

Technical Information

# MP1 Axial Piston Motors

## Size 20/24



**Revision history***Table of revisions*

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## General Description

### Overview

The MP1 motor is a fixed displacement axial piston motor and is intended for closed and open circuit medium power applications. These motors are designed primarily to be combined with other products in closed and open circuit systems to transfer and control hydraulic power. The MP1 motor consist of two rotating groups (displacements) and three housing (mounting) configurations. An SAE-A two bolt, SAE-B two-bolt and a cartridge style (for space optimized gear box mounting ) configurations.

The motor is ideally configured for installations requiring compact packaging and optimized plumbing such as wheel ends. The standard porting configuration is twin radial (side) O-ring boss main ports.

### Features

- Two displacements allow the optimum selection of hydraulic motor for the lowest possible installed cost.
- SAE-A & B, two bolt, and cartridge style mounting configurations available.
- Metric and inch O-ring boss system port interfaces.
- Short and compact; fits into existing installation with improve porting.
- Proven reliability and performance.
- Worldwide sales and service.

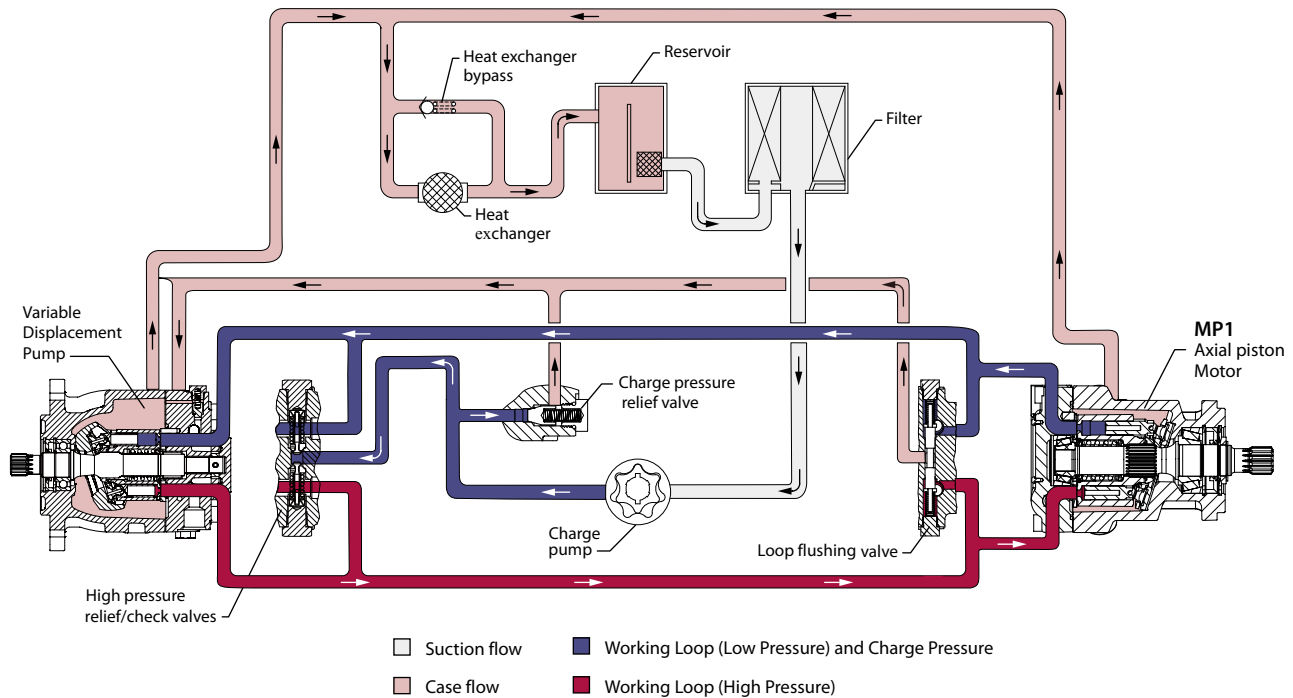
#### Expanded Functionality

- Open circuit fan drive application.
- PLUS+1<sup>®</sup> Compliant speed sensor option.
- Integrated flushing valve option available.
- Anti-cavitation valve option available.
- Shock valve option available.

**General Description**

**System Diagram**

*Pictorial system diagram*



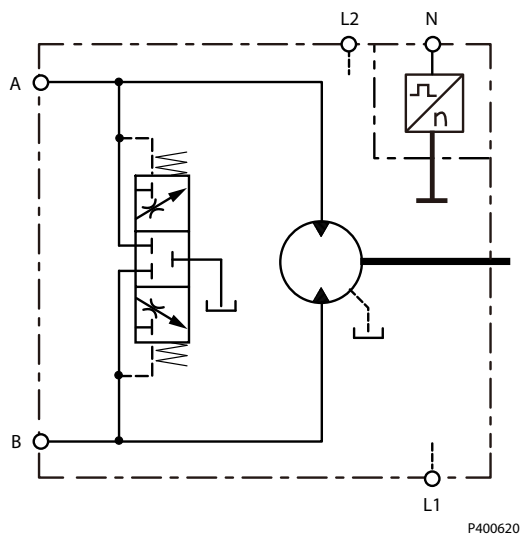
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The system diagram above shows the MP1 motor in a simple closed-loop hydrostatic propel application. The motor is driven by a variable displacement pump. The motor shows an integral loop flushing option that will remove heat and contaminants from the main loop.

## General Description

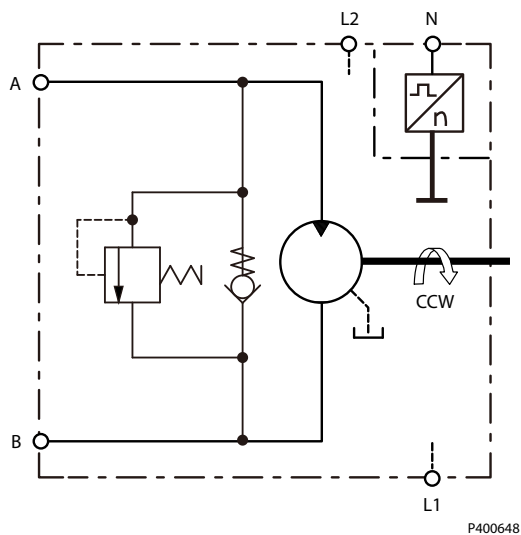
### Schematic Diagram

*Closed Circuit*



For a close loop system, the system ports (A and B) connect to the high pressure work lines. The motor receives pressurized fluid in its inlet port and discharges de-energized fluid through the outlet port. Either port can act as inlet or outlet; flow is bidirectional. The motor has two case drains (L1 and L2). The motor may include loop flushing. Loop flushing provides additional cooling and filtration capacity.

*Open Circuit*



An open circuit configuration is also possible for the motor and such a system is shown above. A shock valve and an anti-cavitation valve is provided to protect the unit from sudden pressure surges as well as cavitation. The flow path of pressurized fluid is from port A through port B. In this configuration, the direction of rotation of the motor is counter clockwise as seen from shaft side. Similarly, if the anti-cavitation and shock valve is oriented in the reverse position, the direction of rotation will be clockwise. Thus, pressurized fluid flow path is from port B through port A.

## Technical Specification

### Design Specifications

Features	MP1 Motors
Design	Axial piston motor with fixed displacement design.
Direction of output rotation (as seen from shaft side)	Clockwise or counterclockwise
Recommended installation position	Motor installation position is discretionary, The housing must always be filled with hydraulic fluid. Consult Danfoss for non-conformance to these guidelines.

### Technical Data

Feature	Unit	MP1M20	MP1M24
Model configuration		Fixed displacement motor	
Displacement	cm <sup>3</sup> /rev [in <sup>3</sup> /rev]	20.0 [1.22]	24.0 [1.46]
Mass moment of inertia of rotating components	kg·m <sup>2</sup> [slug·ft <sup>2</sup> ]	0.0010 [0.0007]	
Mass (Weight) dry	kg [lb]	5.6 [12]	
Mounting flange		ISO 3019-1 flange 82-2 (SAE-A), 2 bolt ISO 3019-1 flange 101-2 (SAE-B), 2 bolt Cartridge mounting style	
Output shaft options		Spline 13T 16/32 Spline 15T 16/32 Spline 17T 24/48	
		Straight keyed 22.225 dia. Tapered 22.225 dia. 1:8	
Main port configuration A, B		ISO 11926-1, 7/8-14 (SAE O-ring boss) Twin port, radial	
		ISO 6149-1, M22x1.5 (Metric O-ring boss)	
Case drain ports A, B		ISO 11926-1, 3/4-16 (SAE O-ring boss)	
		ISO 6149-1, M18x1.5 (Metric O-ring boss)	

### Operating Parameters

Parameter		Unit	20/24
Speed limit	Closed Circuit	Rated	4200
		Maximum <sup>1)</sup>	4700
	Open Circuit	Rated	3400
		Maximum	3800
System pressure	Maximum working pressure <sup>2)</sup>		350 [5000]
	Maximum pressure		380 [5429]
Case pressure	Rated		2 [29]
	Maximum		6 [87]

<sup>1)</sup> At Maximum speed, system minimum low pressure is 18 bar.

<sup>2)</sup> Applied pressures above maximum working pressure requires Danfoss application approval.



## Technical Specification

### Fluid Specifications

Features		Units	20/24
Viscosity	Intermittent <sup>1</sup>	mm <sup>2</sup> /sec. [SUS]	5 [42]
	Minimum		7 [49]
	Recommended range		12 - 80 [66 - 370]
	Maximum (cold start) <sup>2</sup>		1600 [7500]
Temperature range <sup>3</sup>	Minimum (cold start)	°C [°F]	-40 [-40]
	Recommended range		60 - 85 [140 - 185]
	Maximum continuous		104 [220]
	Maximum intermittent		115 [240]
Cleanliness per ISO 4406			22/18/13 (as per ISO 4406)

<sup>1</sup> Intermittent=Short term t < 1 min per incident and not exceeding 2 % of duty cycle based load-life.

<sup>2</sup> Cold start = Short term t < 3 min, p < 50 bar [725 psi], n < 1000 min<sup>-1</sup> (rpm)

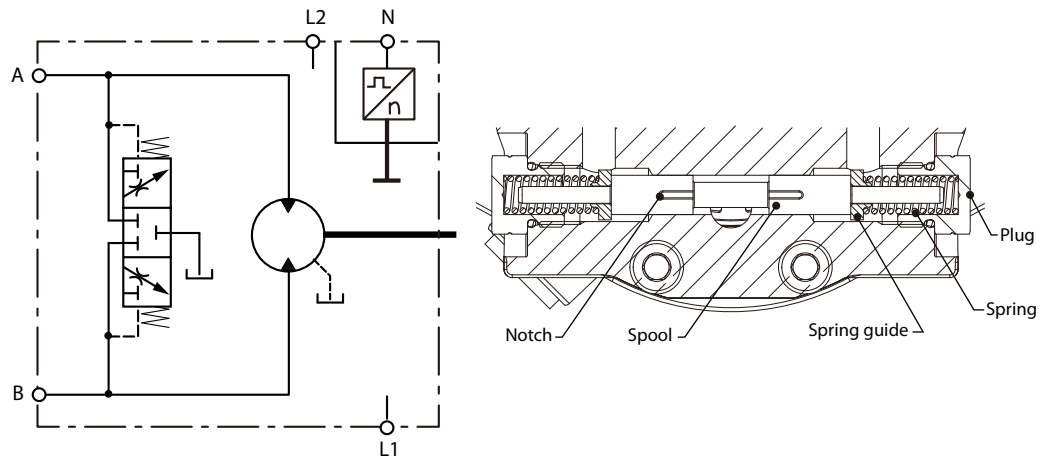
<sup>3</sup> At the hottest point, normally case drain port.

**Operation**

**Loop Flushing Valve**

Closed circuit systems may require loop flushing to meet temperature and cleanliness requirements. MP1 motors are available with an optional integral loop flushing. A loop flushing valve will remove heat and contaminants from the main loop at a rate faster than otherwise possible.

