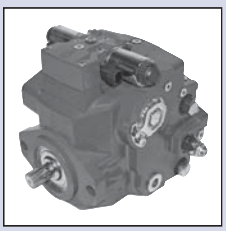
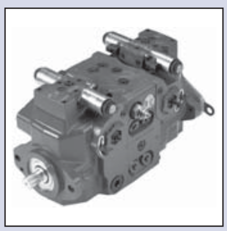
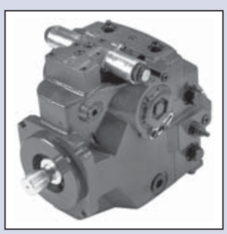
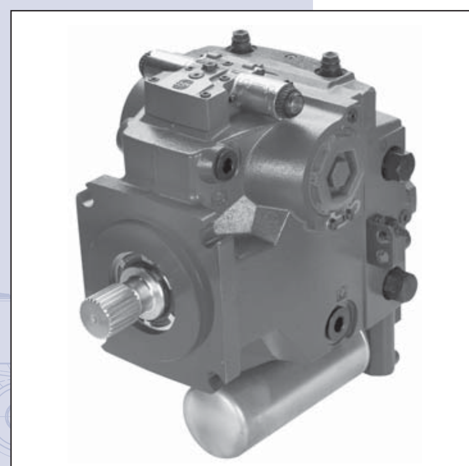
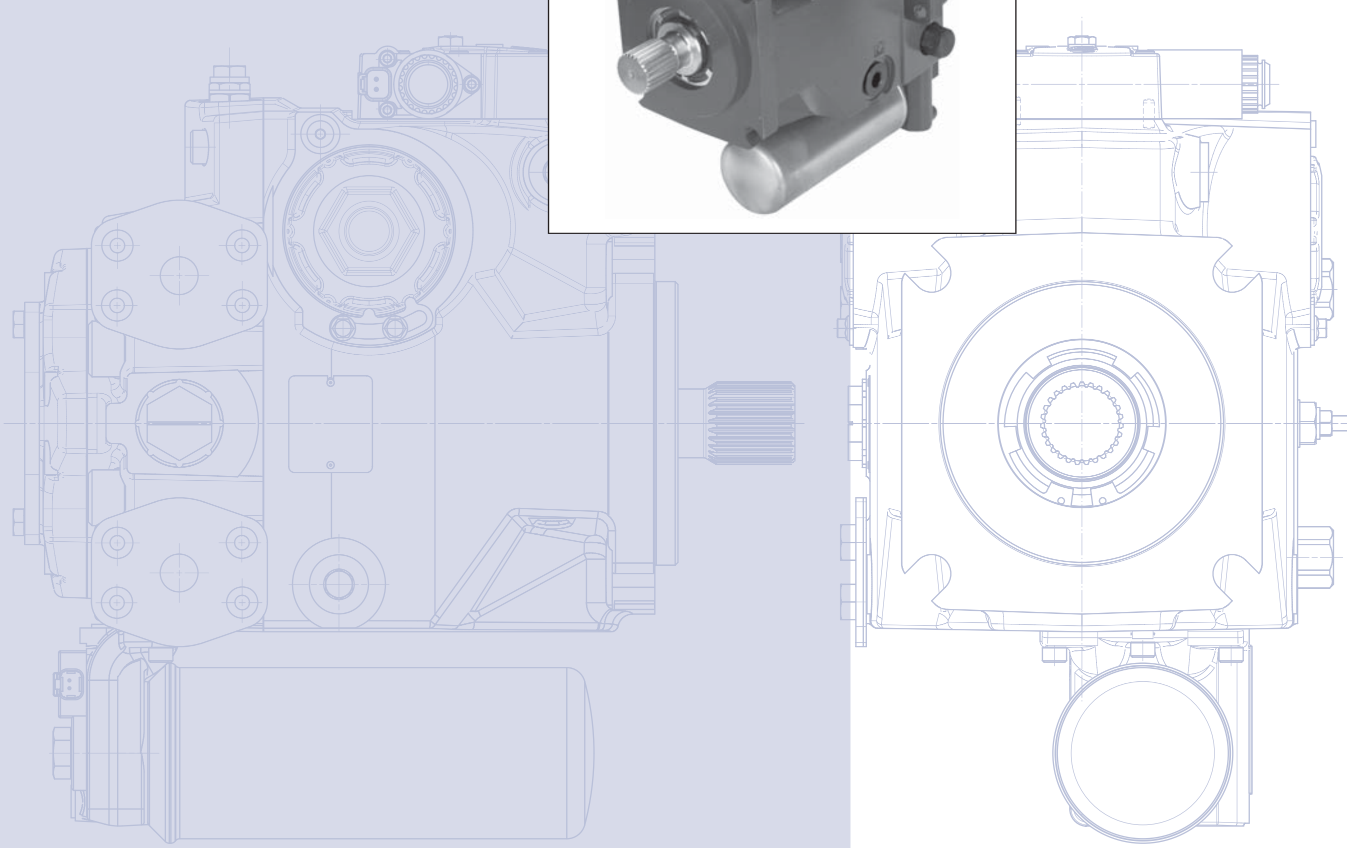
H1

Axial Piston Pumps
045/053 Tandem
147/165 Single

Technical Information

History of Revisions

Table of Revisions

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Contents

Sauer-Danfoss Hydrostatic Product Family

General Description 4
General Description H1 Family of Hydrostatic Pumps 4

H1 General Information

The H1 Range of Products 5
A Word about the Organization of this Manual 5
System Diagram 6
  Single Pump 6
System Schematic 7
  Single Pump 7
System Diagram 8
  Tandem Pump 8
System Schematic 9
  Tandem Pump 9

Operation

Pressure Limiter Valves 10
High Pressure Relief Valve (HPRV) and Charge Check 10
Bypass 11
Charge Pressure Relief Valve (CPRV) 12
Electrical Displacement Control (EDC) 13
Manual Over Ride (MOR) 14
Control Cut Off (CCO) 15

Operating Parameters

Overview 16
Input Speed 16
System Pressure 16
Servo Pressure 17
Charge Pressure 17
Charge Pump Inlet Pressure 17
Case Pressure 18
External Shaft Seal Pressure 18
Temperature and Viscosity 18

System Design Parameters

Filtration System 19
Filtration 20
Independent Braking System 23
Fluid Selection 24
Reservoir 24
Case Drain 24
Charge Pump 25
Bearing Loads & Life 25
Mounting Flange Loads 27
Shaft Torque Rating and Spline Lubrication 28
Shaft Availability and Torque Ratings 28
Understanding and Minimizing System Noise 29
Sizing Equations 30

Frame 045/053 cm³ Tandem Pump

Frame 045/053 cm³ Tandem Pump 32

Frame 147/165 cm³ Single Pump

Frame 147/165 cm³ Single Pump 58

SAUER DANFOSS

H1 Axial Piston Pumps
Technical Information
Sauer-Danfoss Hydrostatic Product Family

General Description

The **H1** axial piston variable displacement pumps are of cradle swashplate design and are intended for closed circuit applications.

The flow rate is proportional to the pump input speed and displacement.
The latter is infinitely adjustable between zero and maximum displacement.
Flow direction is reversed by tilting the swashplate to the opposite side of the neutral (zero displacement) position.

- 4 different displacements: 45 cm^3 [2.74 in^3], 53.8 cm^3 [3.28 in^3], 147 cm^3 [9 in^3] and 165 cm^3 [10 in^3]
- Electric displacement control
- Improved reliability and performance
- More compact and lightweight

General Description H1 Family of Hydrostatic Pumps

The H1 family of closed circuit variable displacement axial piston pumps is designed for use with all existing Sauer-Danfoss hydraulic motors for the control and transfer of hydraulic power. H1 pumps are compact and high power density where all units utilize an integral electro-hydraulic servo piston assembly that controls the rate (speed) and direction of the hydraulic flow. H1 pumps are specifically compatible with the Sauer-Danfoss family of PLUS+1™ microcontrollers for easy Plug-and-Perform™ installation.
H1 pumps can be used together in combination with other Sauer-Danfoss pumps and motors in the overall hydraulic system. Sauer-Danfoss hydrostatic products are designed with many different displacement, pressure and load-life capabilities. A quick overview of the total Sauer-Danfoss hydrostatic pump and motor product line is shown below. Go to the Sauer-Danfoss website or applicable product catalog to choose the components that are right for your complete closed circuit hydraulic system.

Hydrostatic Products Family Overview

Product Name	Product Description	Displacement Range	Pressure Rated	Control Options available	Technical Information No.
Series 70	Pumps, Intergral Transmission	10-21 cc/rev	145 bar	Pumps: DDC	BLN-10006
Series 15	Pumps, Integral Tandem Pumps, Fixed Motors, Integral Transmissions	15 cc/rev	310 bar	Pumps: DDC Motors: Fixed	BLN-10006
Series 40	Pumps, Integral Tandem Pumps, Fixed & Variable Motors	25-46 cc/rev	350 bar	Pumps: DDC, MDC, EDC, FNR Motors: Fixed	520L0635 520L0636
Series 42	Pumps	28-51 cc/rev	400 bar *	MDC, NFPH	BLN-10092
L/K	Variable Motor	25-45 cc/rev	400 bar *	Hydraulic Pilot	520L0627
Series 90	Pumps Fixed Motors	42-250 cc/rev 42-100 cc/rev	450 bar	MDC, EDC, FNR, NFPE Fixed	520L0603 520L0604
H1	Pumps	45-165 cc/rev	480 bar *	EDC	520L0823
Series 51	Variable Motors	60-250 cc/rev	450 bar	2-Position & Proportional (hydraulic & electric)	520L0440
LSHT	LSHT motors exist in many sizes and pressure ranges.				

* Varies by displacement

DDC: Direct Displacement Control (non servo)
MDC: Manual Displacement Control (integral servo)
EDC: Electric Displacement Control (integral servo)
FNR: Forward – Neutral – Reverse (electric 3 position)
NFPE: Non Feedback Proportional Electric (integral servo)
NFPH: Non Feedback Proportional Hydraulic
LSHT: Low Speed High Torque motors
NA: Not Applicable.

The H1 Range of Products

A growing Family

- Initial release of four displacements
- Development plans include additional displacements

A Word about the Organization of this Manual

General information covering all displacements of the H1 range is given in the beginning of this manual. This includes definitions of operating parameters and system design considerations. Sections later in this book detail the specific operating limitations for each frame and give a full breakdown of available displacements, features and options, and basic installation drawings.

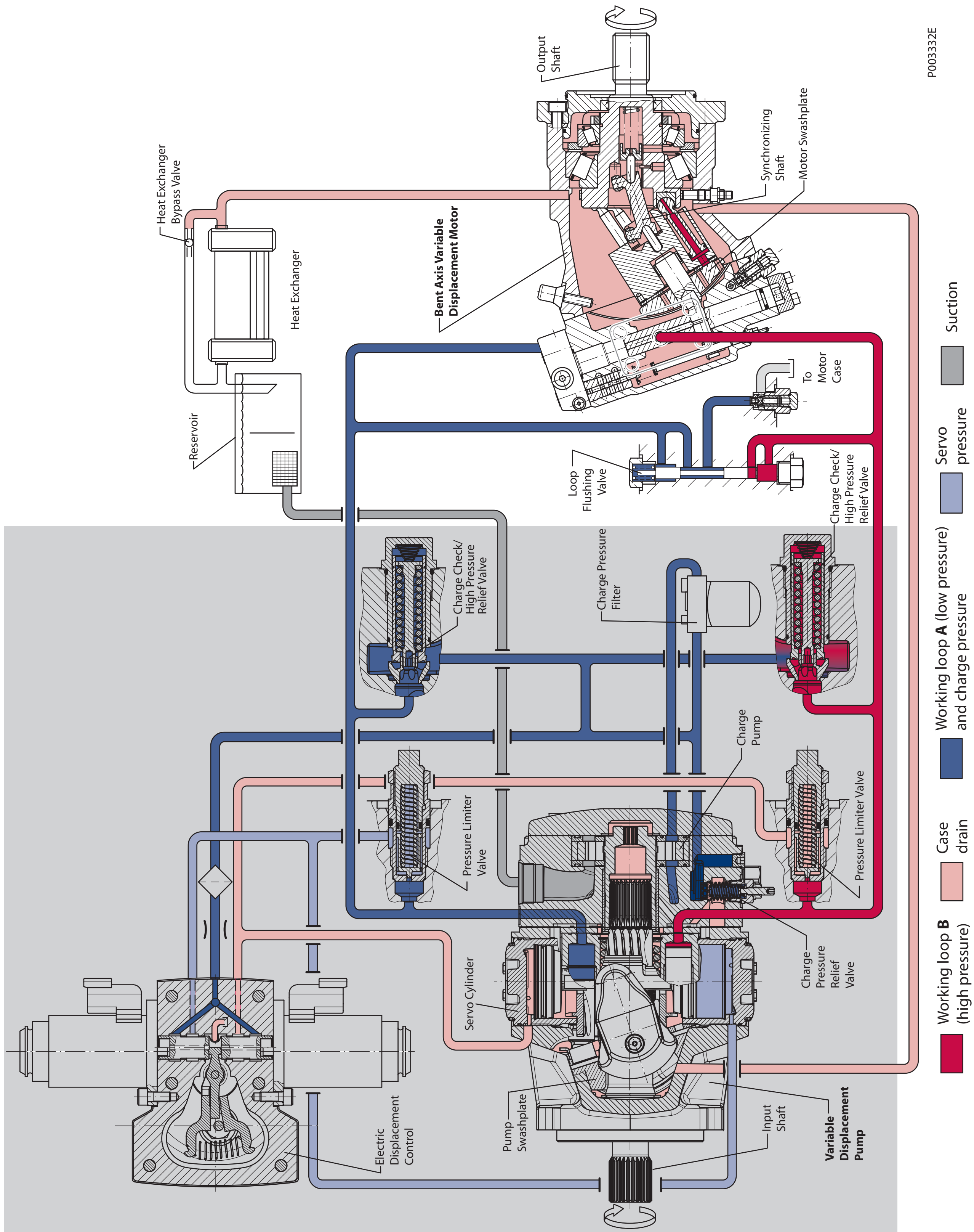
The table below shows the available range of H1 pumps as of this printing, with their respective speed, pressure, theoretical flow ratings, and mounting flange. The starting page number of the specific section is shown for each frame.

