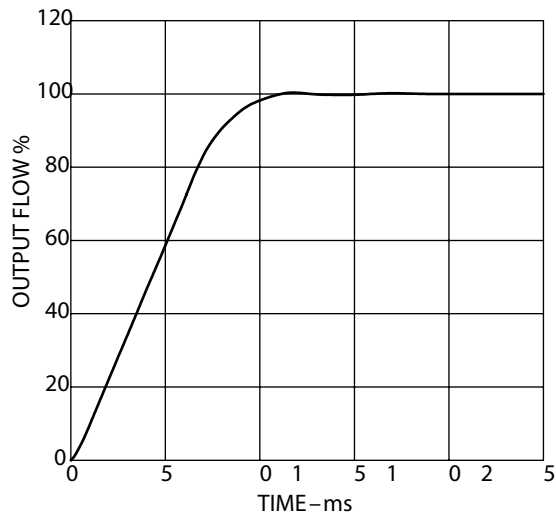
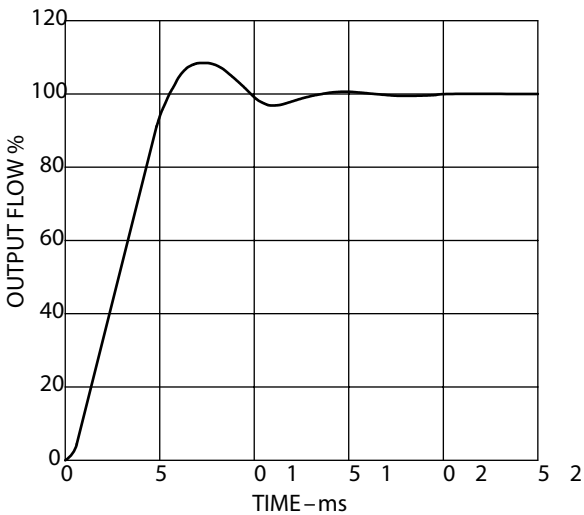


## Typical Step Response Curves for Standard Models

SM4-20 shown at 210 bar (3000 psi)

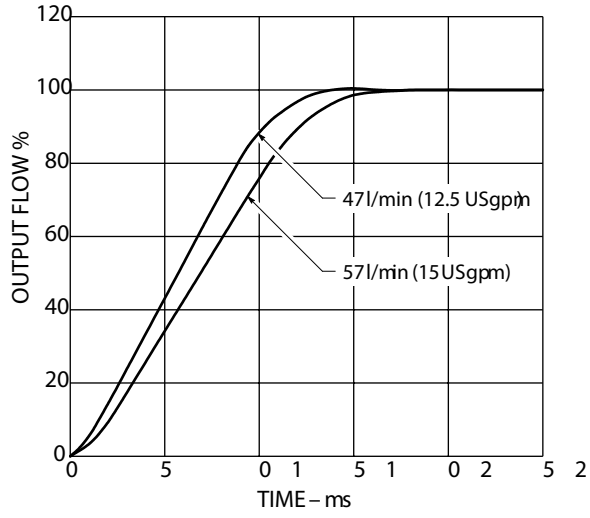
- 3,8 l/min (1.0 USgpm)
- 9 l/min (2.5 USgpm)
- 19 l/min (5.0 USgpm)
- 28 l/min (7.5 USgpm)

38 l/min (10 USgpm)

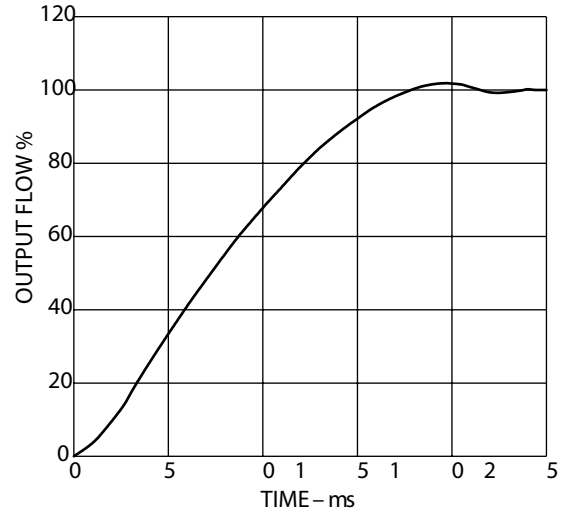


# Performance Curves

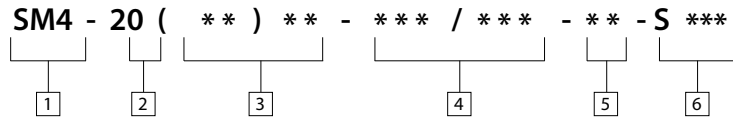
47 l/min (12.5 USgpm)  
57 l/min (15 USgpm)



76 l/min (20 USgpm)



# Model Code



**1 Series Designation**

**SM4** – Servovalve, high performance, four-way

**2 Valve Size**

**20** – 22,2 mm (0.875 in) port circle

**3 Flow Rating**

At 70 bar (1000 psi)  $\Delta p$   
 P → A → B → T.  
 Other flows available on request.