The hydraulic circuit of an MP1 motor with loop flushing option is shown below. The MP1 motor loop flushing design is a simple spring centered shuttle spool with an orifice notch.



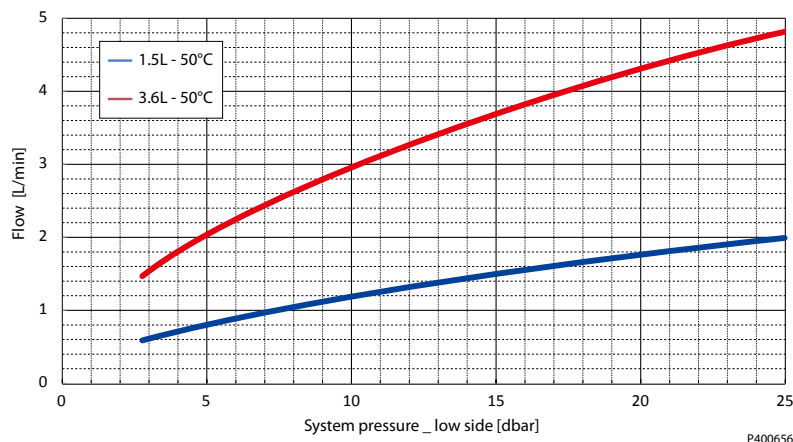
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A loop flush shuttle spool is used to separate system A and system B pressures. System delta pressure will cause the shuttle spool to shift, allowing the low side system pressure to flow to the orifice towards the case. The shuttle shifts at approximately 4 bar [57 psi]. The flushing flow is a function of the low loop system pressure and the size of the notch.

Loop flush flow options of 1.5 & 3.6 l/min [0.4 & 1.0 gal/min] are available and are adequate for most applications. Contact your Danfoss representative for assistance.

*Loop flush characteristic curves*

1.5 L and 3.6 L@15 bar, oil temp=50°C



P400656

When a MP1 pump is used with an external loop flushing shuttle valve, ensure that the charge setting of the pump matches the setting of the loop flushing shuttle valve. Contact your Danfoss representative for the availability of additional charge relief settings.

## Operation

### Anti-Cavitation and Shock Valve

The MP1M fixed motors are available with an anti-cavitation valve option. The key application for this option is open circuit fan drives.

The anti cavitation valve function as a check valve within the same cavity which is integrated into the endcap. The check valve function provides protection against cavitation that can occur upon introduction of an overrunning load or due to loss of input flow. In such case, the system delta pressure becomes negative and the check valve opens connecting the motor inlet and outlet, effectively short-circuiting the motor. The shock valve function is intended to be used for system overpressure protection events of limited duration only. It is not intended for continuous system pressure limitation.

The shock valve is available with 280 bar [4061 psi] or 345 bar [5004 psi] setting.

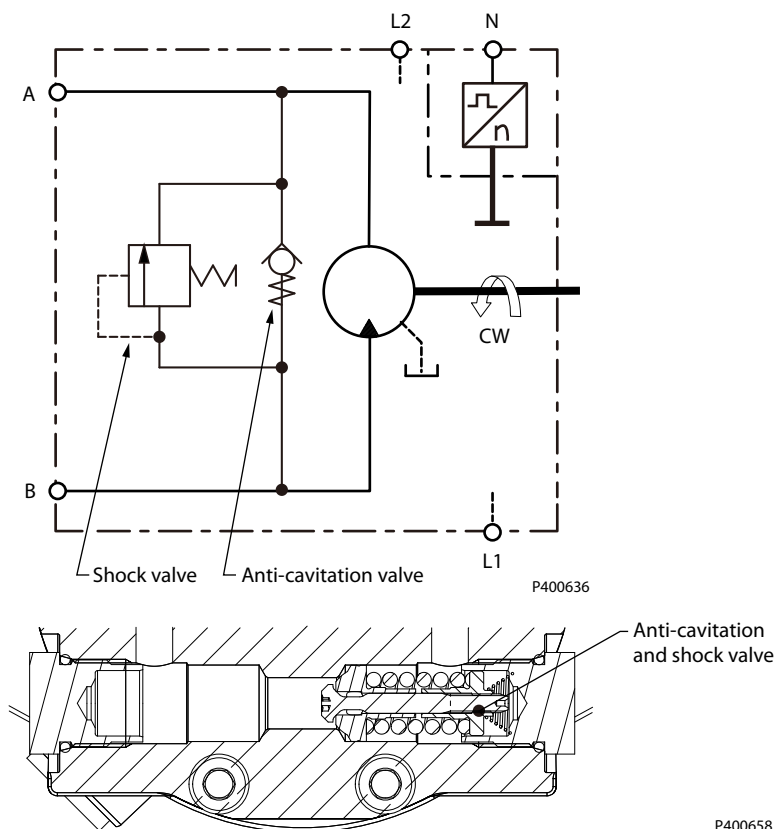
For this option the high pressure port needs to be defined upfront to get the correct motor rotation. Reversing the motor is not possible with this option.

#### Flow direction

Motor shaft rotation (as seen from shat side)	Port A	Port B	System Port type, Loop Flushing & Anti-cavitation*
Clockwise (CW)	Out	In	MD1/MD2/SD1/SD2
Counterclockwise (CCW)	In	Out	MC1/MC2/SC1/SC2

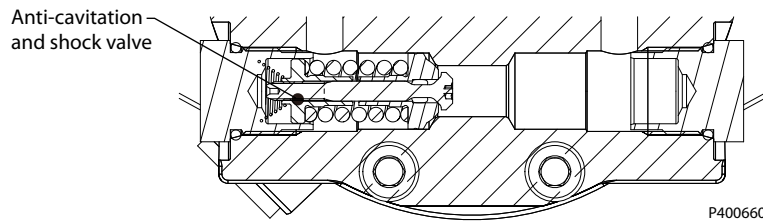
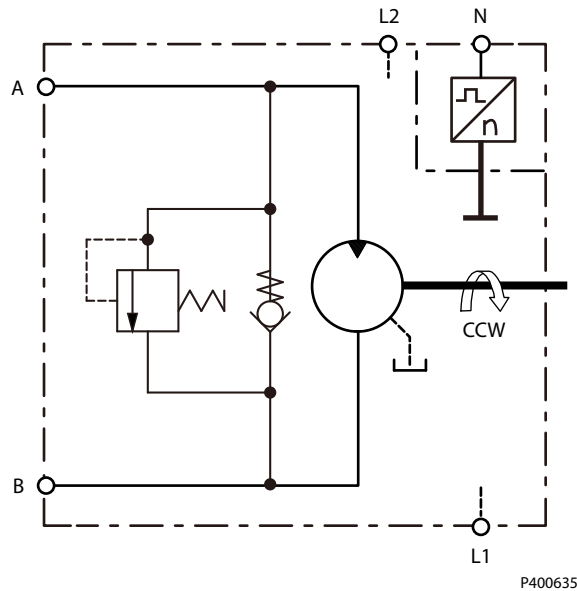
\* See [Master Model Code](#) on page 22

#### Anti cavitation and shock valve, Port B High Pressure, Clockwise rotation



## Operation

*Anti cavitation and shock valve, Port A High Pressure, Counter Clockwise rotation*



## Speed Sensor

MP1 motors are available with an optional speed sensor. This hall-effect pulse pick-up is located in the motor housing. The sensor accepts supply voltage and outputs a digital pulse signal in response to the speed of the cylinder block. The output changes its high/low state as the target teeth pass by the sensor's face. The digital (on-off-on-off) pulse train is fed to a controller, which interprets its rate of change as a speed. A logic circuit decodes the two signals to provide an additional direction indication (high or low depending on direction).

This sensor will operate with a supply voltage of 4.5 to 8 Vdc, and requires a current of 12 mA at 5.0 Vdc (minimum) under no load. Maximum operating current is 20 mA at 5 Vdc (maximum). Maximum operating frequency is 15 kHz. Output voltage in High State (VOH) is sensor supply voltage minus 0.5 Vdc, minimum. Output voltage in Low State (VOL) is 0.5 Vdc, maximum. The sensor is available with a DEUTSCH DTM06-6S, Black and Grey connector.

[Contact your Danfoss representative for production availability on specific motor frame sizes, or for special speed sensor options.](#)

The speed sensor is designed for rugged outdoor, mobile or heavy industrial speed sensing applications. The detection of the speed is contactless and does not need any calibration or adjustments.

For more information, see *Speed and Temperature Sensor, Technical Information, BC152886482203*.

## Temperature Range

Parameter	Minimum	Maximum
Operation temperature range	-40 °C	104 °C

## Operation

115°C Intermittent = Short term;  $t < 1$  min per incident and not exceeding 2 % of duty cycle based load-life.

### Protection Characteristics

Parameter	Data
Protection Code (IP class) according IEC 60529 and DIN 40050	IP 67 (without connector installed) IP 69k (with connector installed)
EMC Emission	EN 61000-6-3
EMC Immunity (EMI)	100 V/m incl. 1 kHz AM 80 %; ISO 11452-5 and -2
ESD	EN 61000-4-2 Air discharge: 15 kV Contact discharge: 8 kV
Vibration	6 G (59 m/s <sup>2</sup> )
Shock	10 G (98 m/s <sup>2</sup> )
Case maximum pressure	6 bar [87 psi]

### Mating Connectors

Ordering number	
<b>11033865</b>	<b>11033863</b>
Assembly Bag, DEUTSCH DTM06-6S-E004; black, (24-20 AWG) 0.21 -0.52 mm <sup>2</sup>	Assembly Bag, DEUTSCH DTM06-6S, gray, (24-20 AWG) 0.21 -0.52 mm <sup>2</sup>

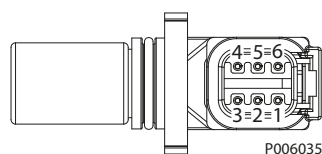
### Available Sensors

Description	Order number
	<b>149055</b>
Supply voltage	4.5 – 8 V
Speed signals	Two, 90° Phase shift
Direction signal	One
Temperature signal	One

For more information, see [Speed Sensor 4.5 – 8 V Technical Data](#) on page 13.

### Speed Sensor 4.5 – 8 V Technical Data

Speed sensor connector, 6-pin



Pinout:

1. Speed signal 2
2. Direction signal
3. Speed signal 1
4. Supply
5. Ground
6. Temperature

### Technical data

Parameter	Min.	Nom.	Max.	Note
Supply voltage	4.5 V <sub>DC</sub>	5 V <sub>DC</sub>	8 V <sub>DC</sub>	Regulated supply voltage. Reverse polarity protected.
Supply protection	–	–	30 V <sub>DC</sub>	Shuts off above 9 V.
Pulses per revolution	NPN & PNP			

## Operation

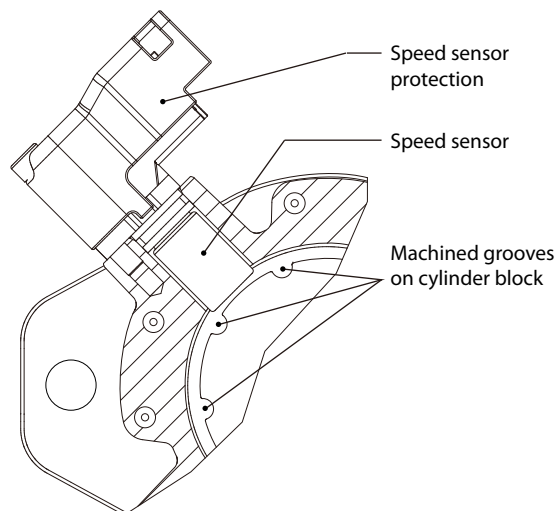
*Technical data (continued)*

Parameter	Min.	Nom.	Max.	Note
<b>Max. required supply current</b>	–	–	25 mA	At supply voltage
<b>Max. output current</b>	–	–	50 mA	
<b>Operation mode</b>	<b>NPN &amp; PNP</b>			Push-Pull amplifier
<b>Temperature signal</b>	-40°C = 2.318V	–	100°C = 0.675V	
<b>Output low speed signal</b>	5 %	8.5 %	12 %	Ratiometric output voltage Low state > 0 V to provide wire fault detection
<b>Output high speed signal</b>	88 %	91.5 %	95 %	
<b>Detectable frequency range</b>	1 Hz	–	10 000 Hz	
<b>Ordering number</b>	<b>149055</b>			
<b>Color of connector</b>	Black			

### Sensor Position

Sensor position in SAE and Cartridge housing.