Pump	Displacement		Speed			Pressure				Theoretical Flow *(at rated speed)*		Mounting Flange
			Rated	Min.	Max.	Rated*		Maximum				
	cm^3	[in^3]	min^{-1} (rpm)			bar	[psi]	bar	[psi]	l/min	[US gal/min]	SAE
Frame 045/053 Tandem Pumps												
H1T045	45.0	[2.75]	3400	500	3500	400	[5800]	420	[6092]	158	[42]	B
H1T053	53.8	[3.28]				350	[5075]	400	[5800]	188	[50]	
Frame 147/165 Single Pumps												
H1P147	147.0	[8.97]	3000	500	3100	450	[6525]	480	[6960]	441	[117]	D
H1P165	165.0	[10.07]				400	[5800]	450	[6525]	495	[131]	

* Operation above pressure ratings is permissible with Sauer-Danfoss application approval

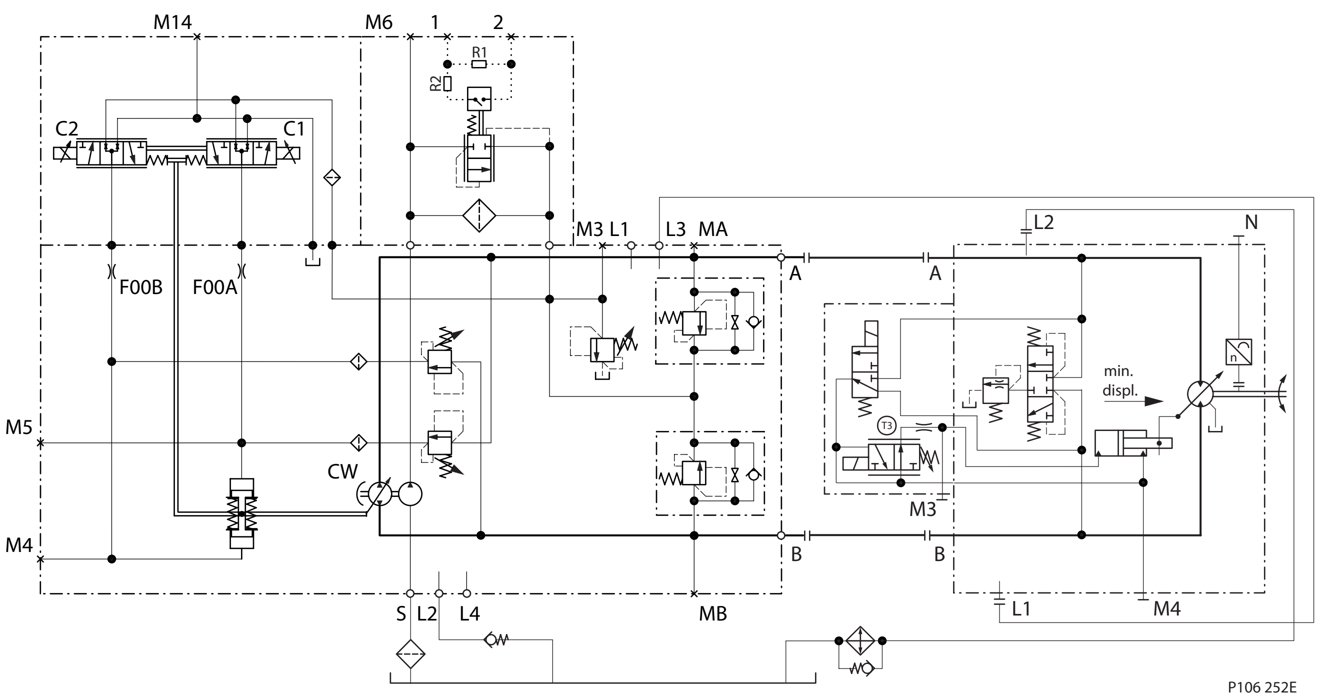
System Diagram

Single Pump



System Schematic

Single Pump



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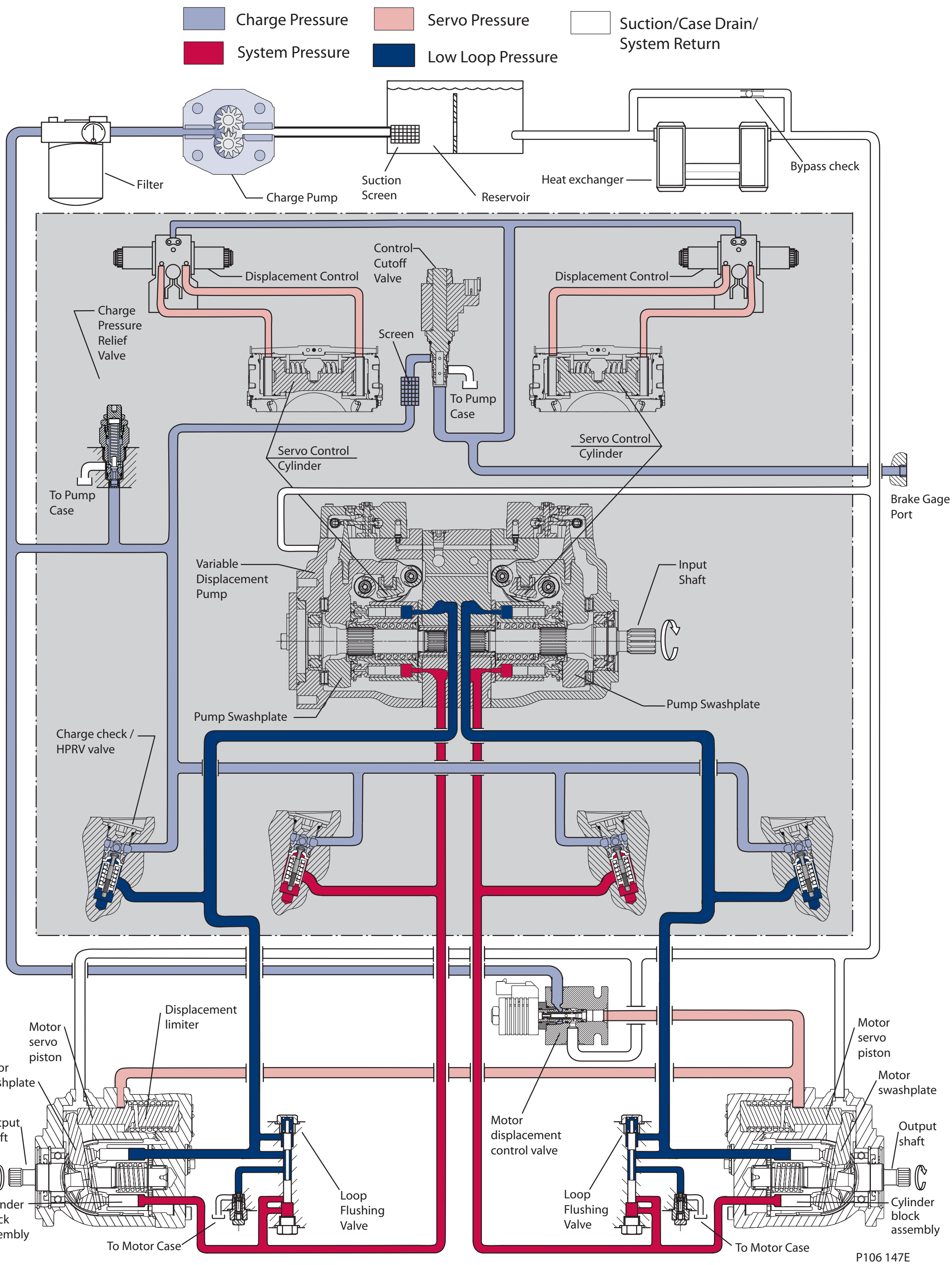
Above schematics show the function of a hydrostatic transmission using a H1 axial piston variable displacement pump with electric proportional displacement control (EDC) and a bent axis variable displacement motor with electric two-position control and Pressure Compensator Over Ride (PCOR) with electric Brake Pressure Defeat (BPD).

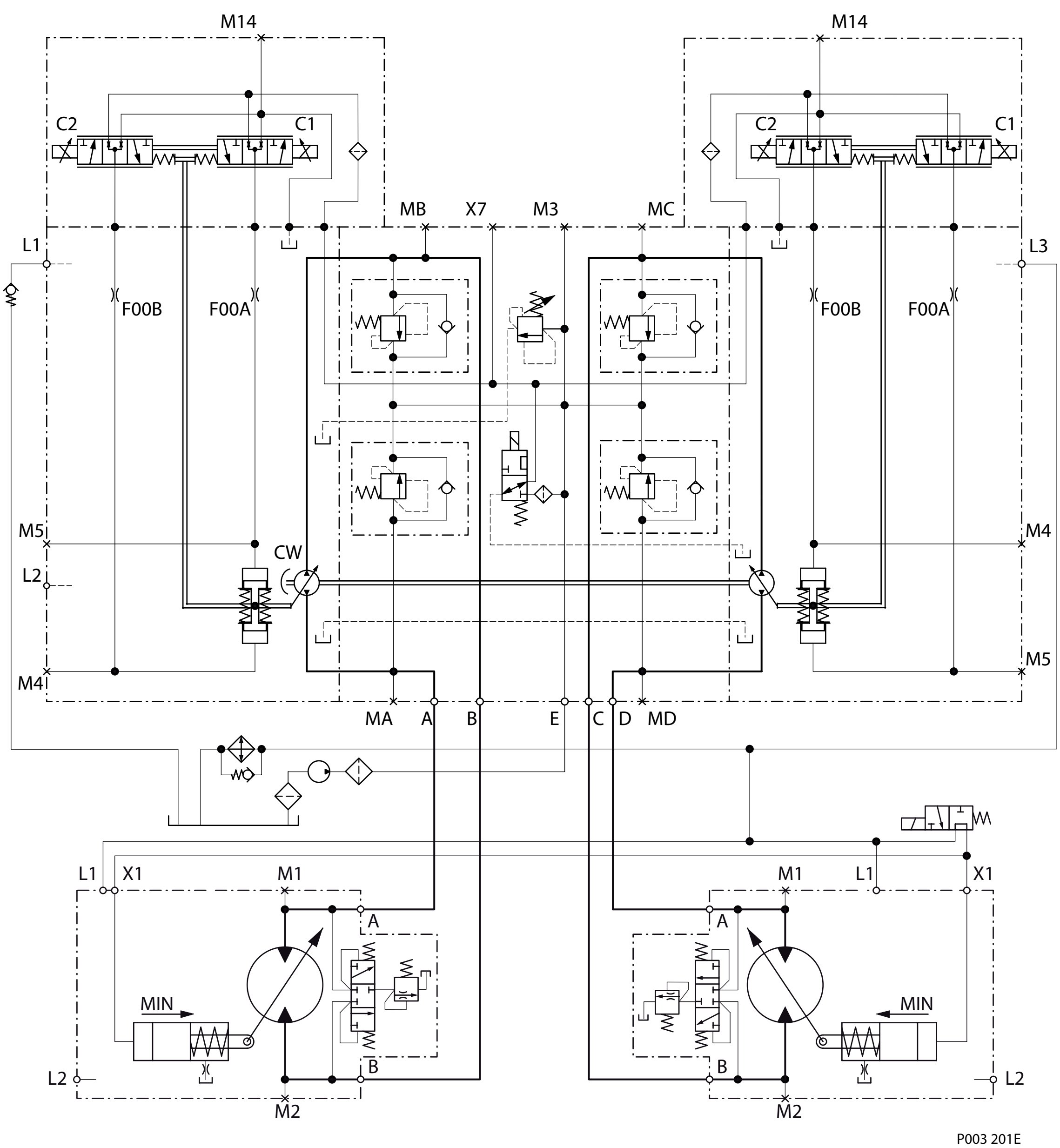
System Diagram

Tandem Pump



System Schematic

Tandem Pump



Pressure Limiter Valves

Pressure limiter valves provide system pressure protection by compensating the pump swashplate position when the set pressure of the valve is reached. A pressure limiter is a non-dissipative (non heat generating) pressure regulating system.