Code	USgpm	l/min
(1) <b>3,8</b>	1.0	3,8
(2.5) <b>9</b>	2.5	9
(5) <b>19</b>	5.0	19
(7.5) <b>28</b>	7.5	28
(10) <b>38</b>	10.0	38
(12) <b>45</b>	12.0	45
(12.5) <b>47</b>	12.5	47
(15) <b>57</b>	15.0	57
(20) <b>76</b>	20.0	76

**4 Coil resistance/rated current**

Ohms/mA at 21°C (70°F).  
 Other coils available on request.

Code	Ohms	mA
<b>20/200</b>	20	200
<b>30/100</b>	30	100
<b>80/40</b>	80	40
<b>80/50</b>	80	50
<b>140/40</b>	140	40
<b>200/15</b>	200	15
<b>200/20</b>	200	20
<b>300/30</b>	300	30
<b>1000/10</b>	1000	10
<b>1500/8</b>	1500	8

**5 Design Number**

Subject to change. Installation dimensions same for designs 10 through 19.

**6 Special Features Suffix**

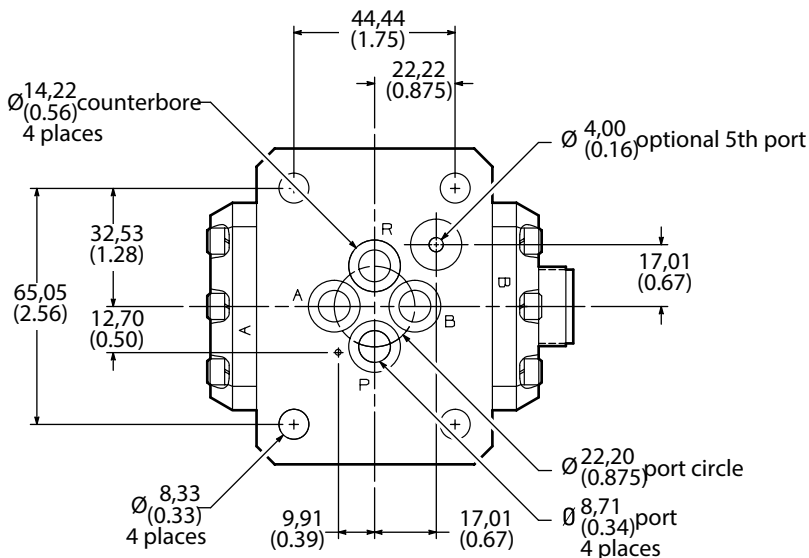
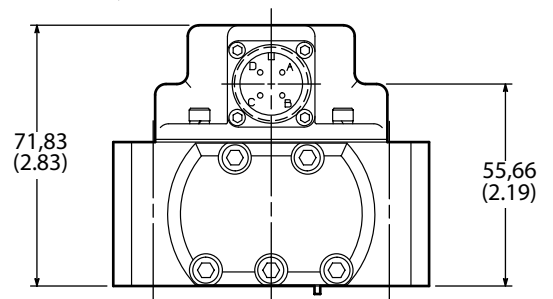
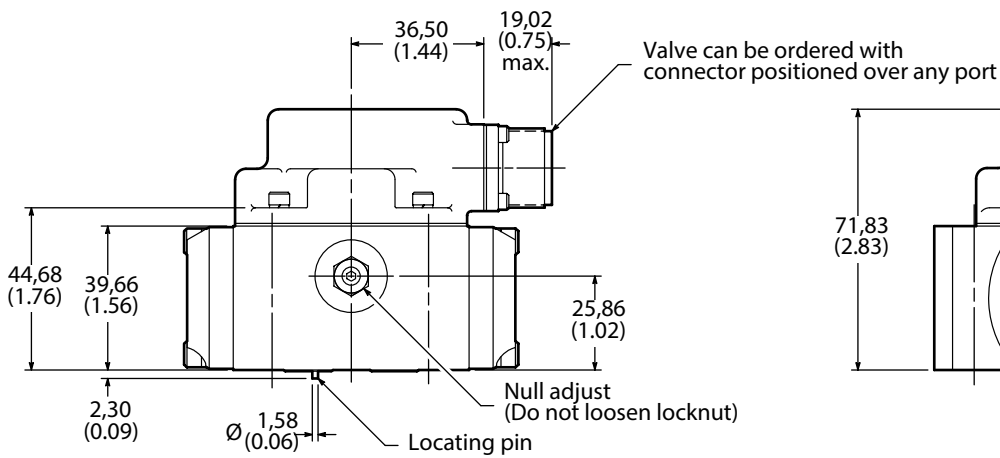
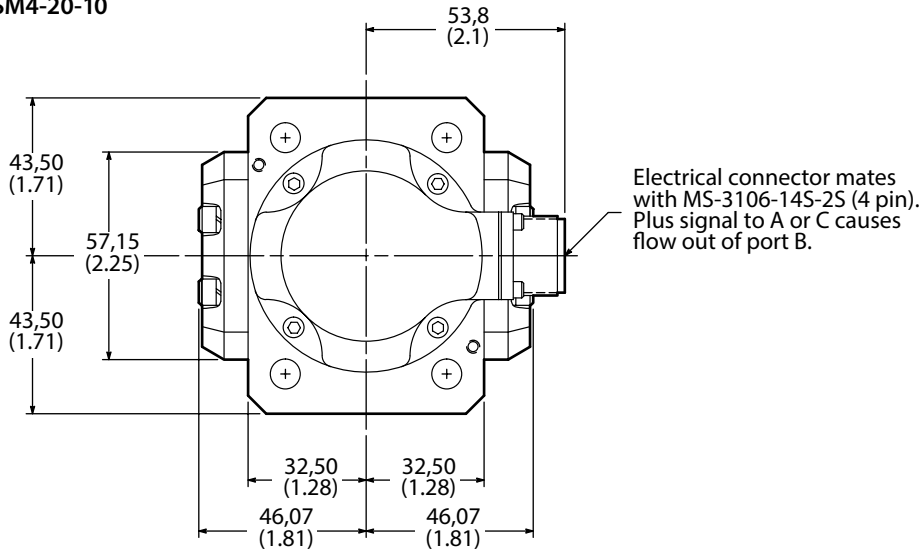
**S81** – Intrinsically safe valve. Contact your Danfoss representative for details.