*SAE & Cartridge housing*



P400649

### Target block

Speed sensor target block has nine arc groove on cylinder block for detection of direction (CW/CCW) and rotation.

### Output Pulses

The expected number of output pulses per revolution is shown below.

<b>The number of pulses (per rev)</b>	<b>9</b>
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## Operating Parameters

### Overview

This section defines the operating parameters and limitations with regard to output speeds and pressures.

### Speed Ratings

Smooth operation and output torque ripple determine the acceptable low speed operating condition. Generally Danfoss axial piston motors will operate smoothly down to 150 rpm. In some instances, it is possible to operate smoothly at less than 150 rpm, but performance must be verified for the specific application. We do not recommend that any axial piston motor be sized to operate continuously at speeds less than 100 rpm.

**Rated speed** is the highest input speed recommended at full power condition. Operating at or below this speed should yield satisfactory product life.

**Maximum speed** is the highest operating speed permitted. Exceeding maximum speed reduces product life and can cause loss of hydrostatic power and braking capacity. Never exceed the maximum speed limit under any operating conditions.

Operating conditions between Rated speed and Maximum speed should be restricted to less than full power and to limited periods of time. For most drive systems, maximum unit speed occurs during downhill braking or negative power conditions.

#### **Warning**

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#### **Unintended vehicle or machine movement hazard**

The loss of hydrostatic drive line power, in any mode of operation (forward, neutral, or reverse) may cause the system to lose hydrostatic braking capacity. You must provide a braking system, redundant to the hydrostatic transmission, sufficient to stop and hold the vehicle or machine in the event of hydrostatic drive power loss.

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### System Pressure

**System pressure** is the differential pressure between system ports A and B. It is the dominant operating variable affecting hydraulic unit life. High system pressure, which results from high load, reduces expected life. Hydraulic unit life depends on the speed and normal operating, or weighted average, pressure that can only be determined from a duty cycle analysis.

**Application pressure** is the high pressure relief setting normally defined within the order code of the pump. This is the applied system pressure at which the driveline generates the maximum calculated pull or torque in the application.

**Maximum working pressure** is the highest recommended Application pressure. Maximum working pressure is not intended to be a continuous pressure. Propel systems with Application pressures at, or below, this pressure should yield satisfactory unit life given proper component sizing.

**Maximum pressure** is the highest allowable Application pressure under any circumstance. Application pressures above Maximum Working Pressure will only be considered with duty cycle analysis and factory approval. Pressure spikes are normal and must be considered when reviewing maximum working pressure.

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All pressure limits are differential pressures referenced to low loop (charge) pressure. Subtract low loop pressure from gauge readings to compute the differential.

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**Minimum low loop pressure** (above case pressure) is the lowest pressure allowed to maintain a safe working condition in the low side of the loop.

## Operating Parameters

### Case Pressure

Under normal operating conditions, **the rated case pressure** must not be exceeded. During cold start, case pressure must be kept below maximum intermittent case pressure. Size drain plumbing accordingly.

 **Caution**

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**Possible component damage or leakage.**

Operation with case pressure in excess of stated limits may damage seals, gaskets, and/or housings, causing external leakage. Performance may also be affected since charge and system pressures are referenced to case pressure.

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*Case pressure limits*

<b>Maximum (continuous)</b>	2 bar [29 psi] maximum pressure
<b>Intermittent (cold start)</b>	6 bar [87 psi] maximum pressure

### Temperature

The high temperature limits apply at the hottest point in the transmission, which is normally the motor case drain. The system should generally be run at or below the published **rated temperature**.

The **maximum intermittent temperature** is based on material properties and should never be exceeded.

Cold oil will generally not affect the durability of the transmission components, but it may affect the ability of oil to flow and transmit power.

The **minimum temperature** relates to the physical properties of component materials.

Size heat exchangers too keep the fluid within these limits. Danfoss recommends testing to verify that these temperature limits are not exceeded.

### Viscosity

**Viscosity** For maximum efficiency and bearing life, ensure the fluid viscosity remains in the recommended range.

The **minimum viscosity** should be encountered only during brief occasions of maximum ambient temperature and severe duty cycle operation.

The **maximum viscosity** should be encountered only at cold start.

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Ensure fluid temperature and viscosity limits are concurrently satisfied.

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## System Design and Parameters

### Installation

MP1 motors may be installed in any position. The motor housing must always remain full of hydraulic fluid.

Fill the motor housing and system lines with clean fluid during installation. Connect the case drain line to the uppermost drain port (L1 or L2) to keep the housing full during operation.

To allow unrestricted flow to the reservoir, use a dedicated drain line. Connect it below the minimum reservoir fluid level and as far away from the reservoir outlet as possible. Use plumbing adequate to maintain case pressure within prescribed limits (see [Case Pressure](#) on page 16). To prevent premature wear, ensure that only clean fluid enters the hydrostatic transmission circuit. A filter capable of controlling the fluid cleanliness to ISO 4406, class 22/18/13 (SAE J1165) or better, under normal operating conditions, is recommended. These cleanliness levels cannot be applied for hydraulic fluid residing in the component housing/case or any other cavity upon delivery from the factory.

### Filtration

To prevent damage to the MP1 motor, including premature wear, fluid entering the motor must be free of contaminants. MP1 motors require system filtration capable of maintaining fluid cleanliness at ISO 4406-1999 class 22/18/13 or better.

Consider these factors when selecting a system filter:

- Cleanliness specifications
- Contaminant ingress rates
- Flow capacity
- Desired maintenance interval

Typically, a filter with a beta ratio of  $\beta_{10} = 1.5$  to 2.0 is adequate. However, open circuit systems supplied from a common reservoir may have considerably higher requirements. Because each system is unique, only a thorough testing and evaluation program can fully validate the filtration system. For more information, see Danfoss publication Design Guidelines for Hydraulic Fluid Cleanliness, **BC152886482150**.

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Filter  $\beta_x$ -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 diameter ("x" in microns) upstream of the filter to the number of these particles downstream of the filter.

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### Reservoir

The reservoir provides clean fluid, dissipates heat, and removes entrained air from the hydraulic fluid. It allows for fluid volume changes associated with fluid expansion and cylinder differential volumes.

Minimum reservoir capacity depends on the volume needed to perform these functions. Typically, a capacity of one half the charge pump flow (per minute) is satisfactory for a closed circuit system reservoir. Open circuit systems sharing a common reservoir will require greater fluid capacity.

Locate the reservoir outlet (suction line) near the bottom, allowing clearance for settling foreign particles. Place the reservoir inlet (return lines) below the lowest expected fluid level, as far away from the outlet as possible.

### Overpressure Protection (Only for open circuit system)

MP1 motors have shock valves intended to be used for system over-pressure limitation. However, it is not intended for continuous system pressure limitation. Therefore, relief valves or pressure limiters are required to maintain system pressure within prescribed limits. Relief valves are adequate to protect

## System Design and Parameters

against transient or unusually rapid load application, but excessive or continuous flow through them adds heat to the system and can damage the fluid. In applications operating at or near pressure, use a pressure compensating variable pump. The shock valve function is intended to be used for system overpressure protection events of limited duration only. It is not intended for continuous system pressure limitation. The shock valve is available with 280 bar or 345 bar setting.

## Summing System Pressure Conditions

The sum of system pressure, i.e., system high pressure loop + system low pressure loop must be less than 500-bar pressure. In an application where the motors are in series, the sum pressure of port A & B of the front motor (A+B) should not exceed 500 Bar. As an example, A: 300-Bar / B: 170-Bar.

## Loop Flushing

Closed circuit systems may require loop flushing to meet temperature and cleanliness requirements. A loop flushing valve removes hot fluid from the low pressure side of the system loop for additional cooling and filtering. Ensure the charge pump provides adequate flow for loop flushing and the loop flushing valve does not cause charge pressure to drop below recommended limits.

## Case Pressure / Open Circuit Operation

MP1 motors can be operated with zero pressure in the low side of the system loop. The case pressure must not be higher than 2 bar over the low side loop system pressure. With zero backpressure, the maximum allowed case pressure is 2 bar [29 psi]. Case drain lines must be plumbed accordingly to insure this 2 bar case pressure differential is not exceeded under any circumstances.

## Redundant Braking System Requirement

### **Warning**

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#### **Unintended vehicle or machine movement hazard.**

The loss of hydrostatic drive line power, in any mode of operation (forward, neutral, or reverse) may cause the system to lose hydrostatic braking capacity. You must provide a braking system, redundant to the hydrostatic transmission, sufficient to stop and hold the vehicle or machine in the event of hydrostatic drive power loss.

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## Fluid selection

Ratings and performance data are based on operating with hydraulic fluids containing oxidation, rust and foam inhibitors. These fluids must possess good thermal and hydrolytic stability to prevent wear, erosion, and corrosion of motor components.

### **Caution**

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Never mix hydraulic fluids of different types.

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Fire resistant fluids are also suitable at modified operating conditions. For more information, see *Hydraulic Fluids and Lubricants, Technical Information* **BC152886484524**.

## Case drain

A case drain line must be connected to the case outlets of each motor to return the internal leakage oil to the system reservoir. When filling the case before start up, use the highest case drain outlet to promote complete filling of the case. The case drain fluid is typically the hottest fluid in the system. It is highly

## System Design and Parameters

recommended to route the case drain flow through a heat exchanger before it is returned to the reservoir.

In some applications, it may be required the use of additional cross-flushing of the motor. If the motor is used mainly in a high speed application, higher cooling requirements may be needed for the rotating kit and tapered roller bearings. Use the lowest case drain port as the inlet port and the highest case drain port as the outlet port. This will ensure that the case is full of oil at all times.

Apply unit case pressure ratings to case drain routing and design.

## Bearing loads and life

Bearing life is a function of speed, system pressure and any external side or thrust loads. External side loads are found in some applications such as a helical gear without its own support bearings, installed directly on to the motor shaft. All external side loads will act to reduce the normal bearing life of the motor. Other life factors include oil type and viscosity.

When external side loads are present, the allowable radial shaft loads are a function of the load position relative to the mounting flange, the load orientation relative to the internal loads and the operating pressures of the hydraulic unit. In applications where external shaft loads cannot be avoided, the impact on bearing life can be minimized by proper orientation of the load. Optimal motor orientation is a consideration of the net loading on the shaft from the external load and the motor rotating kit.

Contact Danfoss for a bearing life review if external side loads and thrust loads are present.

## Shaft torque

Available shafts are capable to transmit the maximum torque capability at maximum working pressure. Lubrication or similar treatment of splined motor shaft is recommended for proper torque transmission.

For more information, see **Lubrication of Splined Shafts, Data Sheet, AI152986482538**.

## Shaft Loads

MP1 motors have bearings capable of accepting some external radial and thrust loads. The external radial shaft load limits are a function of the load position, orientation, and the operating conditions of the motor.

### Shaft external load limits

Frame	20/24		
Mounting configuration		SAE	Cartridge
Maximum allowable external moment ( $M_e$ )	N·M	31	104
	lbf·in	274	920
Maximum allowable thrust load (T)	N	1000	
	lbf	225	

All external shaft loads have an effect on bearing life. In motor applications where external shaft loads cannot be avoided, the impact on bearing life can be minimized by orienting the load to the 180 degree position (see Direction of external shaft load, next page).