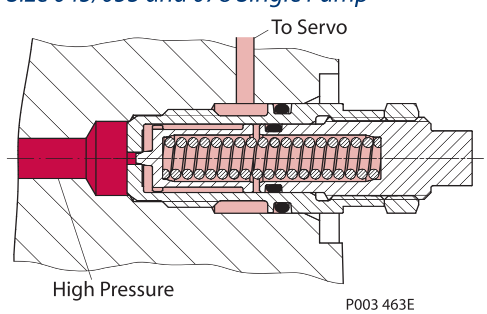
Each side of the transmission loop has a dedicated pressure limiter valve that is set independently. A pump configured with pressure limiter must have pressure limiters on both sides of the system pressure loop. The pump order code allows for different pressure settings to be used at each system port.

The pressure limiter setting is the differential pressure between the high and low loops. When the pressure limiter setting is reached, the valve ports oil to the low-pressure side of the servo piston. The change in servo differential pressure rapidly reduces pump displacement. Fluid flow from the valve continues until the resulting drop in pump displacement causes system pressure to fall below the pressure limiter setting.

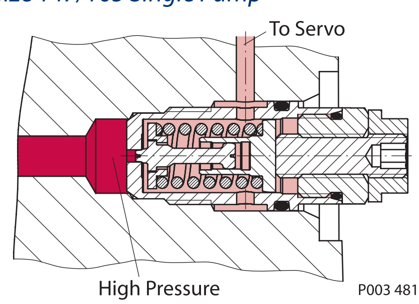
An active pressure limiter destrokes a pump to near neutral when the load is in a stalled condition. The pump swashplate moves in either direction necessary to regulate the system pressure, including into stroke (overrunning) or over-center (winch payout).

The pressure limiter is optional for H1 single pumps and not available for tandem pumps.

Size 045/053 and 078 Single Pump



Size 147/165 Single Pump



High Pressure Relief Valve (HPRV) and Charge Check

All H1 pumps are equipped with a combination high pressure relief and charge check valve. The high-pressure relief function is a dissipative (with heat generation) pressure control valve for the purpose of limiting excessive system pressures. The charge check function acts to replenish the low-pressure side of the working loop with charge oil. Each side of the transmission loop has a dedicated HPRV valve that is non-adjustable with a factory set pressure. When system pressure exceeds the factory setting of the valve, oil is passed from the high pressure system loop, into the charge gallery, and into the low pressure system loop via the charge check.
The pump order code allows for different pressure settings to be used at each system port. When a HPRV valve is used in conjunction with a pressure limiter, the HPRV valve is always factory set above the setting of the pressure limiter. The system pressure order code for pumps with only HPRV is a reflection of the HPRV setting.
The system pressure order code for pumps configured with pressure limiter and HPRV is a reflection of the pressure limiter setting.

The HPRV are set at below flow rates.

Tandem 045/053	5 l/min	[1.32 US gal/min]
Single 045/053/078	5 l/min	[1. 32 US gal/min]
Single 147/165	20 l/min	[5.28 US gal/min]

HPRV´s are factory set at a low flow condition. Any application or operating condition which leads to elevated HPRV flow will cause a pressure rise with flow above a valve setting. Consult factory for application.

Bypass

The HPRV valve also provides a loop bypass function when each of the two HPRV hex plugs are mechanically backed out 3 full turns. Engaging the bypass function mechanically connects both A & B sides of the working loop to the common charge gallery. The bypass function allows a machine or load to be moved without rotating the pump shaft or prime move.

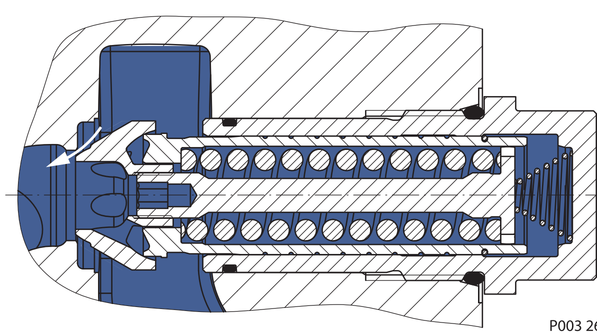
Bypass function not available for tandem pumps.

Caution

Excessive speeds and extended load/vehicle movement must be avoided. The load or vehicle should be moved not more than 20 % of maximum speed and for a duration not exceeding 3 minutes. Damage to drive motor(s) is possible. When the bypass function is no longer needed care should be taken to reseat the HPRV hex plugs to the normal operating position.

Single Pumps

High Pressure Relief and Charge Check Valve with Bypass Valve in Charging Mode



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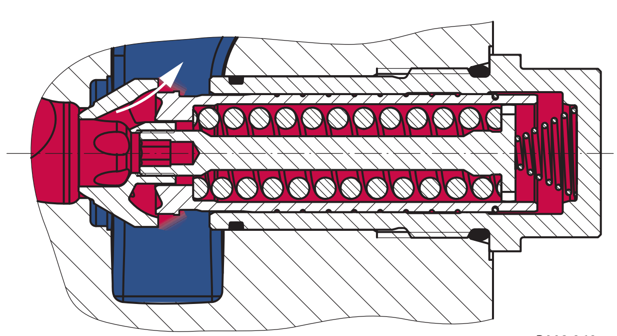
High Pressure Relief and Charge Check Valve with Bypass Valve in Relief Mode



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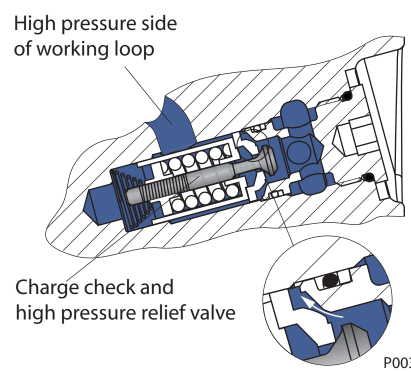
Tandem Pumps

High Pressure Relief and Charge Check Valve in Charging Mode



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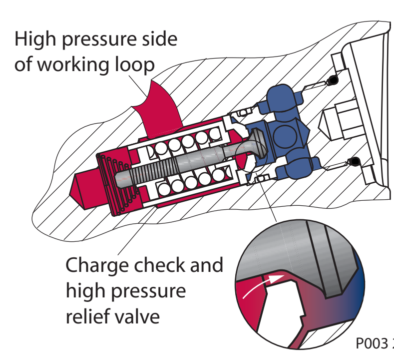
High Pressure Relief and Charge Check Valve in Relief Mode



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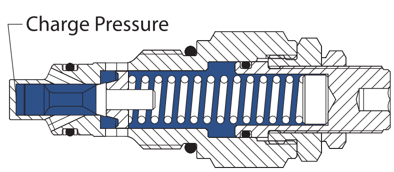
Charge Pressure Relief Valve (CPRV)

The charge pressure relief valve maintains charge pressure at a designated level above case pressure. The charge pressure relief valve is a direct acting poppet valve which opens and discharges fluid to the pump case when pressure exceeds a designated level. This level is nominally set with the pump running at 1800 rpm. For external charge flow the CPRV is set with 30 l/min [8 US gal/min]. In forward or reverse, charge pressure will be slightly lower than when in neutral position. The charge pressure relief valve setting is specified on the model code of the pump.
Typical charge pressure increase from 1.2 - 1.5 bar per 10 l/min [17.4 - 21.8 psi per 2.64 US gal/min].

Charge Pressure Relief Valve 045/053 Tandem



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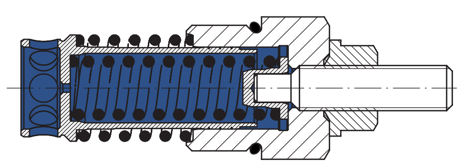
Charge Pressure Relief Valve 147/165 Single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Electrical Displacement Control (EDC)

EDC Principle

The Electrical Displacement Control (EDC) consists of a pair of proportional solenoids on each side of a three-position, four-way porting spool. The proportional solenoid applies a force input to the spool, which ports hydraulic pressure to either side of a double acting servo piston. Differential pressure across the servo piston rotates the swashplate, changing the pump's displacement from full displacement in one direction to full displacement in the opposite direction.

EDC Operation

H1 EDC's are current driven controls requiring a Pulse Width Modulated (PWM) signal. Pulse width modulation allows more precise control of current to the solenoids. The PWM signal causes the solenoid pin to push against the porting spool, which pressurizes one end of the servo piston, while draining the other. Pressure differential across the servo piston moves the swashplate. A swashplate feedback link, opposing control links, and a linear spring provide swashplate position force feedback to the solenoid.
The control system reaches equilibrium when the position of the swashplate spring feedback force exactly balances the input command solenoid force from the operator. As hydraulic pressures in the operating loop change with load, the control assembly and servo/swashplate system work constantly to maintain the commanded position of the swashplate.

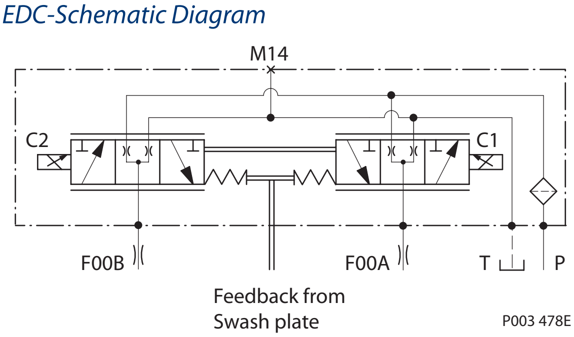
The EDC incorporates a positive neutral deadband as a result of the control spool porting, preloads from the servo piston assembly, and the linear control spring. Once the neutral threshold current is reached, the swashplate is positioned directly proportional to the control current. To minimize the effect of the control neutral deadband, we recommended the transmission controller or operator input device incorporate a jump up current to offset a portion of the neutral deadband.

The neutral position of the control spool does provide a positive preload pressure to each end of the servo piston assembly.

When the control input signal is either lost or removed, or if there is a loss of charge pressure, the spring-loaded servo piston will automatically return the pump to the neutral position.
A serviceable 125 µm screen is located in the supply line immediately before the control porting spool.

An EDC is a displacement (flow) control. Pump swashplate position is proportional to the input command and therefore vehicle or load speed (excluding influence of efficiency), is dependent only on the prime mover speed or motor displacement.

EDC-Schematic Diagram



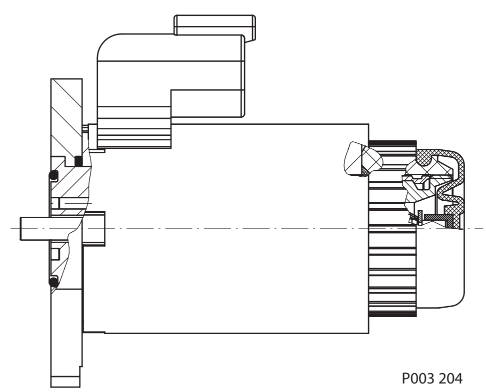
Manual Over Ride (MOR)

All controls are available with a Manual Over Ride (MOR) either standard or as an option for temporary actuation of the control to aid in diagnostics.
FNR controls are always supplied with MOR functionality.

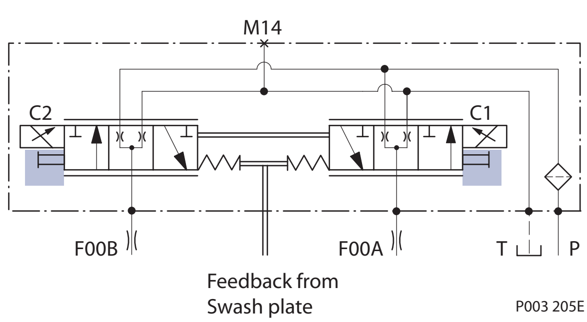
The vehicle or device must always be in a „safe" condition (i.e. vehicle lifted off the ground) when using the MOR function. The MOR plunger has a 4 mm diameter and must be manually depressed to be engaged. Depressing the plunger mechanically moves the control spool which allows the pump to go on stroke. The MOR should be engaged anticipating a full stroke response from the pump.

An o-ring seal is used to seal the MOR plunger. Initial actuation of the function will require additional force to overcome the o-ring resistance. A threshold force of 45 N is typically required at first actuation. Additional actuations typically require a threshold force of 12 N to move the MOR plunger. Force required to keep the pump at full stroke is typically 51 N. Proportional control of the pump using the MOR should not be expected.