**S\*\*\*** – Vickers by Danfoss assigns a unique suffix to denote a particular group of special features. Contact your Danfoss representative for details.

**Blank** – Standard valve

# Installation Dimensions

SM4-20-10



## NOTES

Torque mounting screws to 14 to 15 Nm (120 to 130 lb.in.).

Valve mounting surface requires 32 microinch finish flat within 0,025 (0.001).

Viton® port O-rings (AS568-013) provided: 1,78 (0.070) cross section and 10,82 (0.426) inner diameter. Replacement O-rings available in seal kit 920320 only.

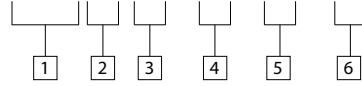
Dimensions in inches (mm)

# Model Code

## SM4M(E) Mounting Subplates

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### SM4 M (E) - 20 - 10 - (M)



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#### 1 Series Designation

**SM4** – Servo valve, high performance, four-way

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#### 2 Accessory Designation

**M** – Mounting subplate. Maximum supply pressure of 210 bar (3000 psi).

#### 3 Port Connection Locations

**Blank** – Rear ports  
**E** – Side ports

---

#### 4 Standard SM4 Valve Size

**20** – SM4-20 or SP4-25

#### 5 Design Number

Subject to change. Installation dimensions same for designs 10 through 19.

-10 design indicates 210 bar (3000 psi) maximum supply pressure.