### Radial load formula

$$M_e = R_e \cdot L$$

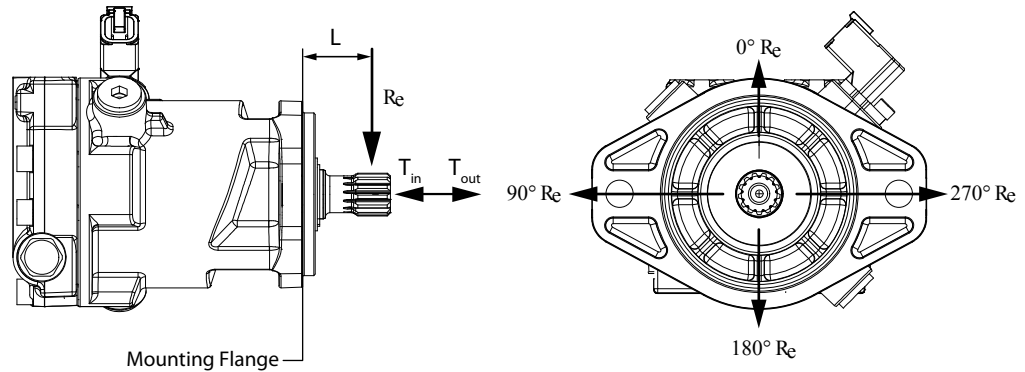
L = Distance from mounting flange to point of load

$M_e$  = Maximum external moment

$R_e$  = Maximum radial side load

## System Design and Parameters

### Shaft load orientation



P400657

## Duty Cycle and Bearing Life

All shaft loads affect bearing life. We recommend tapered shafts or clamp-type couplings for applications with radial shaft loads.

Knowing the operating conditions of your application is the best way to ensure proper motor selection. With accurate duty cycle information, your Danfoss representative can assist in calculating expected motor life.

## Hydraulic Equations Helpful for Motor Selection

Use the following equations to compute output power, torque, speed, and input flow. Selecting the right motor starts with an evaluation of system requirements such as speed and torque. Select a motor that will transmit the required torque, then select a pump that will meet the flow and pressure requirements of the motor.

## System Design and Parameters

### Determination of Nominal Motor Size

The following equations are used to compute the input flow, output torque, output power and speed. Generally, sizing the right motor starts with an evaluation of the machine requirements such as speed and torque. Select a motor that will transmit the required torque, then select a pump that will meet the flow and pressure requirements of the motor.

<i>Unit:</i>	<i>Metric System:</i>	<i>Inch System</i>
<i>Input flow</i>	$Q_e = \frac{V_g \cdot n}{1000 \cdot \eta_v}$ l/min	$Q_e = \frac{V_g \cdot n}{231 \cdot \eta_v}$ [gpm]
<i>Output torque</i>	$M_e = \frac{V_g \cdot \Delta p \cdot \eta_m}{20 \cdot \pi}$ Nm	$M_e = \frac{V_g \cdot \Delta p \cdot \eta_m}{2 \cdot \pi}$ [lbf·in]
<i>Output power</i>	$P_e = \frac{Q_e \cdot \Delta p \cdot \eta_t}{600}$ kW	$P_e = \frac{V_g \cdot n \cdot \Delta p \cdot \eta_t}{396\,000}$ [hp]
<i>Speed</i>	$n = \frac{Q_e \cdot 1000 \cdot \eta_v}{V_g}$ min <sup>-1</sup>	$n = \frac{Q_e \cdot 231 \cdot \eta_v}{V_g}$ (rpm)

### Variables

#### ***SI units [US units]***

$Q_e$  = Input flow l/min (US gal/min)

$M_e$  = Output torque N·m (lbf·in)

$p_e$  = Output power kW (hp)

$n$  = Speed min<sup>-1</sup> (rpm)

$V_g$  = Displacement per revolution cm<sup>3</sup>/rev [in<sup>3</sup>/rev]

$p_o$  = Outlet pressure bar [psi]

$p_i$  = Inlet pressure bar [psi]

$\Delta p$  =  $p_o - p_i$  (system pressure) bar [psi]

$\eta_v$  = Volumetric efficiency

$\eta_{mh}$  = Mechanical-hydraulic efficiency

$\eta_t$  = Motor total efficiency ( $\eta_v \cdot \eta_{mf}$ )

## Master Model Code

### Model Code (B-C-D-E)



#### B - Configuration

Code	Description
F	Mounting Flange: SAE Flange
C	Mounting Flange: CARTRIDGE Flange

#### C - Displacement

Code	Description
020N	20 cm <sup>3</sup> /rev [1.22 in <sup>3</sup> /rev]
024N	24 cm <sup>3</sup> /rev [1.46 in <sup>3</sup> /rev]

#### D - Output Shaft

Code	Description
A	13 tooth 16/32 pitch per ANSI B92.1-1970 class 5 without dust seal
C	15 tooth 16/32 pitch per ANSI B92.1-1970 class 5 without dust seal
E	Round straight keyed 22.23 mm (long) without dust seal
F	Round straight keyed 22.23 mm (long) with dust seal
G	Tapered 22.225 mm without dust seal
H	Tapered 22.225 mm with dust seal
J	Round straight keyed 22.23 mm (middle) without dust seal
K	Round straight keyed 22.23 mm (middle) with dust seal
L	17 tooth 24/48 pitch per ANSI B92.1 class 6 without dust seal

#### E - System Port Type, Loop Flushing & Anti-Cavitation

Code	Description
SA1	System Ports (Inch) w/ defeated LF Valve
SB1	System Ports (Inch) w/ Loop Flushing (1.5 lpm @ 15 Bar)
SB2	System Ports (Inch) w/ Loop Flushing (3.6 lpm @ 15 Bar)
SC1	System Ports (Inch) Anti-cavitation, Port A 280 Bar Shock Valve
SC2	System Ports (Inch) Anti-cavitation, Port A 345 Bar Shock Valve
SD1	System Ports (Inch) Anti-cavitation, Port B 280 Bar Shock Valve
SD2	System Ports (Inch) Anti-cavitation, Port B 345 Bar Shock Valve
SE1	System Ports (Inch) w/ Gauge Ports, None
MA1	System Ports (Metric) w/ defeated Loop Flushing Valve
MB1	System Ports (Metric) w/ Loop Flushing (1.5 lpm @ 15 Bar)
MB2	System Ports (Metric) w/ Loop Flushing (3.6 lpm @ 15 Bar)
MC1	System Ports (Metric) Anti-cavitation, Port A 280 Bar Shock Valve
MC2	System Ports (Metric) Anti-cavitation, Port A 345 Bar Shock Valve
MD1	System Ports (Metric) Anti-cavitation, Port B 280 Bar Shock Valve
MD2	System Ports (Metric) Anti-cavitation, Port B 345 Bar Shock Valve

**Master Model Code**
**Model Code (K-L-M-N)**

**K - Mounting Flange & Case Drain, Speed Sensing**

Code	Description
AN	SAE 'A' Flange (Inch), Speed Sensor None
AA	SAE 'A' Flange (Inch), with Speed Sensor
AB	SAE 'A' Flange (Inch), with Speed Sensor, guard
BN	SAE 'B' Flange (Inch), Speed Sensor None
BA	SAE 'B' Flange (Inch), with Speed Sensor
BB	SAE 'B' Flange (Inch), with Speed Sensor, guard
CN	CATRIDGE Flange (Inch), Speed Sensor None
CA	CATRIDGE Flange (Inch), with Speed Sensor
CB	CATRIDGE Flange (Inch), with Speed Sensor, guard
DN	SAE 'A' Flange (Metric), Speed Sensor None
DA	SAE 'A' Flange (Metric), with Speed Sensor
DB	SAE 'A' Flange (Metric), with Speed Sensor, guard
EN	SAE 'B' Flange (Metric), Speed Sensor None
EA	SAE 'B' Flange (Metric), with Speed Sensor
EB	SAE 'B' Flange (Metric), with Speed Sensor, guard
FN	CATRIDGE Flange (Metric), Speed Sensor None
FA	CATRIDGE Flange (Metric), with Speed Sensor
FB	CATRIDGE Flange (Metric), with Speed Sensor, guard

**L - Setting**

Code	Description
NNN	None

**M - Special Hardware Features**

Code	Description
20A	Cylinder block Kit, 20cc standard
24A	Cylinder Block Kit, 24cc standard

**N - Paint and Nametag**

Code	Description
NNN	Black Paint and Danfoss Nametag
C08	Paint None and Danfoss Nametag

## Features and Options

### Shaft Options

MP1 motors are available with a variety of splined, straight keyed, and tapered shaft ends. Nominal shaft sizes and torque ratings for some available shafts are shown in the accompanying table. Other shaft options may exist. Contact your Danfoss representative for availability.

Torque ratings assume no external radial loading. **Continuous torque** ratings for splined shafts are based on spline tooth wear, and assume the mating spline has a minimum hardness of  $R_c 55$  to full spline depth and coupling has good lubrication.

**Maximum torque** ratings are based on shaft torsional strength and assume a maximum of 200,000 load reversals.

#### *Shaft availability and torque ratings*

N•m [lbf•in]		20/24
Spline, 13 tooth, 16/32 pitch	Max	226 [2000]
Spline, 15 tooth, 16/32 pitch	Max	362 [3200]
Spline, 17 tooth, 24/48 pitch	Max	165 [1460]
Tapered, $\varnothing 22.225$ mm	Max	362 [3200]
Straight keyed, $\varnothing 22.225$ mm	Max	226 [2000]

Recommended mating splines for MP1 motor splined output shafts should be in accordance with ANSI B92.1 Class 5. Danfoss external splines are modified Class 5 Fillet Root Side Fit. The external spline Major Diameter and Circular Tooth Thickness dimensions are reduced in order to assure a clearance fit with the mating spline.

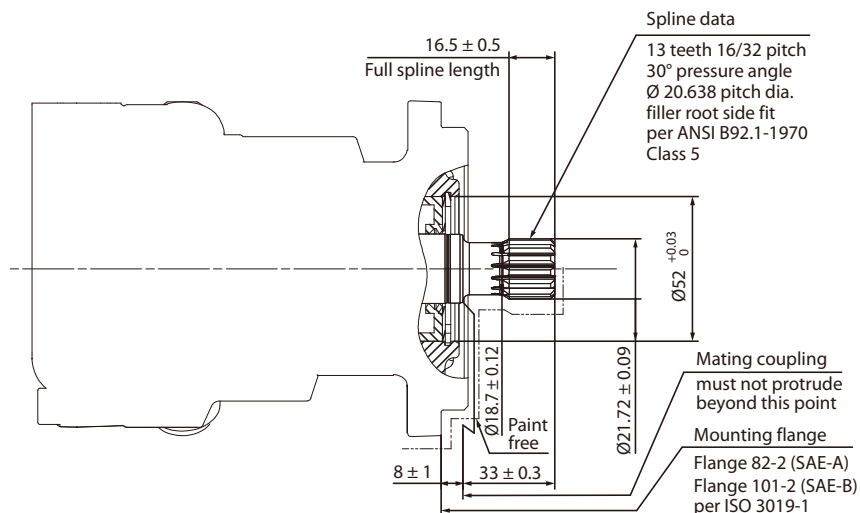
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**Installation drawings**

**Output Shafts: Option A (SAE A, B, 13 teeth)**

*Option A, ISO 3019-1, Outer dia 21.72 mm*



P400638

	<b>20/24</b>
Full spline length	16.5 ± 0.5

*Specifications*

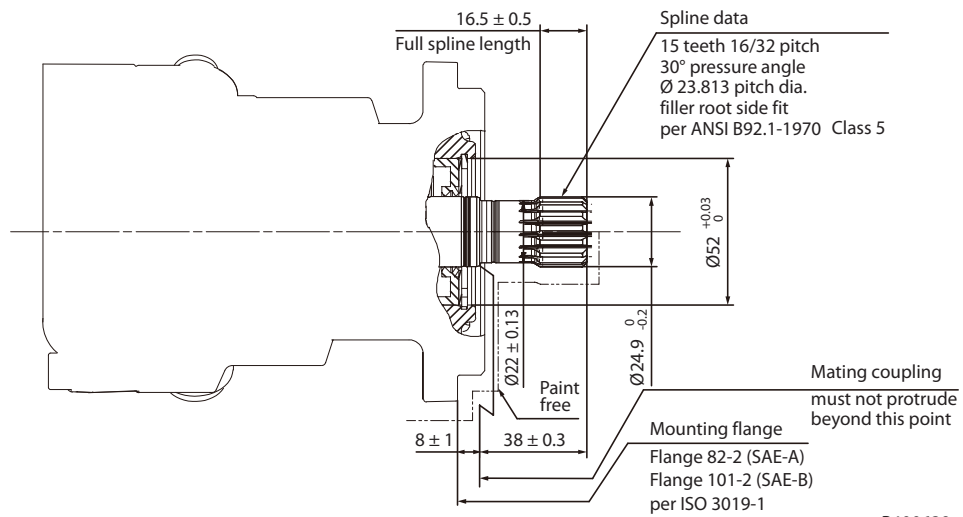
<b>Option</b>	<b>A</b>	
<b>Spline</b>	13 teeth, 16/32 pitch	
<b>Torque rating</b>	Maximum	226 N·m (2000 lbf-in)