Refer to control flowtable for the relationship of solenoid to direction of flow.



MOR-Schematic Diagram (EDC shown)



Control Cut Off (CCO)

The H1 tandem pump offers an optional control cut off valve integrated into the pump center section. This valve will block charge pressure from the servos in both pumps, allowing the servo springs to de-stroke both pumps regardless of the pump´s primary control input. There is also a hydraulic logic port, X7, which can be used to control other machine functions, such as spring applied pressure release brakes. The pressure at X7 is controlled by the control cut off solenoid. The control cut off option can be used with our without the use of the X7 logic port. The X7 port would remain plugged if not needed.
In the normal (de-energized) state of the solenoid charge flow is prevented from reaching the controls. At the same time the control passages and the X7 logic port are connected and drained to the pump case. The pump will remain in neutral, or return to neutral, independent of the control input signal.

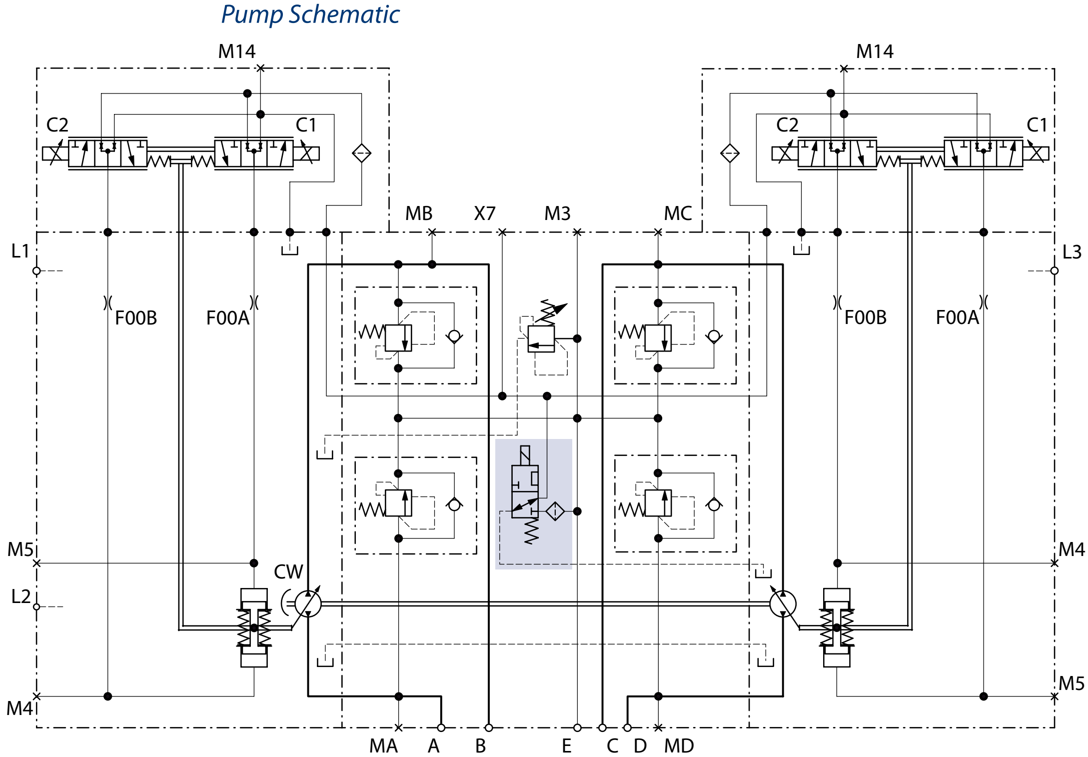
When the solenoid is energized, charge flow is allowed to reach the pump controls. The X7 logic port will also be connected to charge pressure.

The charge supply side of the control cut off valve is internally screened to protect the spool from contamination.

If the X7 port is used, it is recommended that a screen be placed in the X7 line or port adaptor in order to protect the pump/valve from outside contaminants.

The solenoid control is intended to be independent of the primary pump control making the control cut off an override control feature. It is however recommended that the control logic of the CCO valve be maintained such that the primary pump control signal is also disabled whenever the CCO valve is de-energized. Other control logic conditions may also be considered.

Pump Schematic



Overview

This section defines the operating parameters and limitations for H1 pumps with regard to input speeds and pressures. For actual parameters, refer to the Operating parameters for each displacement.

Input Speed

Minimum speed is the lowest input speed recommended during engine idle condition. Operating below minimum speed limits the pump's ability to maintain adequate flow for lubrication and power transmission.

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.

For more information consult *Pressure and speed limits*, BLN-9984, when determining speed limits for a particular application.

⚠ Warning

Unintended vehicle or machine movement hazard.
Exceeding maximum speed may cause a loss of hydrostatic drive line power and 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.

System Pressure

System pressure is the differential pressure between system ports A & 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.

Applied pressure, high pressure relief valve or pressure limiter setting, is the chosen application pressure found within the order code for the pump. This is the pressure at which the driveline generates the maximum pull or torque in the application.

Rated pressure is the design pressure for the pump. Applications with applied pressures at, or below, this pressure should yield satisfactory unit life given proper component sizing. Rated pressure is not intended to be a continuous pressure.
With Sauer-Danfoss approval, applied pressures above rated pressure can be considered with duty cycle and application approval.

Maximum pressure is the maximum applied pressure with Sauer-Danfoss approval. Duty cycle analysis is required for all applied pressures above rated.

System Pressure (continued)

Minimum low loop pressure is the lowest pressure allowed during charge pressure drop down under any circumstances.

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

Servo Pressure

Servo pressure is the pressure in the Servosystem needed to put and hold the pump on stroke. It depends on system pressure and speed.

At **minimum** servo pressure the pump will run at reduced stroke depending on speed and pressure.

Minimum servo pressure at corner power holds the pump on full stroke at max speed and max pressure.

Maximum servo pressure is the highest pressure typically given by the charge pressure setting.

Charge Pressure

An internal charge relief valve regulates charge pressure. Charge pressure supplies the control with pressure to operate the swashplate and to maintain a minimum pressure in the low side of the transmission loop. The charge pressure setting listed in the order code is the set pressure of the charge relief valve with the pump in neutral, operating at 1800 min^{-1} [rpm], and with a fluid viscosity of 32 mm^2/s [150 SUS]. Pumps configured with no charge pump (external charge supply) are set with a charge flow of 30 l/min [7.93 US gal/min] and a fluid viscosity of 32 mm^2/s [150 SUS].
The charge pressure setting is referenced to case pressure. Charge pressure is the differential pressure above case pressure.

Minimum charge pressure is the lowest pressure allowed to maintain a safe working condition in the low side of the loop. Minimum control pressure requirements are a function of speed, pressure, and swashplate angle, and may be higher than the minimum charge pressure shown in the Operating parameters tables.

Maximum charge pressure is the highest charge pressure allowed by the charge relief adjustment, and which provides normal component life. Elevated charge pressure can be used as a secondary means to reduce the swashplate response time.

Charge Pump Inlet Pressure

At normal operating temperature charge inlet pressure must not fall below **rated charge inlet pressure**.

Minimum charge inlet pressure is only allowed at cold start conditions. In some applications it is recommended to warm up the fluid (e.g. in the tank) before starting the engine and then run the engine at limited speed.

Maximum charge pump inlet pressure may be applied continuously.

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.

Auxiliary Pad Mounted Pumps. The auxiliary pad cavity of H1 pumps configured without integral charge pumps is referenced to case pressure. Units with integral charge pumps have aux pad cavities referenced to charge inlet (vacuum).

Caution

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 pressure are additive to case pressure.

External Shaft Seal Pressure

In certain applications, the input shaft seal may be exposed to external pressures. The shaft seal is designed to withstand an external pressure up to 0.4 bar [5.8 psi] above the case pressure. The case pressure limits must also be followed to ensure the shaft seal is not damaged.

Temperature and Viscosity

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 quoted **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; therefore temperatures should remain 16 °C [30 °F] above the pour point of the hydraulic fluid.

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

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

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.

Filtration System

To prevent premature wear, ensure 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.

The filter may be located on the pump (integral) or in another location (remote). The integral filter has a filter bypass sensor to signal the machine operator when the filter requires changing. Filtration strategies include suction or pressure filtration. The selection of a filter depends on a number of factors including the contaminant ingression rate, the generation of contaminants in the system, the required fluid cleanliness, and the desired maintenance interval. Filters are selected to meet the above requirements using rating parameters of efficiency and capacity.

Filter efficiency can be measured with a Beta ratio[1] (β_x). For simple suction-filtered closed circuit transmissions and open circuit transmissions with return line filtration, a filter with a β-ratio within the range of $\beta_{35\text{-}45} = 75$ ($\beta_{10} \geq 2$) or better has been found to be satisfactory. For some open circuit systems, and closed circuits with cylinders being supplied from the same reservoir, a considerably higher filter efficiency is recommended. This also applies to systems with gears or clutches using a common reservoir. For these systems, a charge pressure or return filtration system with a filter β-ratio in the range of $\beta_{15\text{-}20} = 75$ ($\beta_{10} \geq 10$) or better is typically required.

Because each system is unique, only a thorough testing and evaluation program can fully validate the filtration system. Please see *Design Guidelines for Hydraulic Fluid Cleanliness Technical Information,* 520L0467 for more information.

Cleanliness level and β_x-ratio			
Filtration (recommended minimum)	Cleanliness per ISO 4406		22/18/13
	Efficiency (charge pressure filtration)	β-ratio	$\beta_{15\text{-}20} = 75$ ($\beta_{10} \geq 10$)
	Efficiency (suction and return line filtration)	β-ratio	$\beta_{35\text{-}45} = 75$ ($\beta_{10} \geq 2$)
	Recommended inlet screen mesh size	µm	100 – 125

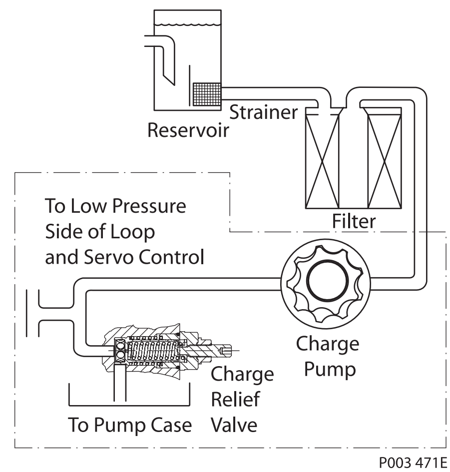
[1] Filter β_x-ratio is a measure of filter efficiency defined by ISO 4572. It is defined as the ratio of the number of particles greater than a given diameter (“x” in microns) upstream of the filter to the number of these particles downstream of the filter.

Filtration

Suction Filtration

The suction filter is placed in the circuit between the reservoir and the inlet to the charge pump as shown in the accompanying illustration.

Suction Filtration



Caution

Clogged filters can cause cavitation, which damages the charge pump.
We recommend a filter bypass with a filter bypass sensor to prevent damage due to blocked suction filters.

Charge Pressure Filtration (Full Charge Pump Flow)

Two types of pressure filtration exist for most H1 pumps. The two types are: remote pressure filtration (filter remotely mounted on vehicle) and integral pressure filtration (filter mounted to the endcap). Verify option availability in the frame specifics sections of this manual.
In either case the filtration circuit is the same with the filter element situated in the circuit downstream the charge pump and upstream of the charge relief valve such that full charge flow is continuously filtered, as shown in the accompanying illustrations.
Charge pressure filtration can mitigate high inlet vacuum in cold start-ups and provides fluid filtration immediately prior to entrance to the loop and the control system. Pressure filtration provides a higher level of filtering efficiency than suction filtration.

Filters used in charge pressure filtration circuits must be rated to at least 35 bar [508 psi] pressure. A 100 – 125 µm screen located in the reservoir or in the charge inlet line is recommended when using charge pressure filtration. A filter bypass valve is necessary to prevent filter damage and to avoid contaminants from being forced through the filter media by high pressure differentials across the filter. In the event of high pressure drop associated with a blocked filter or cold start-up conditions, fluid will bypass the filter. Working with an open bypass should be avoided.

Remote Charge Pressure Filtration

Ports at the endcap are available to allow for the charge filter to be located conveniently for easy service and replacement. Care should be taken to minimize the hydraulic pressure drops associated with long connecting lines, small diameter hoses, or restrictive port adaptors at the filter head or endcap. Ensure the normal operating pressure drop across the remote filtration *in* and *out* ports is sufficiently below the crack pressure setting of the recommended filter bypass valve.

Caution

Remote filter heads without bypass and poor plumbing design can encounter excessive pressure drops that can lead to charge pump damage in addition to contaminants being forced through the filter media and into the transmission loop.