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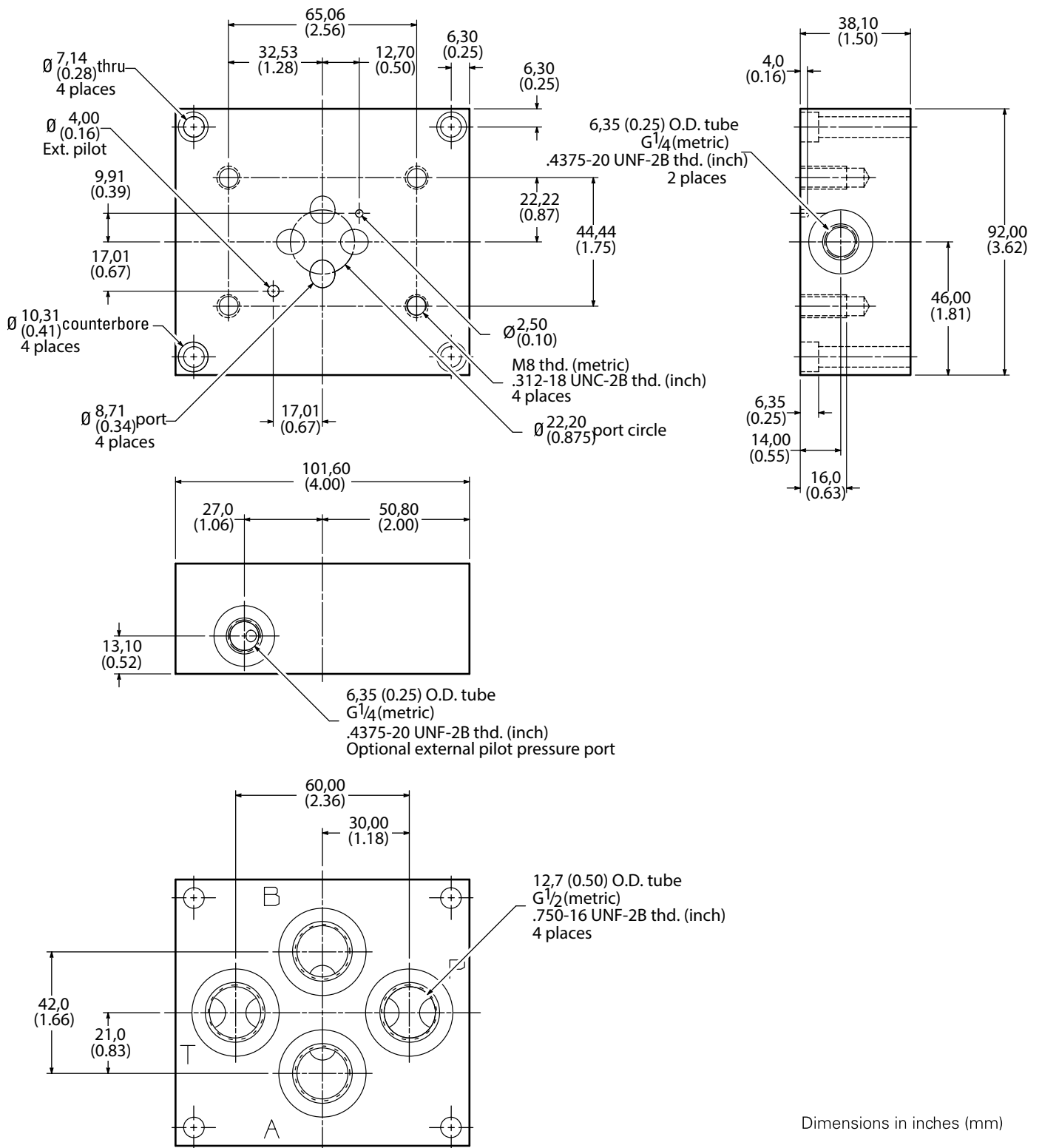
#### 6 Metric Suffix