[Please contact Danfoss representative for specific installation drawings.](#)

**Installation drawings**

**Output Shafts: Option C (SAE A, B, 15 teeth)**

*Option C, ISO 3019-1, Outer dia 24.9 mm*



P400639

	<b>20/24</b>
Full spline length	16.5 ± 0.5

*Specifications*

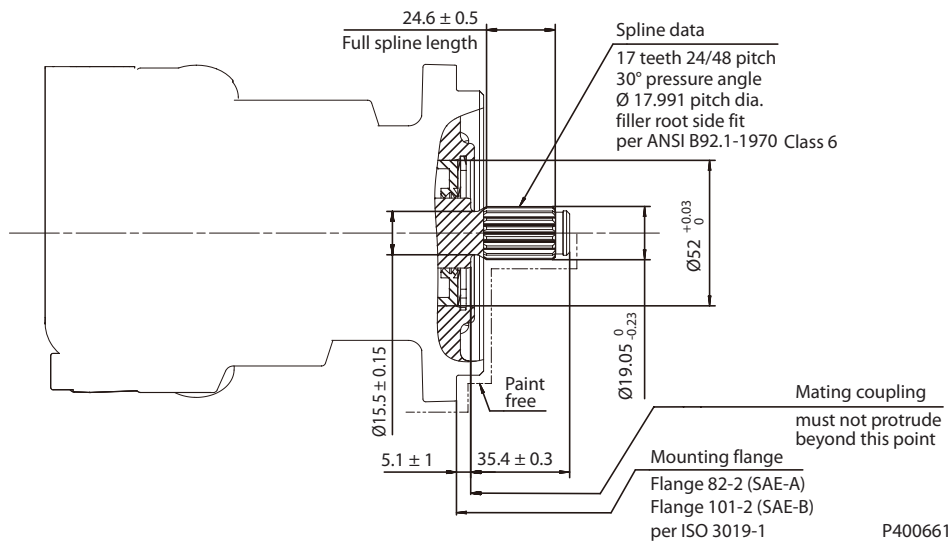
<b>Option</b>	<b>C</b>	
<b>Spline</b>	15 teeth, 16/32 pitch	
<b>Torque rating</b>	Maximum	362 N•m (3200 lbf-in)

[Please contact Danfoss representative for specific installation drawings.](#)

**Installation drawings**

**Output Shafts: Option L (SAE B, 17 teeth)**

*Option L, ISO 3019-1, Outer dia 19.05 mm*



	<b>20/24</b>
Full spline length	24.6 ± 0.5

*Specifications*

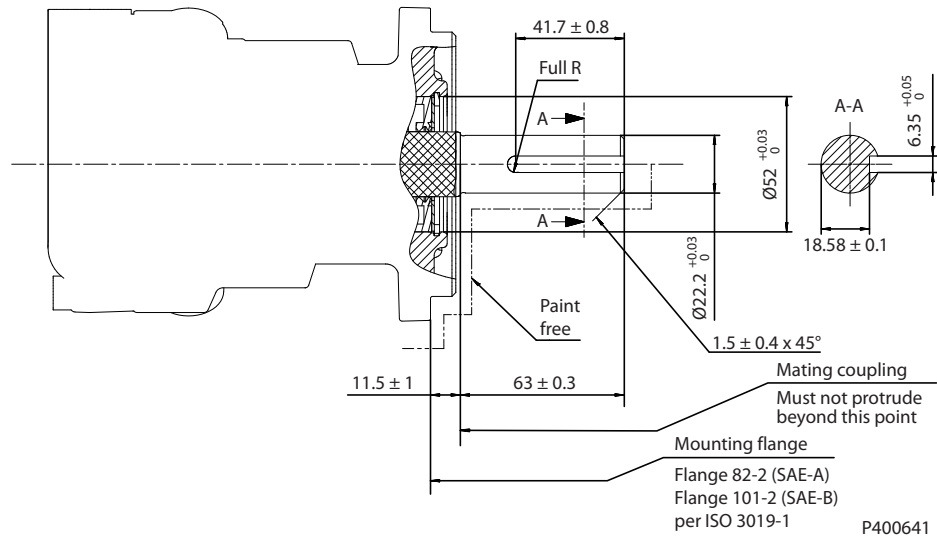
<b>Option</b>	<b>C</b>	
<b>Spline</b>	17 teeth, 24/48 pitch	
<b>Torque rating</b>	Maximum	165 N·m (1460 lbf-in)

[Please contact Danfoss representative for specific installation drawings.](#)

**Installation drawings**

**Output Shafts: Option E, F (SAE A, B, Straight Key Shaft: Long)**

*Option E, F, ISO 3019-1, Outer dia 22.2 mm*



*Specifications*

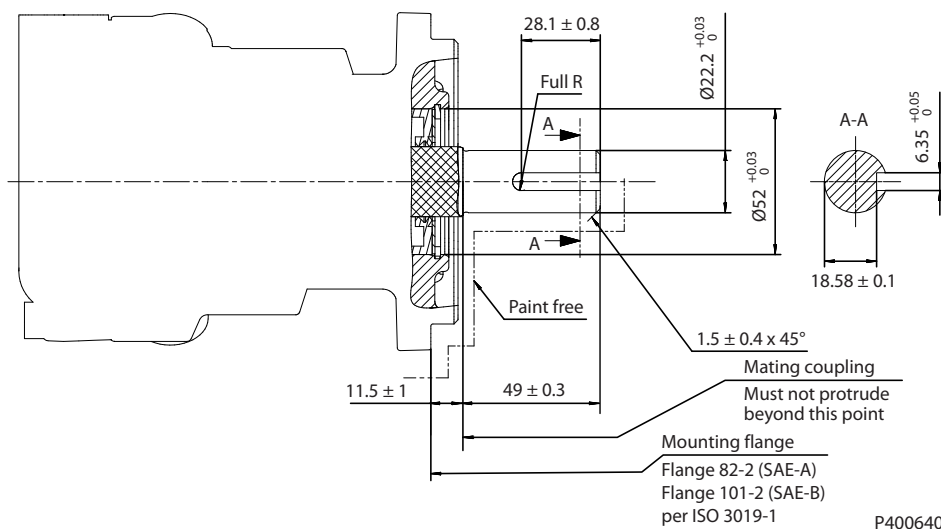
Option		E, F
Torque rating	Maximum	226 N•m (2000 lbf-in)

[Please contact Danfoss representative for specific installation drawings.](#)

**Installation drawings**

**Output Shafts: Option J, K (SAE A, B, Straight Key Shaft: Middle)**

*Option J, K, ISO 3019-1, Outer dia 22.2 mm*



*Specifications*

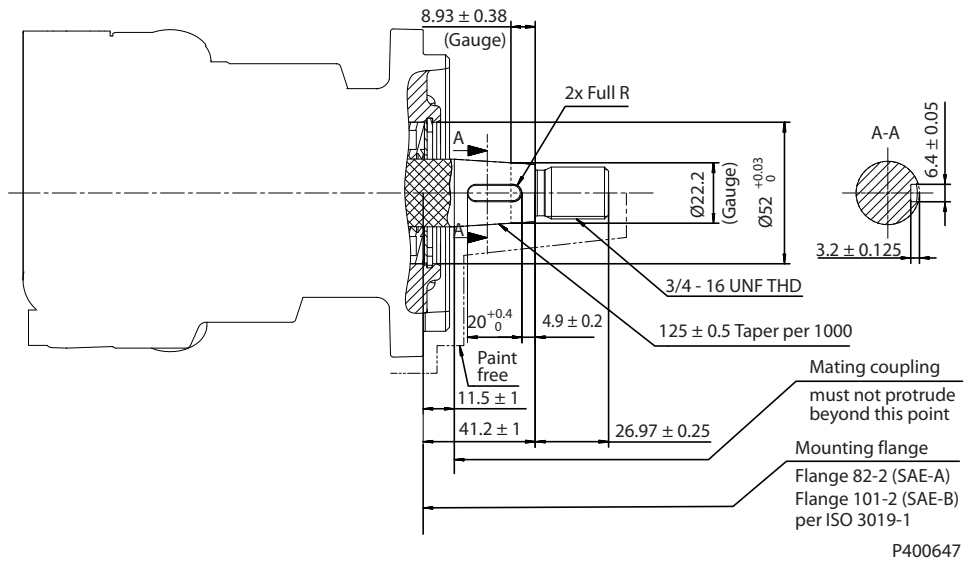
Option		J, K
<b>Torque rating</b>	Maximum	226 N·m (2000 lbf-in)

[Please contact Danfoss representative for specific installation drawings.](#)

Installation drawings

Output Shafts: Option G, H (SAE A, B, Taper Key Shaft)

Output Shafts: Option G, H (SAE A, B, Taper Key Shaft)



Specifications

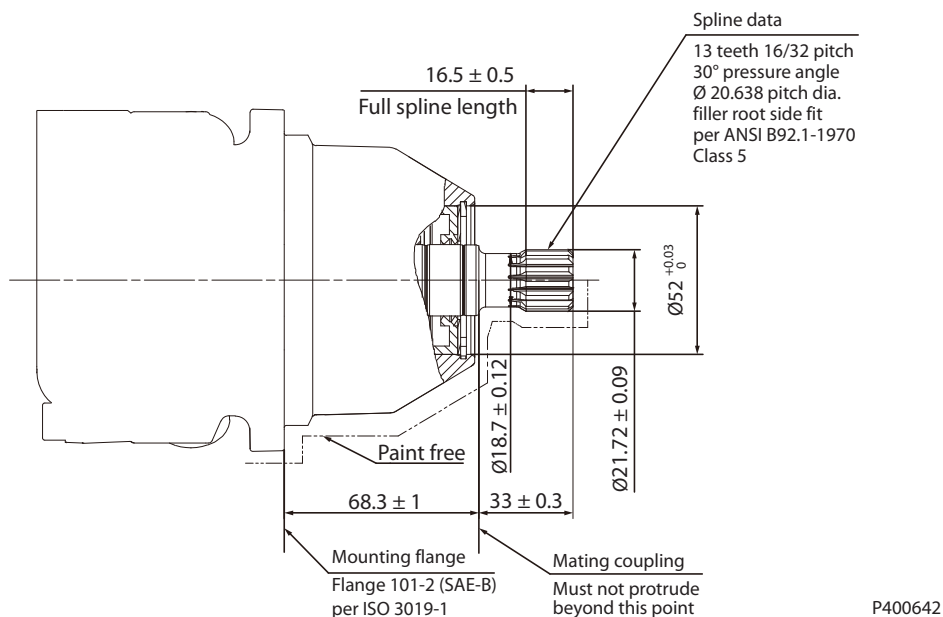
Option	G, H	
Torque rating	Maximum	362 N•m (2000 lbf-in)

Please contact Danfoss representative for specific installation drawings.