Filtration (continued)

Integral Charge Pressure Filtration

The H1 integral pressure filter head is designed with a filter bypass valve and noncontacting bypass sensor. The pressure differential acting on the filter element also acts on a spring biased bypass spool. This spool is designed with a magnetic area. When a certain spool position is reached, the magnet closes a switch in the bypass sensor which
allows R2 to be in parallel with R1. This occurs without any mechanical contact between the spool and the bypass sensor.

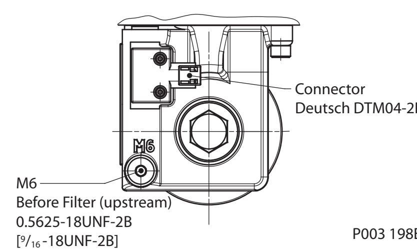
The position of the bypass spool is indicated by the change in the measured sensor resistance. The change in resistance occurs when R2 is switched in and out of the circuit. When the filter is not being bypassed, the nominal measured resistance is 510 ohms. When the switch is closed, the nominal measured resistance is 122 ohms.

The bypass spool is designed so the bypass sensor switch will be closed before oil bypasses the filter element. This gives the machine operator an indication that the filter is very close to bypassing and a filter replacement is required.

For cold start conditions, it is typical that the filter may bypass for a short amount of time while the oil is warming up. At normal operating oil temperatures, a system that does not yet need a filter replacement will operate in the non-bypass mode. The addition of an oil temperature sensor and additional control logic, is recommended to properly determine if a filter replacement is required.

Technical Data, Pressures

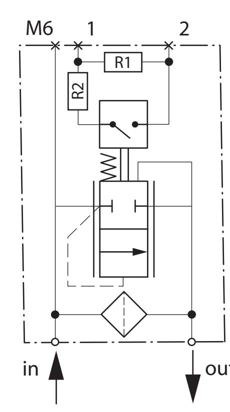
Maximum Charge Pressure	30 bar [435 psi]
Filter Bypass Sensor Switch Closure	Δp 3.7 - 5.1 bar [54 - 74 psi]
Bypass Valve	Δp 5.6 ± 0.9 bar [80 ± 13 psi]



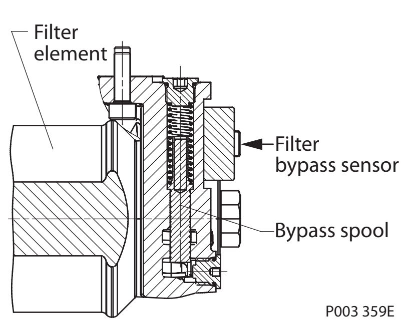
Technical Data, Electric

Max. Voltage	48 V
Max. Power	0.6 W
Resistor R1	510 Ω
Resistor R2	160 Ω
Resistor Tolerance	1 %
Temperature Range	-20 °C ÷ +100 °C [-4 °F ÷ +212 °C]
IP Rating (DIN 40 050) with Mating Connector	IP 69K

Schematic



Integral Filter Head with Filter Bypass Sensors

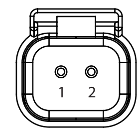


Filtration (continued)

Pinout

Pin	Description
1	Voltage
2	Ground

Pin Location



P003 186

Alternative Pinout

Pin	Description
1	Ground
2	Voltage

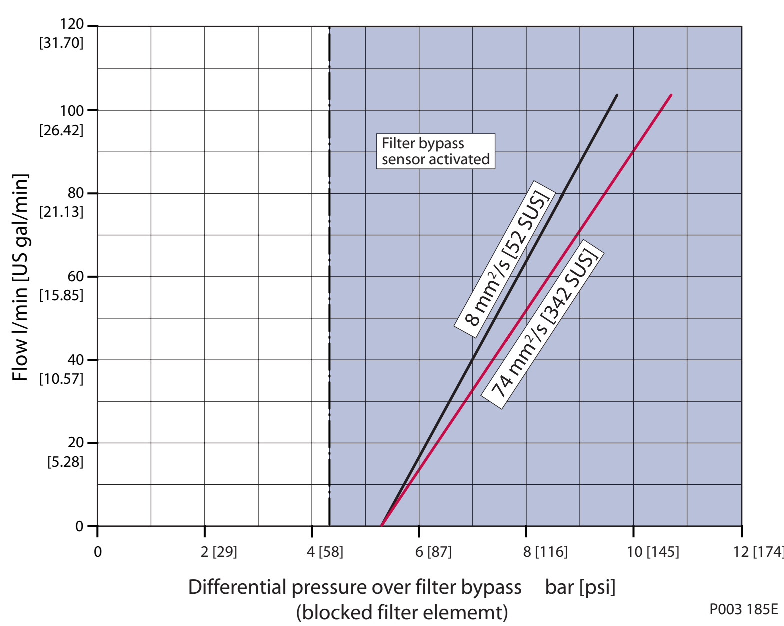
For device electrical schematic, see *Schematic*, page 21.

H1 Filter Bypass Sensor Mating Connector Parts List

Description	Quantity	Ordering number
Connector	1	Deutsch DTM06-2S
Secondary wedge lock	1	Deutsch WM-2S
Socket terminal	2	Deutsch 0462-201-20141

Filter Bypass Characteristic (completely blocked Element)

Below diagramm shows the differental pressure between filter "in" and "out" with a filter element completely blocked, so that all flow runs across the filter bypass valve.

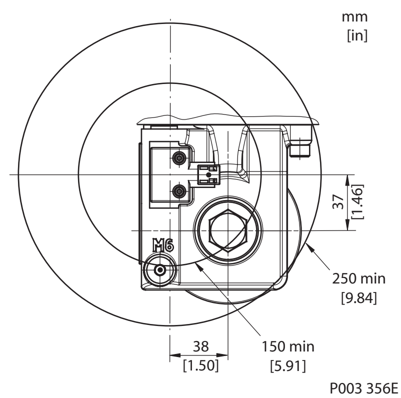


P003 185E

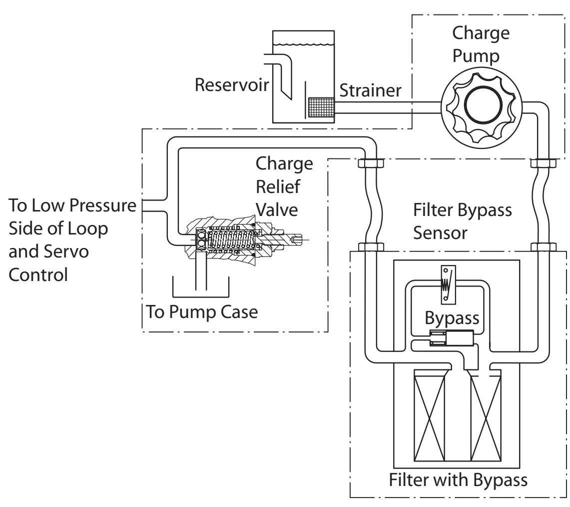
Filtration (continued)

Bypass Sensor Clearance

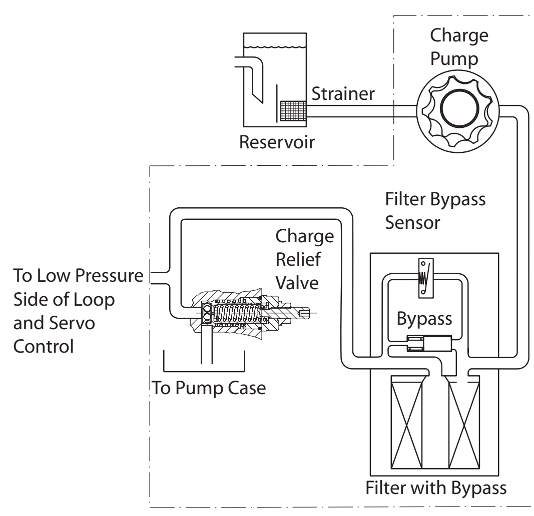
The bypass sensor is activated by the magnetic bypass valve. For proper function it is required to have no steel parts around the sensor within in below radius. No steel parts are allowed within a radius of 150 mm [5.91 in]. Moving steel devices or parts are not allowed within a radius of 250 mm [9.84 in].



Remote Charge Pressure Filtration, Full Flow



Integral Charge Pressure Filtration, Full Flow



Independent Braking System

⚠ Warning

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.

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 pump components. Never mix hydraulic fluids of different types.

Fire resistant fluids are also suitable at modified operating conditions. Please see *Hydraulic Fluids and Lubricants Technical Information,* 520L0463**,** for more information. Refer to *Experience with Biodegradable Hydraulic Fluids Technical Information,* 520L0465**,** for information relating to biodegradable fluids.

The following hydraulic fluids are suitable:

- Hydraulic Oil ISO 11 158 - HM (Seal compatibility and vane pump wear resistance per DIN 51 524-2 must be met)
- Hydraulic Oil ISO 11 158 - HV (Seal compatibility and vane pump wear resistance per DIN 51 524-3 must be met)
- Hydraulic Oil DIN 51 524-2 - HLP
- Hydraulic Oil DIN 51 524-3 - HVLP
- Automatic Transmission Fluid ATF A Suffix A (GM)
- Automatic Transmission Fluid Dexron II (GM), which meets Allison C-3 and Caterpillar TO-2 test
- Automatic Transmission Fluid M2C33F and G (Ford)
- Engine oils API Classification SL, SJ (for gasoline engines) and CI-4, CH-4, CG-4, CF-4 and CF (for diesel engines)
- Super Tractor Oil Universal (STOU) special agricultural tractor fluid

Reservoir

The hydrostatic system reservoir should accommodate maximum volume changes during all system operating modes and promote de-aeration of the fluid as it passes through the tank. A suggested minimum total reservoir volume is ⅝ of the maximum charge pump flow per minute with a minimum fluid volume equal to ½ of the maximum charge pump flow per minute. This allows 30 seconds fluid dwell for removing entrained air at the maximum return flow. This is usually adequate to allow for a closed reservoir (no breather) in most applications.

Locate the reservoir outlet (charge pump inlet) above the bottom of the reservoir to take advantage of gravity separation and prevent large foreign particles from entering the charge inlet line. A 100-125 µm screen over the outlet port is recommended. Position the reservoir inlet (fluid return) to discharge below the normal fluid level, toward the interior of the tank. A baffle (or baffles) will further promote de-aeration and reduce surging of the fluid.

Case Drain

A case drain line must be connected to one of the case outlets to return internal leakage to the system reservoir. Use the higher of the outlets to promote complete filling of the case. Since case drain fluid is typically the hottest fluid in the system, it is a good idea to return this flow to the reservoir via the heat exchanger.

Case drain routing and design must consider unit case pressure ratings. All single H1 pumps are equipped with multiple drain ports whereas some H1 pumps are equipped with two case drains port sizes. Port selection and case drain routing must enable the pump housing to maintain a volume of oil not less than half full.

The tandem rear housing case drain port must be used in order to promote positive flushing flow thru both housing sections (*see case drain details in tandem section*).

Charge Pump

Charge flow is required on all H1 pumps applied in closed circuit installations. The charge pump provides flow to make up internal leakage, maintain a positive pressure in the main circuit, provide flow for cooling and filtration, replace any leakage losses from external valving or auxiliary systems, and to provide flow and pressure for the control system.

Many factors influence the charge flow requirements and the resulting charge pump size selection. These factors include system pressure, pump speed, pump swashplate angle, type of fluid, temperature, size of heat exchanger, length and size of hydraulic lines, control response characteristics, auxiliary flow requirements, hydrostatic motor type, etc. When initially sizing and selecting hydrostatic units for an application, it is frequently not possible to have all the information necessary to accurately evaluate all aspects of charge pump size selection.

Unusual application conditions may require a more detailed review of charge pump sizing. Charge pressure must be maintained at a specified level under all operating conditions to prevent damage to the transmission. Sauer-Danfoss recommends testing under actual operating conditions to verify this.

Charge pump sizing/selection
In most applications a general guideline is that the charge pump displacement should be at least 10% of the total displacement of all components in the system. Unusual application conditions may require a more detailed review of charge flow requirements. Please refer to BLN-9985, Selection of Drive line Components, for a detailed procedure.

Bearing Loads & Life

Bearing life is a function of speed, system pressure, charge pressure, and swashplate angle, plus any external side or thrust loads. The influence of swashplate angle includes displacement as well as direction. External loads are found in applications where the pump is driven with a side/thrust load (belt or gear) as well as in installations with misalignment and improper concentricity between the pump and drive coupling. All external side loads will act to reduce the normal bearing life of a pump. Other life factors include oil type and viscosity.

In vehicle **propel** drives with no external shaft loads and where the system pressure and swashplate angle are changing direction and magnitude regularly, the normal L_{20} bearing life (80 % survival) will exceed the hydraulic load-life of the unit.

In **non propel** drives such as vibratory drives, conveyor drives or fan drives, the operating speed and pressure are often nearly constant and the swashplate angle is predominantly at maximum. These drives have a distinctive duty cycle compared to a propulsion drive. In these types of applications a bearing life review is recommended.