**M** – Metric version to NG (ISO) standards

**Blank** – Omit if not required

# Installation Dimensions

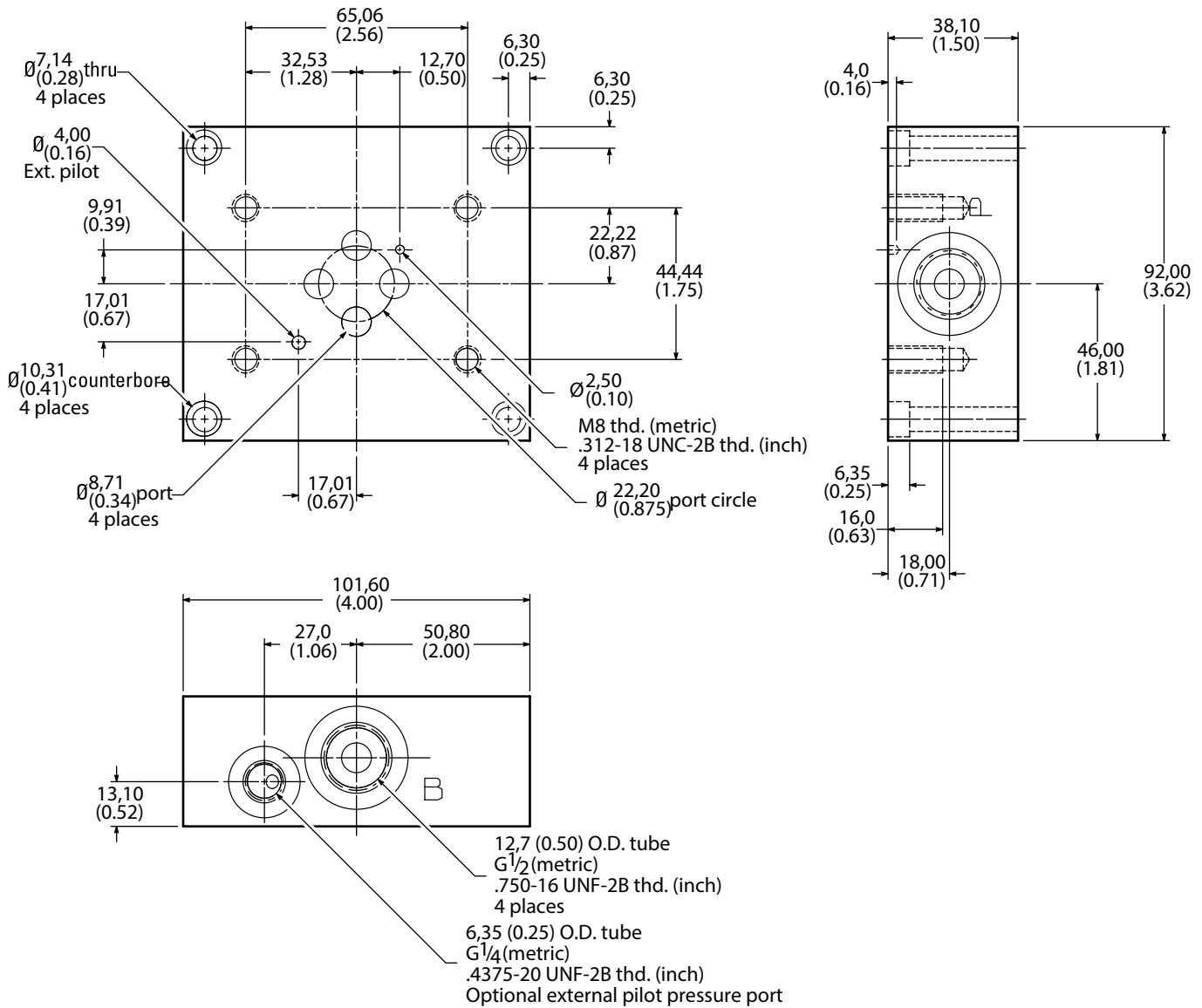
## SM4M-20-10(M)



Dimensions in inches (mm)

# Installation Dimensions

## SM4ME-20-10(M)



Dimensions in inches (mm)

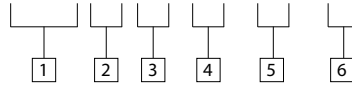


# Model Code

## SM4A Adapter Manifolds

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**SM4 A - 5 - 20 - 10 - (M)**



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**1 Series Designation**

**SM4** – Servovalve, high performance, four-way

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**2 Accessory Designation**

**A** – Adapter manifold. Maximum supply pressure of 210 bar (3000 psi).

**3 Interface**

**5** – ISO 4401-05

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**4 Standard SM4 Valve Size**

**20** – SM4-20 or SP4-25

**5 Design Number**

Subject to change. Installation dimensions same for designs 10 through 19.

-10 design indicates 210 bar (3000 psi) maximum supply pressure.

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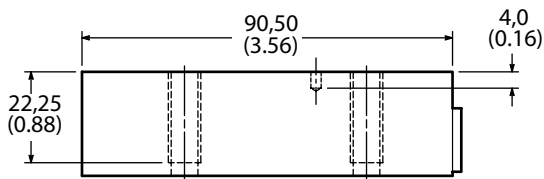
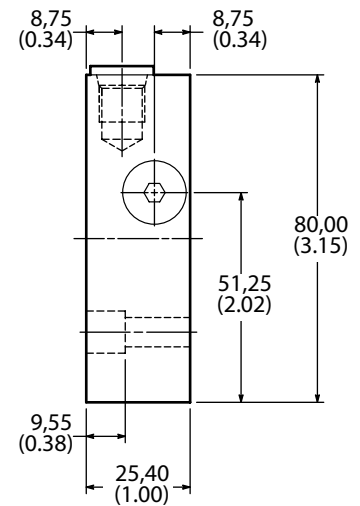
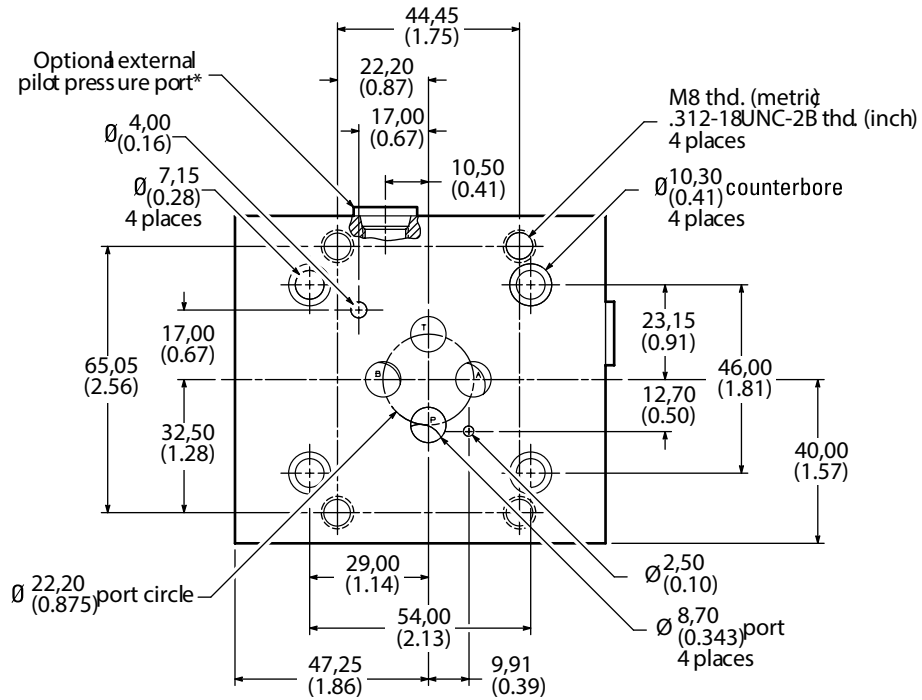
**6 Metric Suffix**