**Installation drawings**

**Output Shafts: Option A (Cartridge, 13 teeth)**

Option A, ISO 3019-1, Outer dia, 21.72mm



	<b>20/24</b>
Full spline length	16.5 ± 0.5

*Specifications*

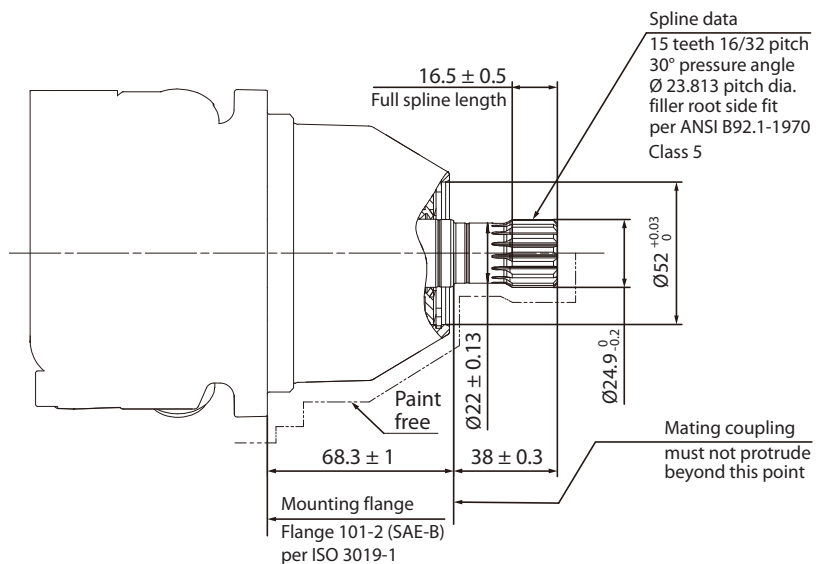
<b>Option</b>	<b>A</b>	
<b>Spline</b>	13 teeth, 16/32 pitch	
<b>Torque rating</b>	Maximum	226 N·m (2000 lbf-in)

[Please contact Danfoss representative for specific installation drawings.](#)

**Installation drawings**

**Output Shafts: Option C (Cartridge, 15 teeth)**

*Option C, ISO 3019-1, Outer dia 24.9 mm*



P400643

	<b>20/24</b>
Full spline length	16.5 ± 0.5

*Specifications*

<b>Option</b>	<b>C</b>	
<b>Spline</b>	15 teeth, 16/32 pitch	
<b>Torque rating</b>	Maximum	362 N·m (3200 lbf-in)

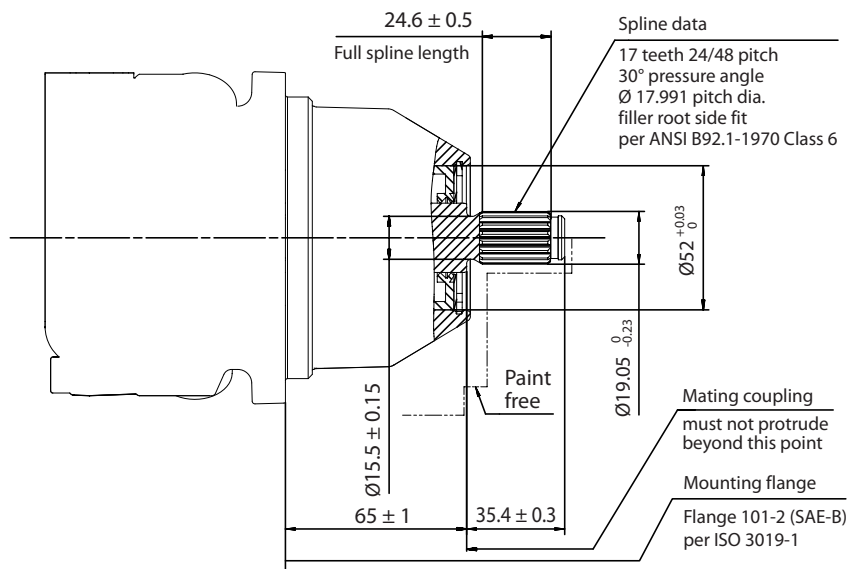
[Please contact Danfoss representative for specific installation drawings.](#)



**Installation drawings**

**Output Shafts: Option L (Cartridge, 17 teeth)**

*Option L, ISO 3019-1, Outer dia 19.05 mm*



P400662

*Specifications*

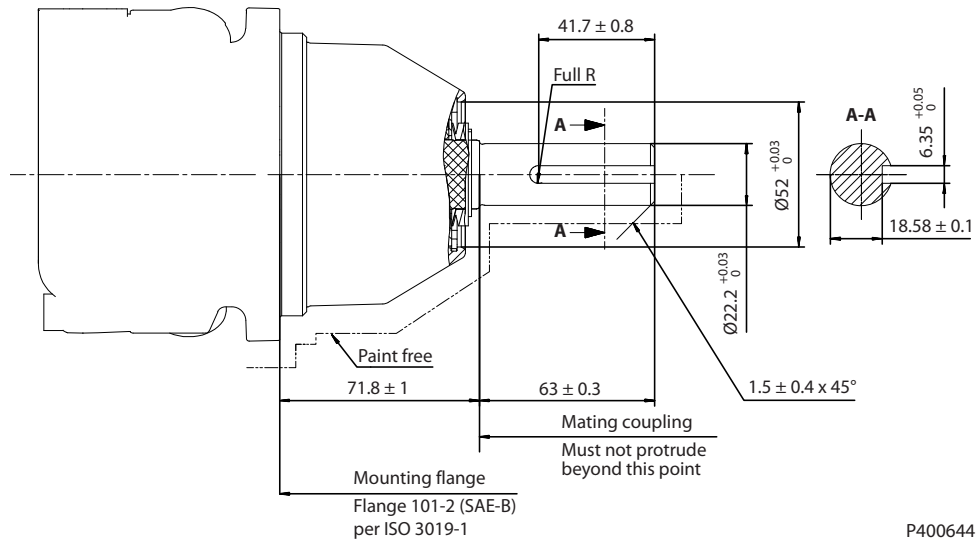
<b>Option</b>	<b>L</b>	
<b>Spline</b>	17 teeth, 24/48 pitch	
<b>Torque rating</b>	Maximum	165 N·m (1460 lbf-in)

[Please contact Danfoss representative for specific installation drawings.](#)

**Installation drawings**

**Output Shafts: Option E, F (Cartridge, Key Shaft : Long)**

Option E, F, ISO 3019-1, Outer dia 22.2 mm



*Specifications*

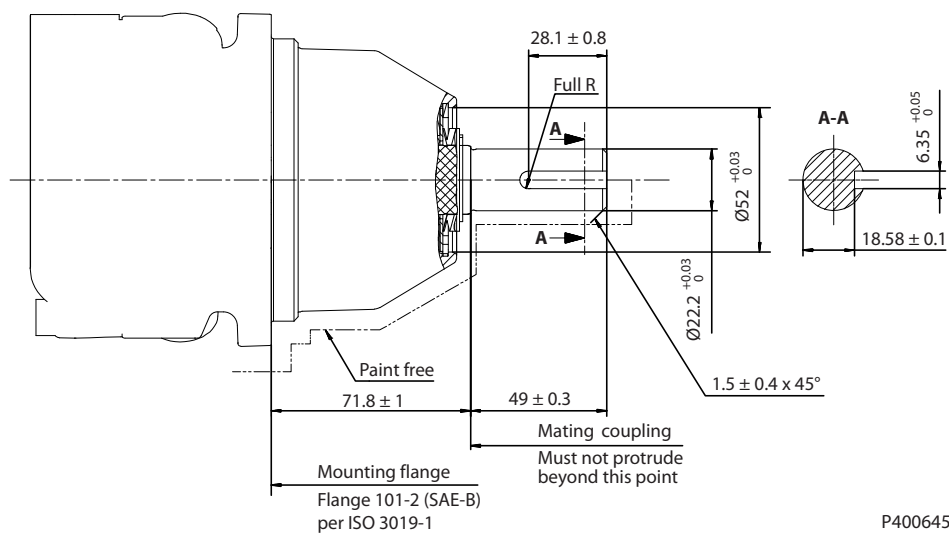
Option		E, F
Torque rating	Maximum	226 N•m (2000 lbf-in)

Please contact Danfoss representative for specific installation drawings.

**Installation drawings**

**Output Shafts: Option J, K (Cartridge, Key Shaft : Middle)**

*Option J, K, ISO 3019-1, Outer dia 22.2 mm*



*Specifications*

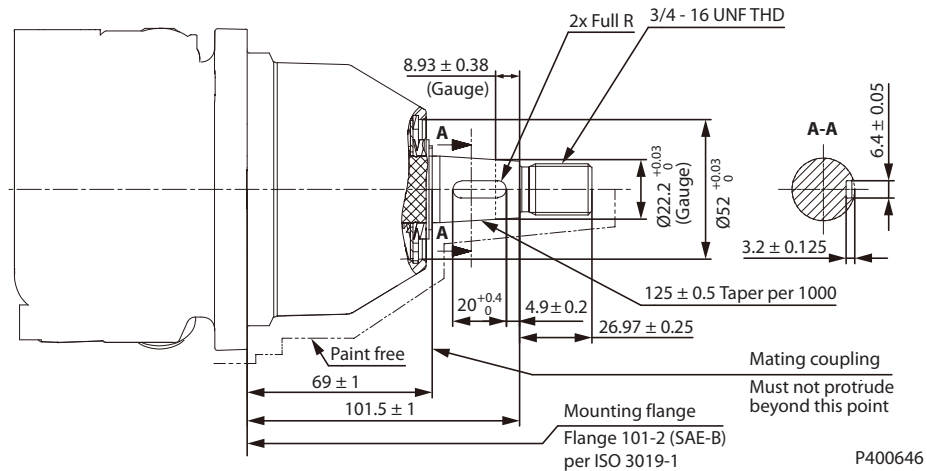
Option		J, K
<b>Torque rating</b>	Maximum	226 N·m (3200 lbf-in)

[Please contact Danfoss representative for specific installation drawings.](#)

**Installation drawings**

**Output Shafts: Option G, H, (Cartridge, Taper key shaft)**

*Option G, H, ISO 3019-1, Outer dia 22.2 mm, 125+0.5 Taper per 1000*



*Specifications*

Option	G, H	
<b>Torque rating</b>	Maximum	362 N•m (3200 lbf-in)

Please contact Danfoss representative for specific installation drawings.

**Tapered shaft customer acknowledgement**

The Danfoss MP1 tapered shaft has been designed using the industry standard ISO 3019-1, minus the through-hole in the end of the shaft. Danfoss recommends a self-locking nut instead of a castle nut and pin. The nut and mating square-cut key are customer supplied.

The specified torque rating of the tapered shaft documented above is based on the cross-sectional diameter of the shaft, through the keyway, and assumes the proper clamp and fit between shaft and coupling. Danfoss guarantees the design and manufactured quality of the tapered shaft. The customer is responsible for the design and manufactured quality of the mating female coupling and key and applied torque on the nut. Danfoss has made provisions for the key in accordance to the ISO specification with the understanding that the key is solely to assist in the installation of the mating coupling.