Applications with external shaft loads
H1 pumps are designed with bearings that can accept some external radial and thrust loads. When external 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. Optimum pump orientation is a consideration of the net loading on the shaft from the external load, the pump rotating group and the charge pump load.

Bearing Loads & Life (continued)

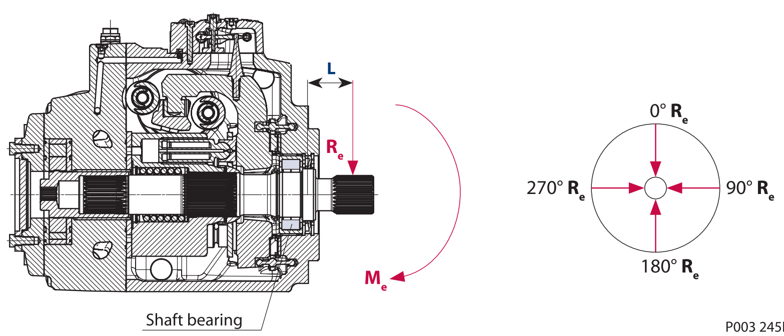
- In applications where the pump is operated such that nearly equal amounts of forward vs. reverse swashplate operation is experienced; bearing life can be optimized by orientating the external side load at 0° or 180° such that the external side load acts 90° to the rotating group load *(for details see drawing next page)*.

- In applications where the pump is operated such that the swashplate is predominantly (> 75 %) on one side of neutral (eg. vibratory, conveyor, typical propel); bearing life can be optimized by orientating the external side load generally opposite of the internal rotating group load. The direction of internal loading is a function of rotation and system port, which has flow **out**. Tables are available in the *Controls* section of each H1 frame that illustrates the flow **out** port as a function of pump rotation and energized EDC solenoid.

- H1 pumps are designed with bearings that can accept some thrust load such that incidental thrust loads are of no consequence. When thrust loads are anticipated the allowable load will depend on many factors and it is recommended that an application review be conducted.

Contact Sauer-Danfoss for a bearing life review if external side loads are present.

Radial and Thrust Load Position



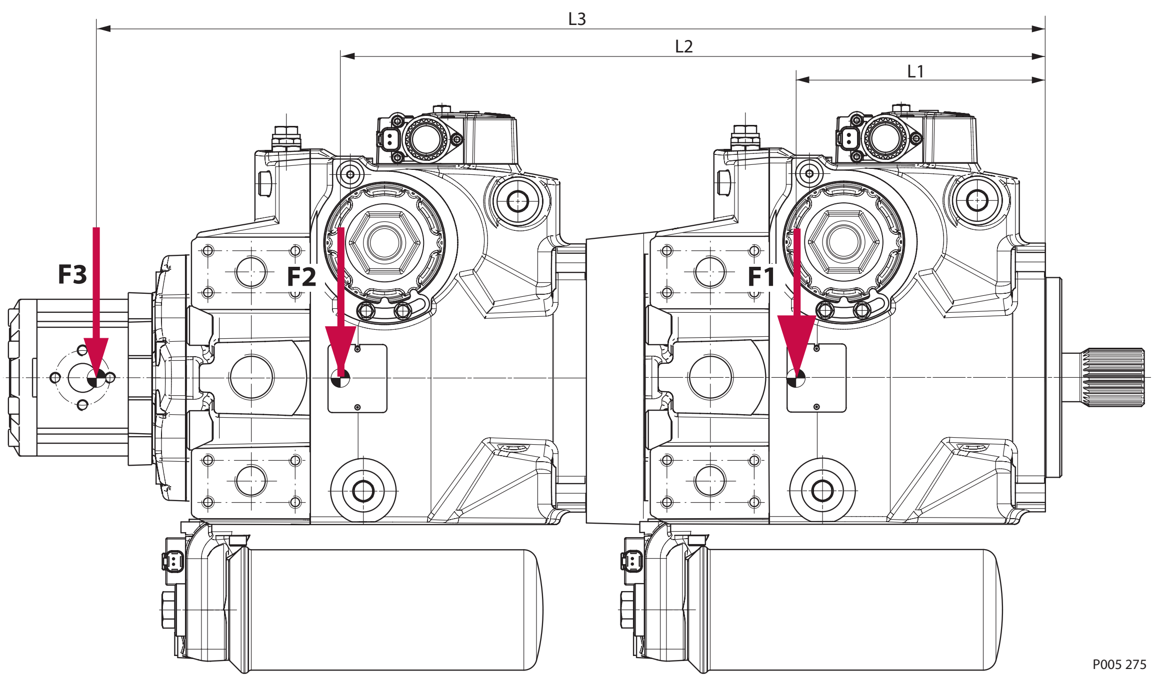
M_e = Shaft moment
L = Flange distance
R_e = External force to the shaft

Allowable shaft loads and moments are shown for each frame within that section.

Mounting Flange Loads

Adding tandem mounted auxiliary pumps and/or subjecting pumps to high shock loads may result in excessive loading of the mounting flange.
Applications which experience extreme resonant vibrations or shock may require additional pump support. The overhung load moment for multiple pump mounting may be estimated *using the formula* below.

Overhung Load Example



Estimated maximum and rated acceleration factors for some typical applications are shown *in the table below.*

Estimating Overhung Load Moments

W	=	Weight of pump	kg [lb]
L	=	Distance from mounting flange to pump center of gravity (refer to pump *Installation drawings* section)	m [ft]

$$M_R = G_R\ (W_1L_1 + W_2L_2 + \ldots + W_nL_n)$$
$$M_S = G_S\ (W_1L_1 + W_2L_2 + \ldots + W_nL_n)$$

Where:

M_R	=	Rated load moment	N•m [lbf•in]
M_S	=	Shock load moment	N•m [lbf•in]
G_R	=	Rated (vibratory) acceleration (G's)*	m/s^2 [ft/s^2]
G_S	=	Maximum shock acceleration (G's)*	m/s^2 [ft/s^2]

* *Calculations will be carried out by multiplying the gravity (g = 9.81 m/s^2 [32 ft/s^2]) with a given factor. This factor depends on the application.*

Allowable overhung load moment values are given for each frame in that section. Exceeding these values requires additional pump support.

Mounting Flange Loads (continued)

*Typical **G** Loads for various Applications*

Application	Rated (vibratory) Acceleration G_R	Maximum (shock) Acceleration G_S
Skid steer loader	8	15-20
Trencher (rubber tires)	3	8
Asphalt paver	2	6
Windrower	2	5
Aerial lift	1.5	4
Turf care vehicle	1.5	4
Vibratory roller	6	10

Use these in the absence of specific data for a rough estimation.

Shaft Torque Rating and Spline Lubrication

The rated torque is a measure of tooth wear and is the torque level at which a normal spline life of 2 x 10^9 shaft revolutions can be expected. The rated torque presumes a regularly maintained minimum level of lubrication via a moly-disulfide grease in order to reduce the coefficient of friction and to restrict the presence of oxygen at the spline interface. It is also assumed that the mating spline has a minimum hardness of R_c 55 and full spline depth.

However, a spline running in oil-flooded environment provides superior oxygen restriction in addition to contaminant flushing. The rated torque of a flooded spline can increase to that of the maximum published rating. Maximum torque ratings are based on torsional fatigue strength. A flooded spline would be indicative of a pump driven by a pump drive or plugged into an auxiliary pad of a pump.

Maintaining a spline engagement at least equal to the Pitch Diameter will also maximize spline life. Spline engagements of less than ¾ Pitch Diameter are subject to high contact stress and spline fretting.

Shaft Availability and Torque Ratings

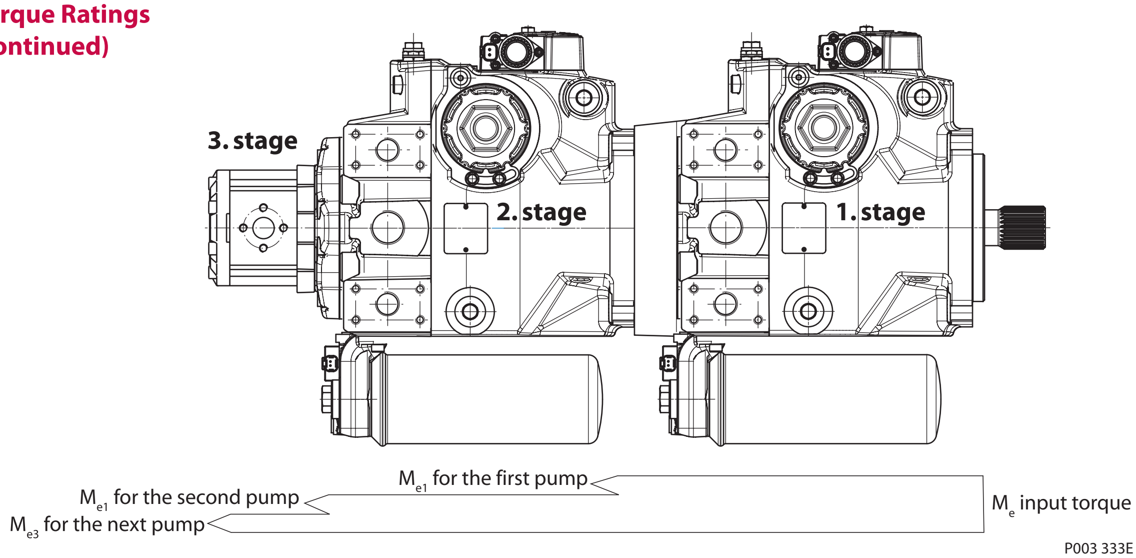
Alignment between the mating spline's Pitch Diameters is another critical feature in determining the operating life of a splined drive connection. *Plug-in*, or *rigid* spline drive installations can impose severe radial loads on the shafts. The radial load is a function of the transmitted torque and shaft eccentricity. Increased spline clearance will not totally alleviate this condition; BUT, increased spline clearance will prevent mechanical interference due to misalignment or radial eccentricity between the pitch diameters of the mating splines. Spline life can be maximized if an intermediate coupling is introduced between the bearing supported splined shafts.

Multiple pump installations must consider the loads from the entire pump stack and all torques are additive. Charge pumps loads must also be included.

Integral tandem pumps also have a center section coupling that must be considered in the through-torque diagram. Refer to the tandem section for details.

Shaft Availability and Torque Ratings (continued)

Through Torque Diagram



Torque required by auxiliary pumps is additive. Ensure requirements do not exceed shaft torque ratings

Rated and maximum torque ratings for each available shaft is shown within the specific H1 frame Technical Information sections of this manual.

Understanding and Minimizing System Noise

Here is some information to help understand the nature of noise in fluid power systems, and some suggestions to help minimize it.

Noise is transmitted in fluid power systems in two ways: as fluid borne noise, and structure borne noise.

Fluid-borne noise (pressure ripple or pulsation) is created as pumping elements discharge oil into the pump outlet. It is affected by the compressibility of the oil, and the pump's ability to transition pumping elements from high to low pressure. Pulsations travel through the hydraulic lines at the speed of sound (about 1400 m/s [4600 ft/sec] in oil) until there is a change (such as an elbow) in the line. Thus, amplitude varies with overall line length and position.

Structure born noise is transmitted wherever the pump casing connects to the rest of the system. The way system components respond to excitation depends on their size, form, material, and mounting.

System lines and pump mounting can amplify pump noise.

Follow these suggestions to help minimize noise in your application:

- Use flexible hoses.
- Limit system line length.
- If possible, optimize system line position to minimize noise.
- If you must use steel plumbing, clamp the lines.
- If you add additional support, use rubber mounts.
- Test for resonants in the operating range; if possible avoid them.

Sizing Equations

The following equations are helpful when sizing hydraulic pumps. Generally, the sizing process is initiated by an evaluation of the machine system to determine the required motor speed and torque to perform the necessary work function. Refer to *Selection of drive line components,* **BLN-9985**, for a more complete description of hydrostatic drive line sizing. First, the motor is sized to transmit the maximum required torque. The pump is then selected as a flow source to achieve the maximum motor speed.