**M** – Metric version to NG (ISO) standards

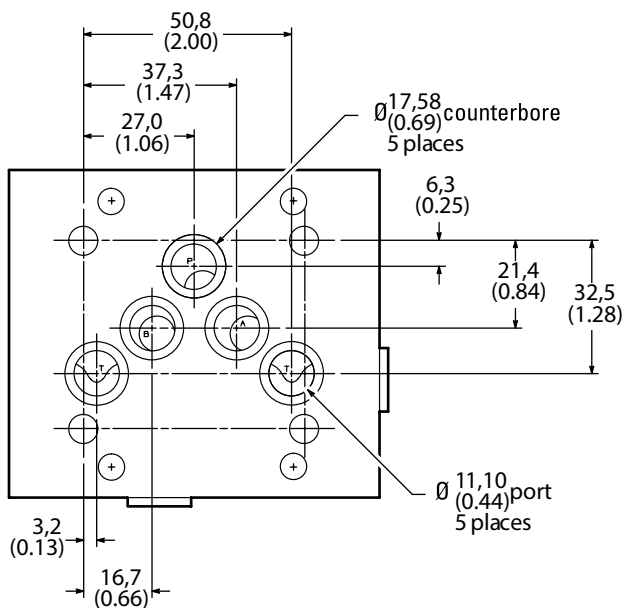
**Blank** – Omit if not required

# Installation Dimensions

## SM4A-5-20-10(M)



\* - 6,35 (0.25) O.D. tube  
G 1/4 (metric)  
.4375-20 UNF-2B thd. (inch)

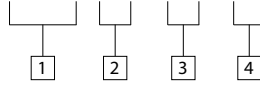


Dimensions in inches (mm)

# Model Code

## SM4FV Flushing Valves

### SM4 FV - 20 - 10



**1 Series Designation**

SM4 – Servo valve, high performance, four-way

**2 Accessory Designation**

FV – Flushing valve. Maximum flushing pressure of 35 bar (500 psi).

**4 Design Number**

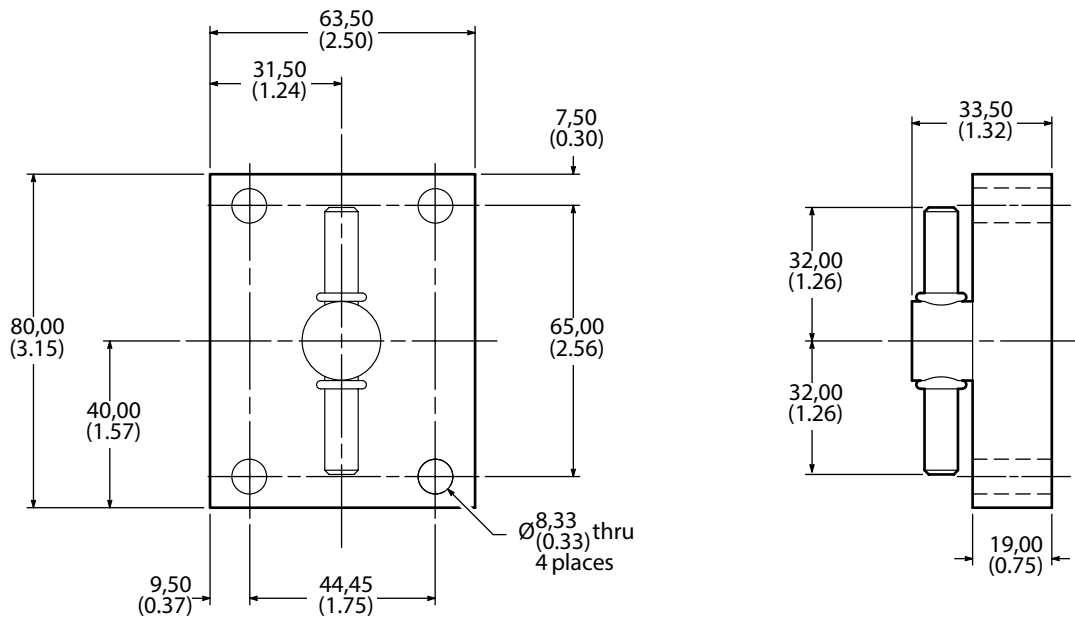
Subject to change. Installation dimensions same for designs 10 through 19.