**! Caution**

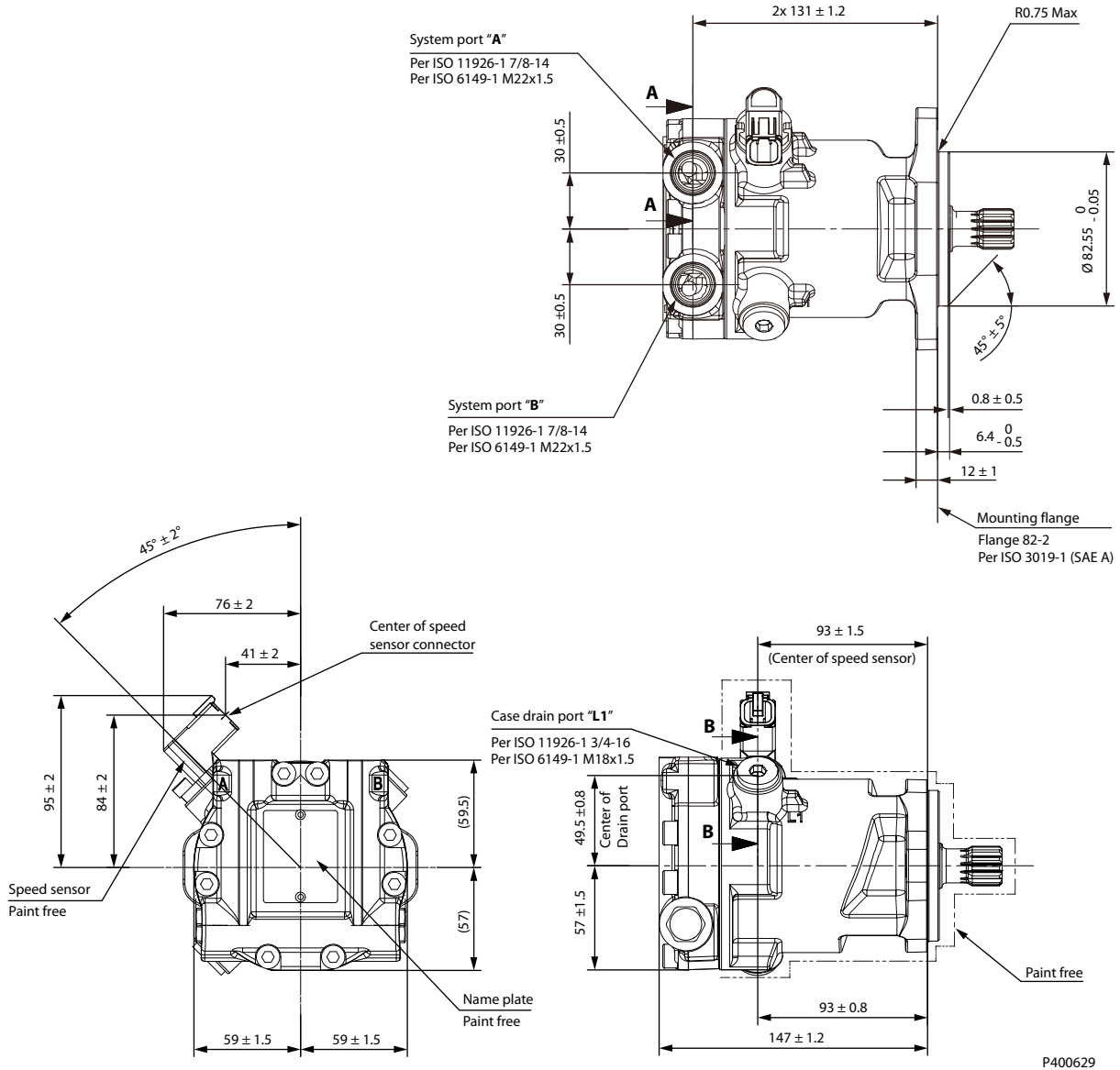
Torque must be transmitted by the taper fit between the shaft and it's mating coupling, not the key. Torque or loading inadvertently transmitted by the customer supplied key may lead to premature shaft failure.

**Installation drawings****Motor Rotation***Rotation by flow direction*

<b>Port A</b>	<b>Port B</b>	<b>Motor shaft rotation</b>
Out	In	Clockwise (CW)
In	Out	Counterclockwise (CCW)

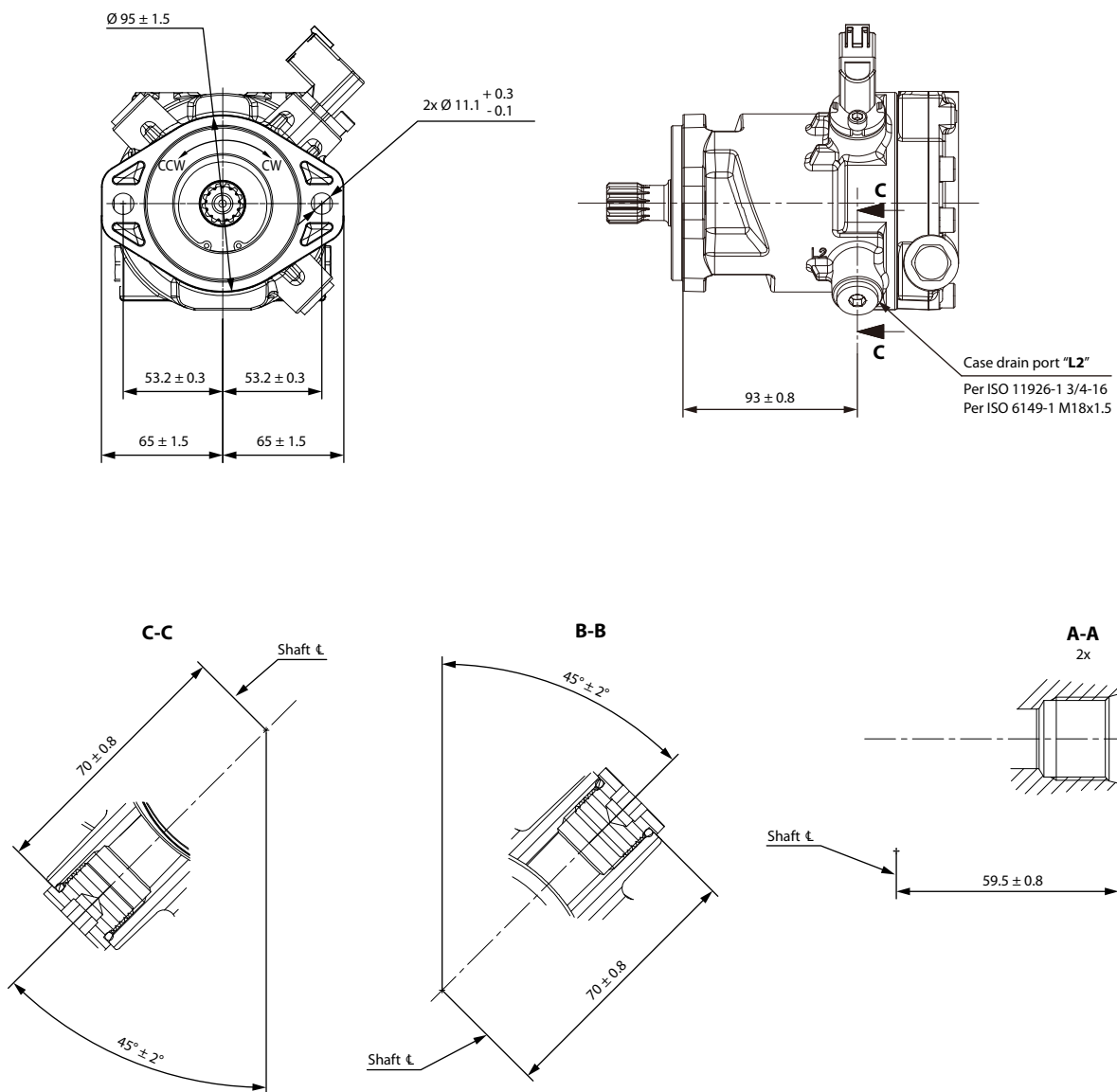
Installation drawings

MP1M20/24: Mounting flange SAE-A



Please contact Danfoss representative for specific installation drawings.

**Installation drawings**

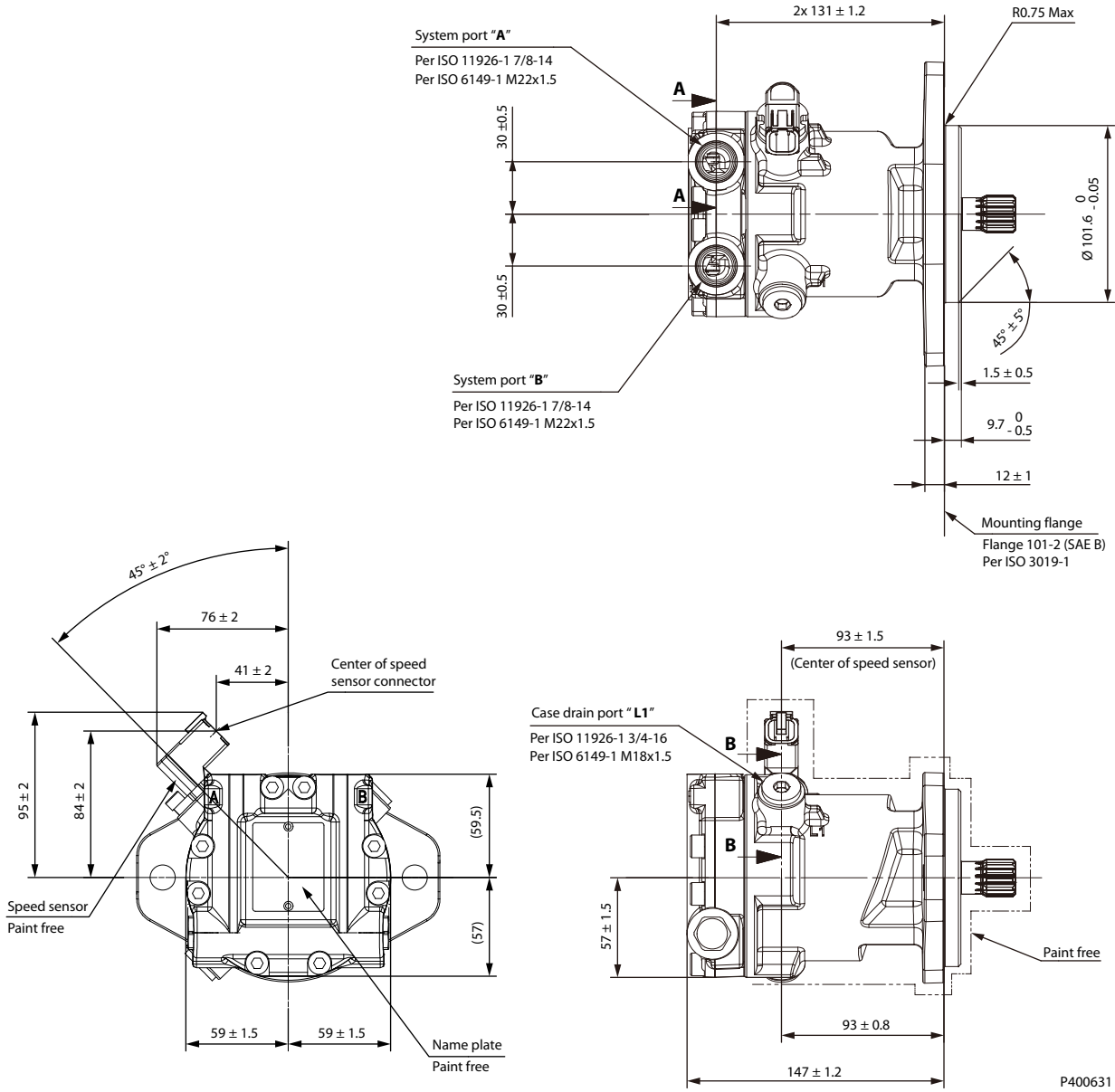


P400630

Please contact Danfoss representative for specific installation drawings.