	Based on SI Units		Based on US Units	
Output flow	$Q_e = \frac{V_g \cdot n \cdot \eta_v}{1000}$	l/min	$Q_e = \frac{V_g \cdot n \cdot \eta_v}{231}$	[US gal/min]
Input torque	$M_e = \frac{V_g \cdot \Delta p}{20 \cdot \pi \cdot \eta_{mh}}$	Nm	$M_e = \frac{V_g \cdot \Delta p}{2 \cdot \pi \cdot \eta_{mh}}$	[lbf•in]
Input power	$P_e = \frac{M_e \cdot n}{9550} = \frac{Q_e \cdot \Delta p}{600 \cdot \eta_t}$	kW	$P_e = \frac{V_g \cdot n \cdot \Delta p}{396\,000 \cdot \eta_t}$	[hp]

Where:

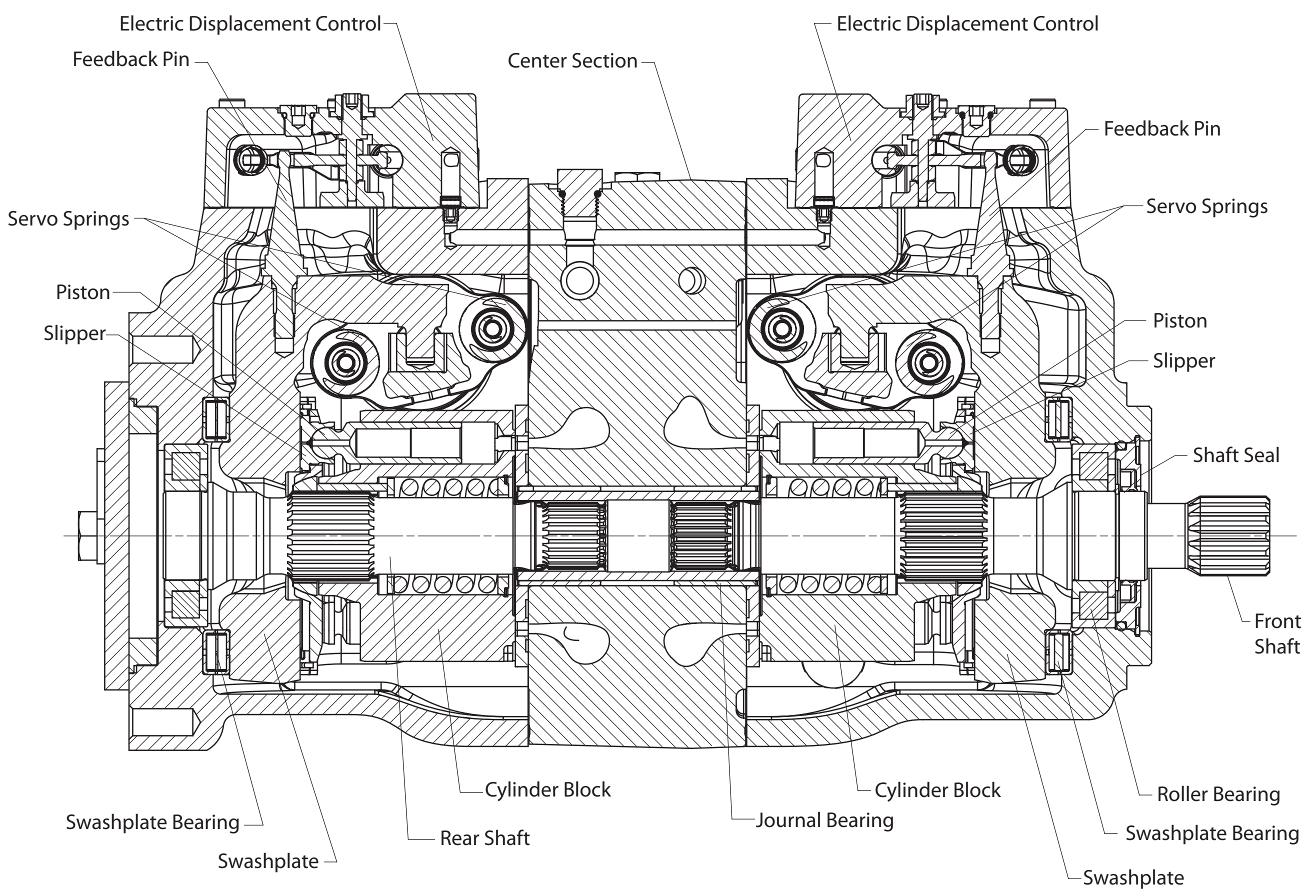
V_g	=	Pump displacement per rev.	cm^3 [in^3]
Δp	=	$p_{HD} - p_{ND}$	bar [psi]
η_v	=	Pump volumetric efficiency	
η_{mh}	=	Pump mechanical-hydraulic (Torque) efficiency	
η_t	=	Pump overall efficiency	
p_{HD}	=	High pressure	bar [psi]
p_{ND}	=	Low pressure	bar [psi]
n	=	Input speed	
p	=	Differential hydraulic pressure	bar [psi]

Contents

Design 33
Technical Specifications 34
Bearing Life 36
Mounting Flange Loads 37
Case Drain 37
Model Code 38
Electrical Displacement Control (EDC) 40
Manual Over Ride (MOR) 42
Input Shafts 44
  Option G1 44
  Option G5 44
    Torque Rating for Center Section Coupling 45
Auxiliary Mounting Pads 46
  Option H1 (SAE "A-A") and H2 (SAE "A") 46
  Option H3 (SAE "B") and H5 (SAE "B-B") 47
Charge Pump 48
Installation Drawings 50
  Port Description 50
  Dimensions 52
  Controls 55
    Control Cut Off (CCO) 55
    Electric Displacement Control (EDC) Option ***A2*** (12 V)/***A3*** (24 V) 56
    Electric Displacement Control (EDC) with Manual Override Option ***A4*** (12 V)/***A5*** (24 V) 56
  Displacement Limiters 57
    Displacement Limiter Option ***B*** and ***D*** 57

Design

Cross Section H1 045/053 cm³ Tandem Pump



P003 302E

Technical Specifications

For definitions of the following specifications, see *Operating parameters*.

General Specifications

Design	Axial piston pump of cradle swashplate design with variable displacement
Direction of Rotation	Clockwise, counterclockwise
Pipe Connections	Main pressure ports: SAE straight thread O-ring boss
	Remaining ports: SAE straight thread O-ring boss
Recommended Installation Position	Pump installation recommended with control position on the top or side. Consult Sauer-Danfoss for non conformance to these guidelines. The housing must always be filled with hydraulic fluid. Rear case drain recommended.
Auxiliary Cavity Pressure	Will be equal to pump case pressure of rear housing. Please verify mating pump shaft seal capability.

Physical Properties

Feature	Unit	Frame Size	
		045	053
Displacement	cm^3 [in^3]	45 [2.75]*	53.8 [3.28]*
Flow at Rated (continuous) Speed	l/min [US gal/min]	158* [42]	188* [50]
Torque at maximum Displacement (theoretical)	N•m/bar [lbf•in/1000psi]	0.72* [437.7]	0.86* [522.03]
Mass Moment of Inertia of Rotating Components	kg•m^2 [slug•ft^2]	0.0083 [0.00612]	0.0082 [0.00605]
Weight Dry (with SAE B pad)	kg [lb]	65.7 [144.8]	
Oil Volume	liter [US gal]	2.3 [0.61]	
Mounting Flange		SAE flange, size B (SAE J 744) compatible mounting pad. Special bolt diameter. *See installation drawings.*	
Auxiliary Mounting		SAE A, SAE B, SAE B-B (with metric fasteners)	
Shafts		Splined: 14-teeth 12/24, 15-teeth 16/32	
External Charge Inlet Port		0.8750-14 [7/8 -14]	
Main Port Configuration		1.3175-12UNF-2B [1 5/16 -12UNF-2B]	
Case Drain Ports L1, L2, L3 (SAE O-ring boss), use L3 as Case Drain for Cooling Purpose		1.0625-12UNF-2B [1 1/16 -12UNF-2B]	
Other Ports		SAE O-ring boss. See *Installation drawings.*	
Customer Interface Threads		Metric fastener	

* applies for each rotating group

Operating Parameters

Feature		Unit	Frame Size	
			045	053
Input Speed	Minimum	min^{-1} (rpm)	500	
	Rated		3400	
	Maximum		3500	
System Pressure	Rated	bar [psi]	400 [5800]	350 [5075]
	Maximum		420 [6090]	400 [5800]
	Minimum low loop		10 [150]	
Charge Pressure	Minimum	bar [psi]	20 [290]	
	Maximum		30 [435]	
Control Pressure	Minimum	bar [psi]	10 [150]	
	Minimum (at corner power)		18 [260]	
	Maximum		40 [580]	
Case Pressure	Rated	bar [psi]	2.0 [29]	
	Maximum		5.0 [75]	

Technical Specifications (continued)

Fluid Specifications

Feature		Unit	Frame Size	
			045	053
Viscosity	Minimum	mm²/s [SUS]	7 [49]	
	Recommended range		12-80 [66-370]	
	Maximum		*1600 [7500]*	
Temperature Range [1]	Minimum	°C [°F]	-40 [-40]	
	Rated		104 [220]	
	Maximum intermittent		*115 [240]*	
Filtration (recommended minimum)	Cleanliness per ISO 4406		22/18/13	
	Efficiency (charge pressure filtration)	β-ratio	$\beta_{15-20} = 75$ ($\beta_{10} \geq 10$)	
	Efficiency (suction and return line filtration)		$\beta_{35-45} = 75$ ($\beta_{10} \geq 2$)	
	Recommended inlet screen mesh size	µm	100 – 125	

[1] At the hottest point, normally case drain port.

Bearing Life

Shaft Loads

Normal bearing life in L_{20} hours is shown *in the table below*. The figures reflect a continuous delta pressure, shaft speed, maximum displacement, and no external shaft side load. The data is based on a 50 % forward, 50 % reverse duty cycle, and standard charge pressure of 20 bar [290 psi].

Bearing Life with no external Shaft Side Load

Pump Displacement	cm^3 [in^3]	**045 [2.75]**	**053 [3.28]**
Shaft Speed	min^{-1} (rpm)	1800	1800
Delta Pressure – Δp	bar [psi]	215 [3100]	190 [2750]
Bearing Life – L_{20}	hours	28 710	22 439

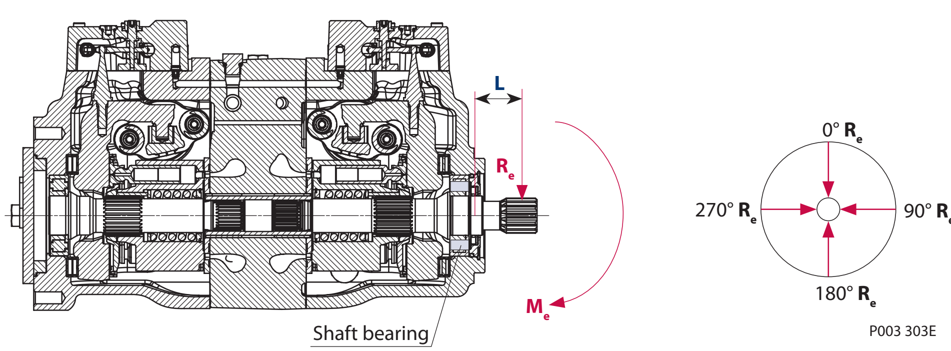
Bearing Life with no external Shaft Side Load

H1 pumps are designed with bearings that can accept some external radial loads. The external radial shaft load limits are a function of the load position and orientation, and the operating conditions of the unit.

The **maximum allowable radial load (R_e)** is based on the maximum external moment (M_e) and the distance (L) from the mounting flange to the load. It may be determined using the following table and formula. Thrust (axial) load limits are also shown.

$$R_e = M_e / L$$

Radial Load Position



M_e = Shaft moment
L = Flange distance
R_e = External force to the shaft

Thrust loads should be avoided. Contact factory in the event thrust loads are anticipated.

Bearing Life (continued)

Allowable External Shaft Load:

Displacement		045	053
External Radial Moment – M_e	Nm [lbf•in]	186 [1646]	

All external shaft loads affect bearing life. In applications with external shaft loads, minimize the impact by positioning the load at 0° or 180° as shown *in the figure.*

Sauer-Danfoss recommends clamp-type couplings for applications with radial shaft loads.

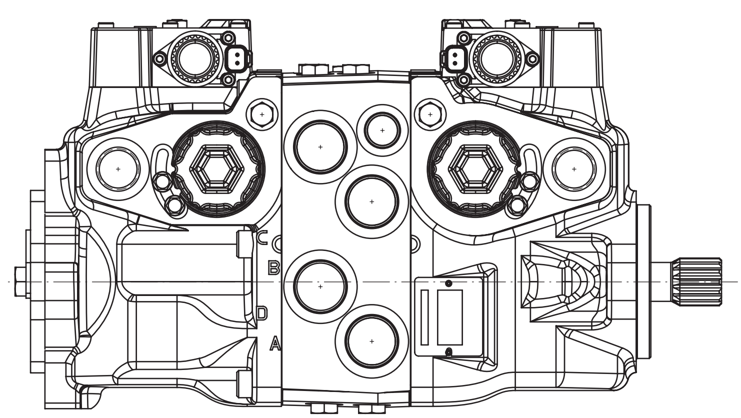
Contact your Sauer-Danfoss representative for an evaluation of unit bearing life if you have continuously applied external loads exceeding 25 % of the maximum allowable radial load (R_e) or the pump swashplate is positioned on one side of center all or most of the time.

Mounting Flange Loads

Displacement		045	053
Rated Moment – M_R	Nm [lbf•in]	2020 [17 880]	
Shock Load Moment – M_S		4110 [36 380]	

Above moments apply only for control orientation top or down, see picture below. Contact Sauer-Danfoss for flange capabilities with control orientation on the side.