**3 Standard SM4 Valve Size**

20 – SM4-20 or SP4-25

## Installation Dimensions

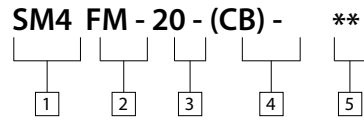
### SM4FV-20-10



Dimensions in inches (mm)

# Model Code

## SM4FM Filter Modules



**1 Series Designation**

**SM4** – Servo valve, high performance, four-way

**2 Accessory Designation**

**FM** – Filter module. Maximum supply pressure of 210 bar (3000 psi).

**3 Standard SM4 Valve Size**

**20** – SM4-20 or SP4-25

**4 Crossport bleed designation**

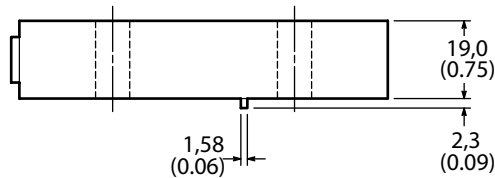
**CB** – Includes crossport bleed feature

**Blank** – Omit if not required

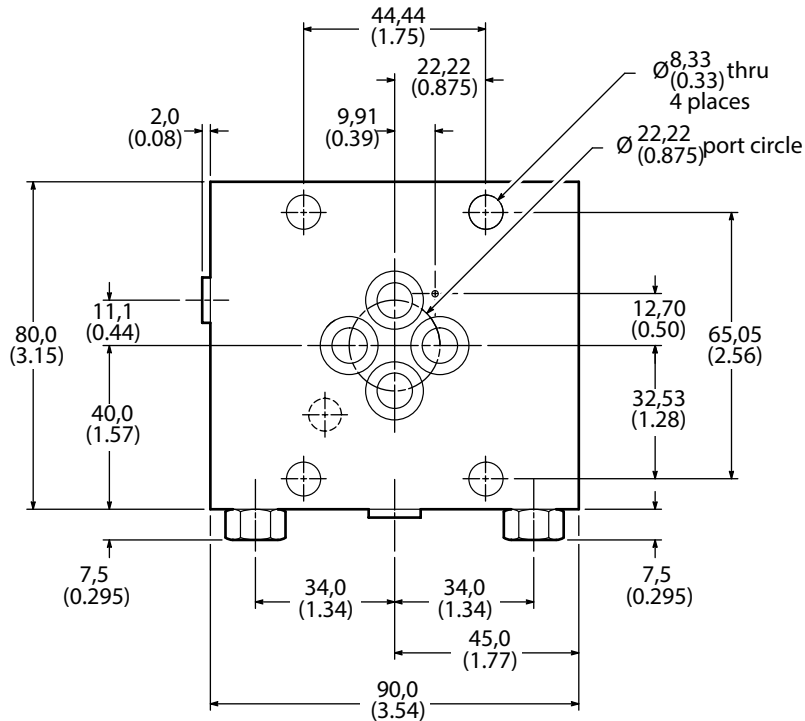
**5 Design Number**

Subject to change. Installation dimensions same for designs 10 through 19.

## Installation Dimensions



SM4FM-20-10



Dimensions in inches (mm)

# Weights

The following table lists approximate dry weights for SM4 servo valves and related accessories.

DESCRIPTION	MODEL CODE	WEIGHT kg (lbs.)
Servo valve	SM4-20	1,05 (2.3)
Mounting subplate	SM4M(E)-20-10(M)	0,91 (2.0)
Adapter manifold	SM4A-5-20-10(M)	0,439 (0.97)
Flushing valve	SM4FV-20-10(M)	0,27 (0.58)
Filter module	SM4FM-20-(CB)-10	0,73 (1.6) est.