**Installation drawings**

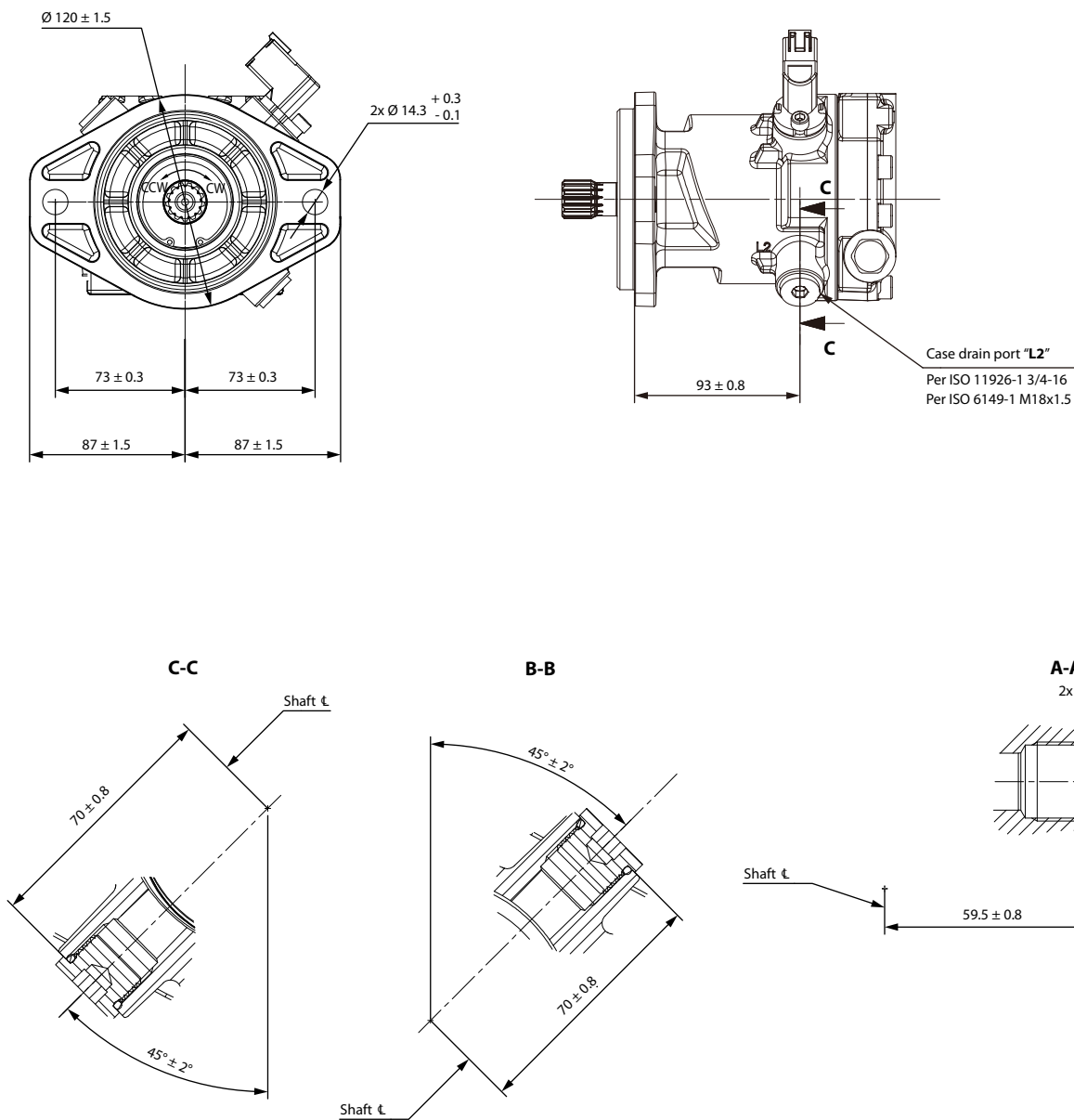
**MP1M20/24: Mounting flange SAE-B**



Please contact Danfoss representative for specific installation drawings.



**Installation drawings**

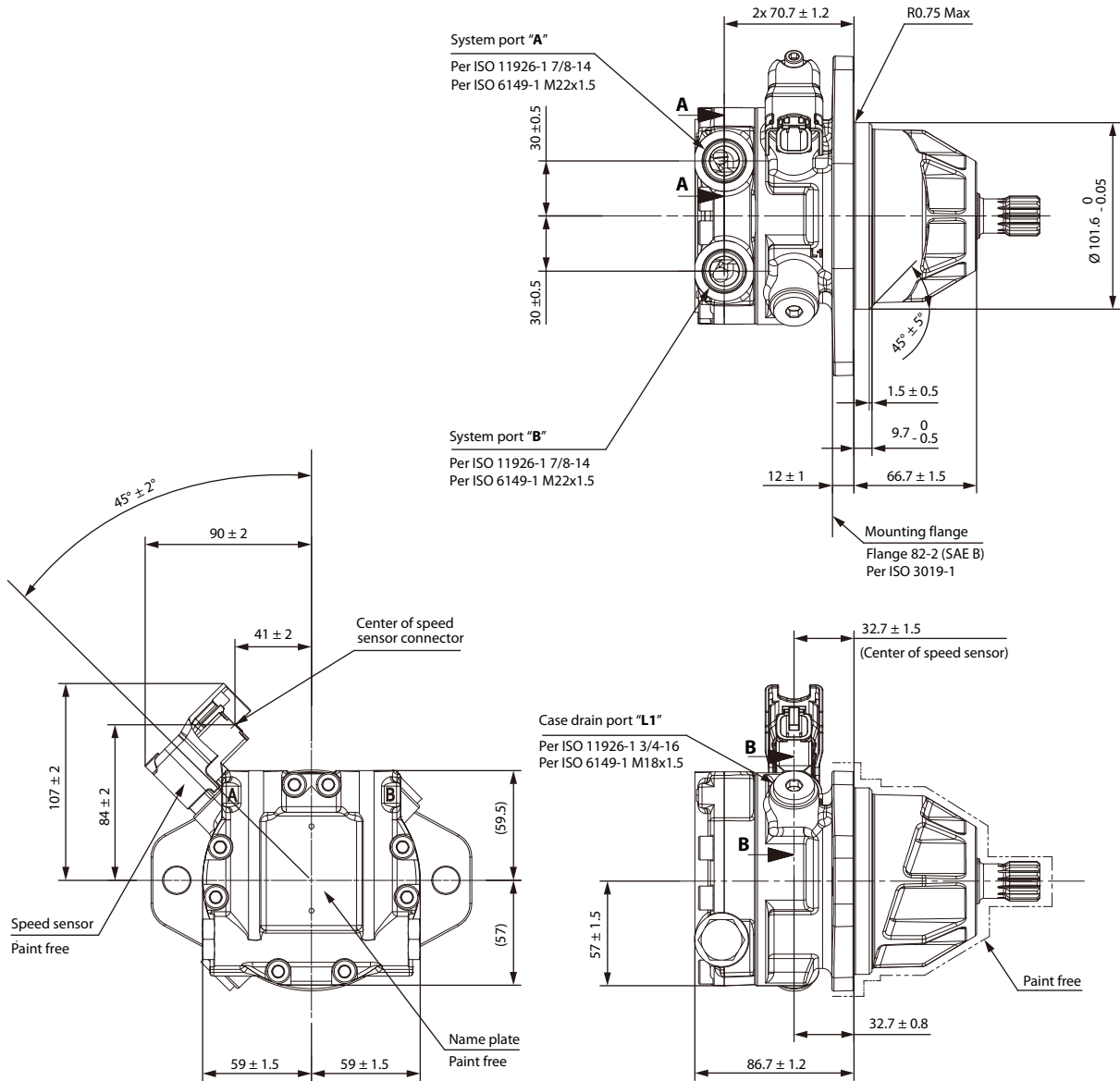


P400632

Please contact Danfoss representative for specific installation drawings.

Installation drawings

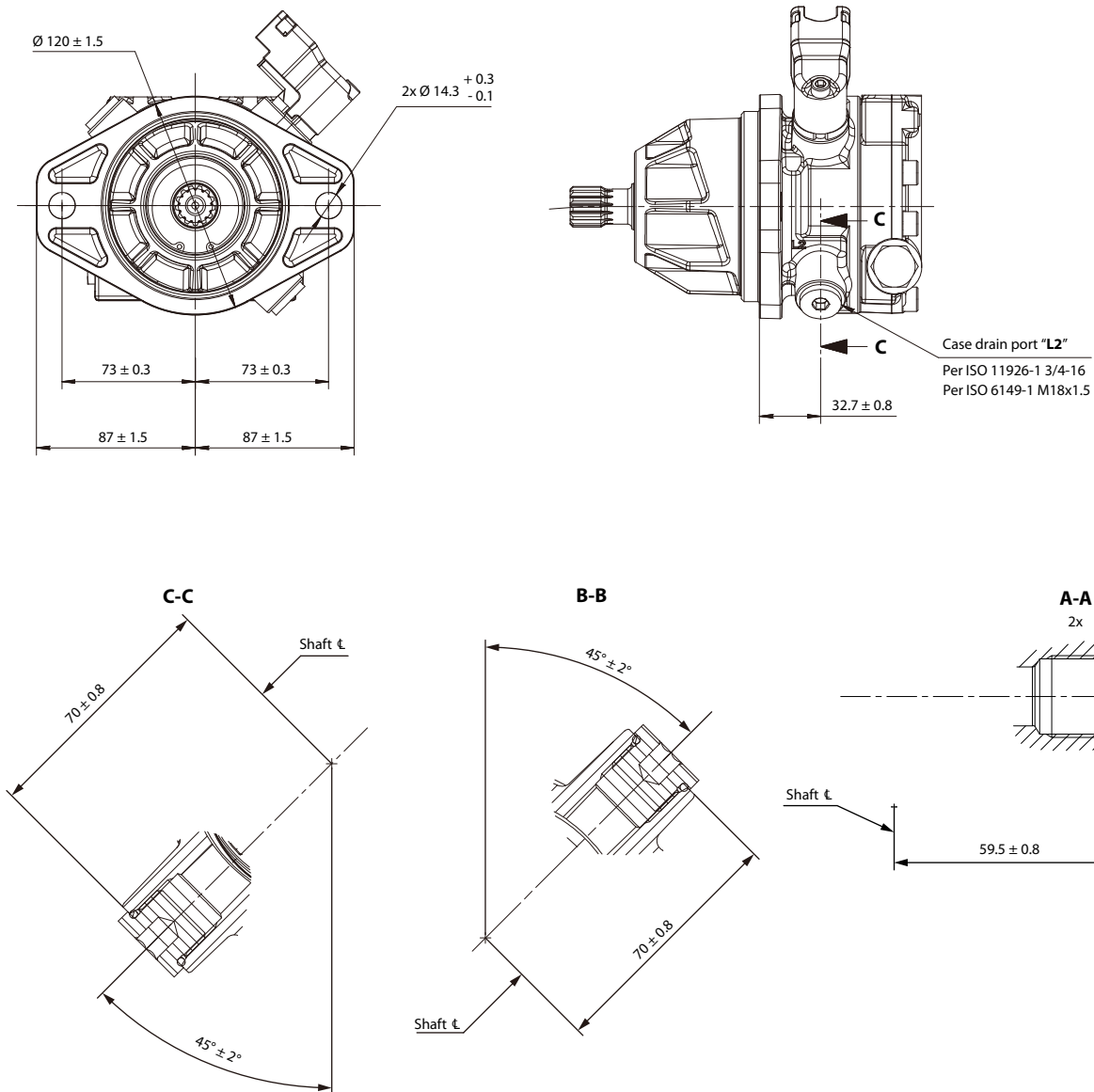
MP1M20/24: Mounting flange Cartridge Style



P400633

Please contact Danfoss representative for specific installation drawings.

**Installation drawings**



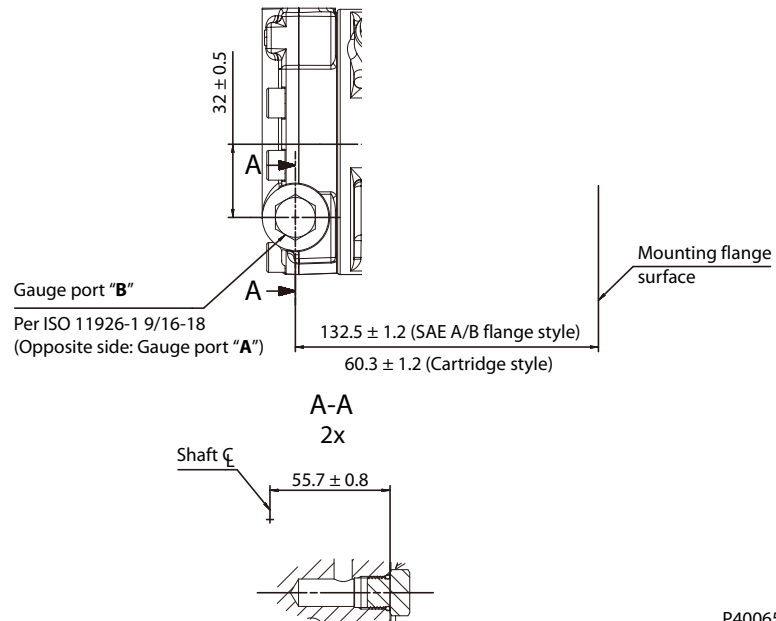
P400634

Please contact Danfoss representative for specific installation drawings.

### Installation drawings

#### Gauge port "A", "B"

(for E-System port style option "SE1" only)



P400659

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