## Additional Accessories

SM4-20 (-10 D ES IGN) ACCESSORIES	MODEL CODE
Adapter manifold mounting bolt kit (inch) 1/4–20 x 1"	BK866686
Adapter manifold mounting bolt kit (metric) M6 x 25mm	BK689629M
Cable clamp (MS3057-6)	126058
Cable connector (MS3106-14S-2S)	242123
Connector kit 926467	
Cross-port bleed module mounting bolt kit (inch) 5/16–18 x 23/4"	BK855421
Filter kit	926469
Filter module kit	886819
Filter module mounting bolt kit (inch) 5/16–18 x 23/4"	BK855421
Filter module mounting bolt kit (metric) M8 x 70mm	BK689624M
Filter module with cross-port bleed mounting bolt kit (inch) 5/16–18 x 31/8"	BK927736
Flushing valve mounting bolt kit (inch) 5/16–18 x 11/4"	BK688701
Flushing valve mounting bolt kit (metric) M8 x 35mm	BK689630M
Seal kit (SM4-20)	920320
Subplate mounting bolt kit (inch) 1/4–20 x 11/2"	BK855992
Subplate mounting bolt kit (metric) M6 x 40mm	BK855993M
Valve mounting bolt kit (inch) 5/16–18 x 2"	BK866687
Valve mounting bolt kit (metric) M8 x 50mm	BK866690M

### Servo Electronics

See application brochure 656 for the complete Vickers by Danfoss line of amplifiers, power supplies, and function modules.

# Application Data

## Fluid Cleanliness

Proper fluid condition is essential for long and satisfactory life of hydraulic components and systems. Hydraulic fluid must have the correct balance of cleanliness, materials, and additives for protection against wear of components, elevated viscosity and inclusion of air.

Essential information on the correct methods for treating hydraulic fluid is included in Danfoss publication 561 "Vickers Guide to Systemic Contamination Control," available from your local Danfoss distributor. Recommendations on filtration and the selection of products to control fluid condition are included in 561.

Recommended cleanliness levels, using petroleum oil under common conditions, are based on the highest fluid pressure levels in the system and are coded in the

chart below. Fluids other than petroleum, severe service cycles, or temperature extremes are cause for adjustment of these cleanliness codes. See Danfoss publication 561 for exact details.

Danfoss products, as any components, will operate with apparent satisfaction in fluids with higher cleanliness codes than those described. Other manufacturers will often recommend levels above those specified. Experience has shown, however, that life of any hydraulic component is shortened in fluids with higher cleanliness codes than those listed below. These codes have been proven to provide a long, trouble-free service life for the products shown, regardless of the manufacturer.

### NOTE

Danfoss will extend, by one year, the standard warranty on all Danfoss products used in a system protected by Danfoss filters (and elements) applied in a manner consistent with the principles presented in Danfoss publication 561.

PRODUCT	SYSTEM PRESSURE LEVEL BAR (PSI)		
	<70 (<2000)	70-207 (2000-3000)	207+ (3000+)
Vane pumps, fixed	20/18/15	19/17/14	18/16/13
Vane pumps, variable	18/16/14	17/15/13	
Piston pumps, fixed	19/17/15	18/16/14	17/15/13
Piston pumps, variable	18/16/14	17/15/13	16/14/12
Directional valves	20/18/15	20/18/15	19/17/14
Proportional valves	17/15/12	17/15/12	15/13/11
<b>Servo valves</b>	<b>16/14/11</b>	<b>16/14/11</b>	<b>15/13/10</b>
Pressure/Flow controls	19/17/14	19/17/14	19/17/14
Cylinders	20/18/15	20/18/15	20/18/15
Vane motors	20/18/15	19/17/14	18/16/13
Axial piston motors	19/17/14	18/16/13	17/15/12

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**Products we offer:**

- Cartridge valves
- DCV directional control valves
- Electric converters
- Electric machines
- Electric motors
- Gear motors
- Gear pumps
- Hydraulic integrated circuits (HICs)
- Hydrostatic motors
- Hydrostatic pumps
- Orbital motors
- PLUS+1® controllers
- PLUS+1® displays
- PLUS+1® joysticks and pedals
- PLUS+1® operator interfaces
- PLUS+1® sensors
- PLUS+1® software
- PLUS+1® software services, support and training
- Position controls and sensors
- PVG proportional valves
- Steering components and systems
- Telematics

**Danfoss Power Solutions** is a global manufacturer and supplier of high-quality hydraulic and electric components. We specialize in providing state-of-the-art technology and solutions that excel in the harsh operating conditions of the mobile off-highway market as well as the marine sector. Building on our extensive applications expertise, we work closely with you to ensure exceptional performance for a broad range of applications. We help you and other customers around the world speed up system development, reduce costs and bring vehicles and vessels to market faster.

Danfoss Power Solutions – your strongest partner in mobile hydraulics and mobile electrification.

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