For calculation details please see: System Design Parameters section Mounting Flange Loads.



P003 230

Case Drain

The tandem housings are connected thru the centersection via a drilled hole. The charge relief valve discharges oil into the front housing. In order to provide positive housing flow thru both housings, use of the rear housing case drain is required. The front housing case drain should only be used if the pump is used as a common drain manifold for the vehicle whereas external drain flow is brought into the rear housing and discharged out the front.

Model Code

H1 T		A	B	C	D	F	E	G	H	J	K	M	N	P	R	S	T	V	W	X	Y
			A	N			N		F												

Displacement (Front Pump, second Pump see "C")

045	**45** cm³ [2.74 in³]
053	**53.8** cm³ [3.28 in³]

A Rotation

L	**L**eft hand (counter clockwise)
R	**R**ight hand (clockwise)

B Product Version

A	Revision code

C Second Pump Size

N	Frame size of rear stage equal front stage (default)

D Control

A2	Electric Displacement Control (EDC) 12 V, Deutsch connector
A3	Electric Displacement Control (EDC) 24 V, Deutsch connector
A4	Electric Displacement Control (EDC) 12 V, Deutsch connector, with Manual override
A5	Electric Displacement Control (EDC) 24 V, Deutsch connector, with Manual override

F Orifices

C1	Orifices, 0.8 mm in Servo supply 1 and 2
C2	Orifices, 1.3 mm in Servo supply 1 and 2

E Displacement Limiters

N	None

G Endcap Options

D1	Tandem same-sided SAE O-ring boss ports with Control Cut Off (HPRV only)	12 V
F7		24 V
E7	Tandem same-sided SAE O-ring boss ports, (HPRV only) Standard	

H Mounting

F	SAE B 2-bolt

J Input Shaft

G1	14 teeth splined shaft 12/24 pitch
G5	15 teeth splined shaft 16/32 pitch

K Auxiliary Mounting Pad

NN	None	
H2	SAE A pad,	9 teeth 16/32 coupling
H1	SAE A-A pad,	11 teeth 16/32 coupling
H3	SAE B pad,	13 teeth 16/32 coupling
H5	SAE B-B pad,	15 teeth 16/32 coupling

Model Code (continued)

	A	B	C	D	F	E	G	H	J	K	M	N	P	R	S	T	V	W	X	Y
H1 T															N	P		N N	N N N	N N N

M *High Pressure Relief Setting, Side "**A**" (Front Pump); No Bypass*

N *High Pressure Relief Setting, Side "**B**" (Front Pump); No Bypass*

P *High Pressure Relief Setting, Side "**C**" (Rear Pump); No Bypass*

R *High Pressure Relief Setting, Side "**D**" (Rear Pump); No Bypass*

18	**18**0 bar [2610 psi]
20	**20**0 bar [2900 psi]
23	**23**0 bar [3335 psi]
25	**25**0 bar [3630 psi]
28	**28**0 bar [4060 psi]
30	**30**0 bar [4350 psi]
33	**33**0 bar [4785 psi]
35	**35**0 bar [5080 psi]
38	**38**0 bar [5510 psi]
40	**40**0 bar [5800 psi] (45 cc only)
42	**42**0 bar [6090 psi] (45 cc only)

Use to selection for ports "A", "B", "C" and "D"

S *Charge Pump*

N	None

T *Filtration Options*

P	Remote full flow filtration

V *Charge Pressure Relief Setting*

20	20 bar [290 psi]
24	24 bar [348 psi]
30	30 bar [435 psi]

W *Special Hardware Features*

NN	None

X *Paint and Nametag*

NNN	Black paint and Sauer-Danfoss nametag

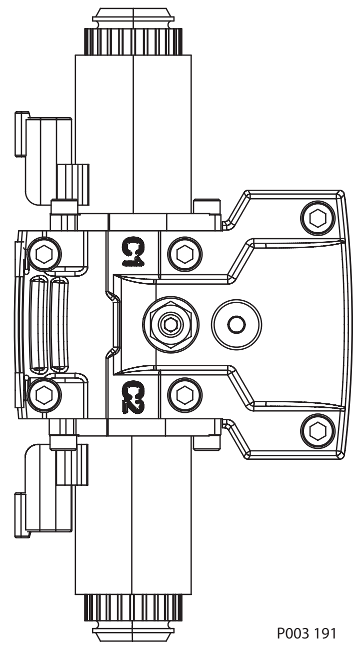
Y *Special Settings*

NNN	None

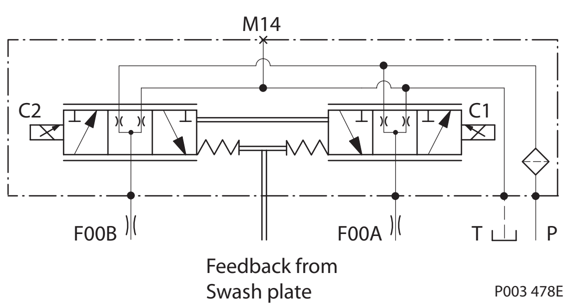
Electrical Displacement Control (EDC)

EDC Principle

The Electrical Displacement Control (EDC) consists of a pair of proportional solenoids on each side of a three-position, four-way porting spool. The proportional solenoid applies a force input to the spool, which ports hydraulic pressure to either side of a double acting servo piston. Differential pressure across the servo piston rotates the swashplate, changing the pump's displacement from full displacement in one direction to full displacement in the opposite direction.



EDC-Schematic Diagram



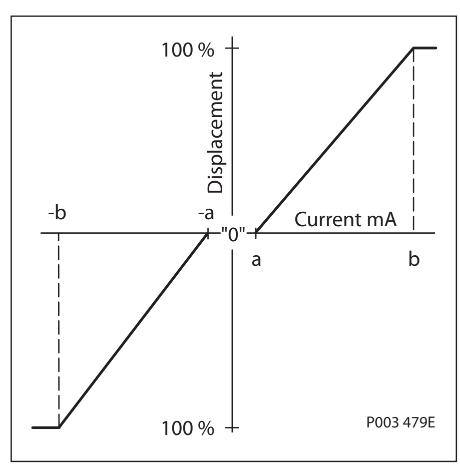
Control Signal Requirements

Control Current

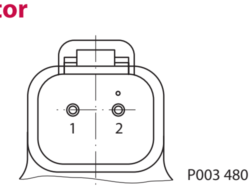
Voltage	a* mA	b mA	Pin Connections
12 V	745	1730	any order
24 V	352	820	

* Factory test current, for vehicle movement or application actuation expect higher value.

Pump Displacement vs. Control Current



Connector



Description	Quantity	Ordering Number
Connector	1	Deutsch® DT06-2S
Wedge Lock	1	Deutsch® W2S
Socket Contact (16 and 18 AWG)	2	Deutsch® 0462-201-16141
Sauer-Danfoss Mating Connector Kit	1	K29657

Electrical Displacement Control (EDC) (continued)

Solenoid Data

Voltage	12 V	24 V
Maximum Current	1800 mA	920 mA
Rated Power	18 W	
Nominal Coil Resistance @ 20 °C [70 °F]	3.66 Ω	14.20 Ω
Nominal Coil Resistance @ 80 °C [176 °F]	4.52 Ω	17.52 Ω
PWM Range	70-200 Hz	
PWM Frequency (preferred)*	100 Hz	
Inductance	33 mH	140 mH
IP Rating (DIN 40 050)	IP 67	
IP Rating (DIN 40 050) with Mating Connector	IP 69K	

* PWM signal required for optimum control performance.

Pump Output Flow Direction vs. Control Signal

Shaft Rotation	CW				CCW			
	Front		Rear		Front		Rear	
Coil Energized*	C2	C1	C2	C1	C2	C1	C2	C1
Port A	in	out	—	—	out	in	—	—
Port B	out	in	—	—	in	out	—	—
Port C	—	—	in	out	—	—	out	in
Port D	—	—	out	in	—	—	in	out
Servo Port Pressurized	M5	M4	M5	M4	M5	M4	M5	M4

* For coil location see installation drawings.

Control Response

H1 controls are available with optional control passage orifices to assist in matching the rate of swashplate response to the application requirements (e.g. in the event of electrical failure). Software ramp or rate limiting should be used to control vehicle response in normal operation. The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure. A swashplate response table is available for each frame indicating available swashplate response times. Testing should be conducted to verify the proper orifice selection for the desired response.

H1 pumps are limited in mechanical orificing combinations. Software is envisioned as the means to control the swashplate response in normal operating conditions.

Mechanical servo orifices are to be used only for fail-safe return to neutral in the event of an electrical failure.
Typical response times shown below at the following conditions:

Δp	=	250 bar	[3626 psi]
Viscosity and temperature	=	30 mm²/s (50 °C)	[141 SUS (122 °F)]
Charge pressure	=	20 bar	[290 psi]
Speed	=	1800 min⁻¹ (rpm)	

Response Times

Frame Size	Stroking Direction	1.3 mm [0.05 in] Orifice	0.8 mm [0.03 in] Orifice
045/053	Neutral to full flow	0.9 s	1.8 s
	Full flow to neutral	0.6 s	1.2 s

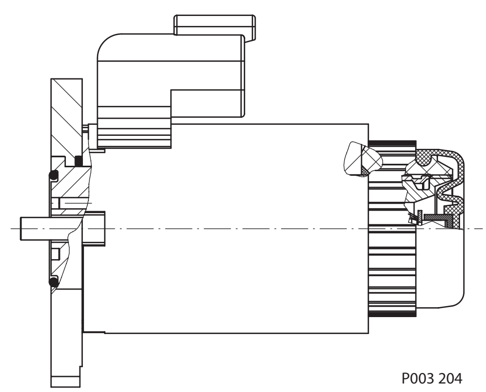
Manual Over Ride (MOR)

All controls are available with a Manual Over Ride (MOR) either standard or as an option for temporary actuation of the control to aid in diagnostics.
FNR controls are always supplied with MOR functionality.

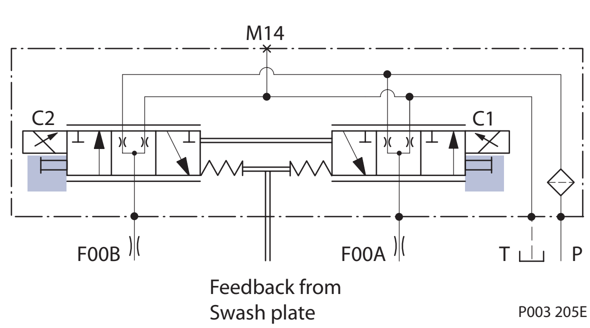
The vehicle or device must always be in a „safe" condition (i.e. vehicle lifted off the ground) when using the MOR function. The MOR plunger has a 4 mm diameter and must be manually depressed to be engaged. Depressing the plunger mechanically moves the control spool which allows the pump to go on stroke. The MOR should be engaged anticipating a full stroke response from the pump.

An o-ring seal is used to seal the MOR plunger. Initial actuation of the function will require additional force to overcome the o-ring resistance. A threshold force of 45 N is typically required at first actuation. Additional actuations typically require a threshold force of 12 N to move the MOR plunger. Force required to keep the pump at full stroke is typically 51 N. Proportional control of the pump using the MOR should not be expected.

Refer to control flowtable for the relationship of solenoid to direction of flow.

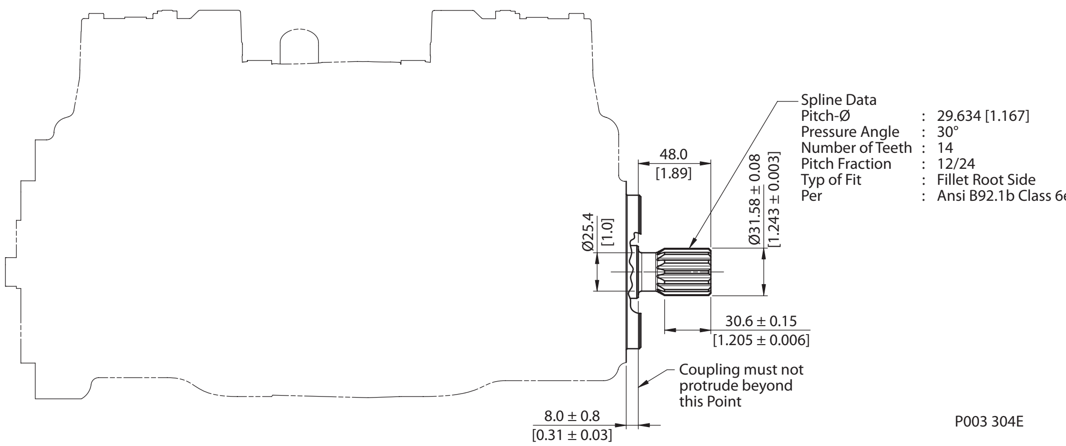


MOR-Schematic Diagram (EDC shown)



Input Shafts

Option G1

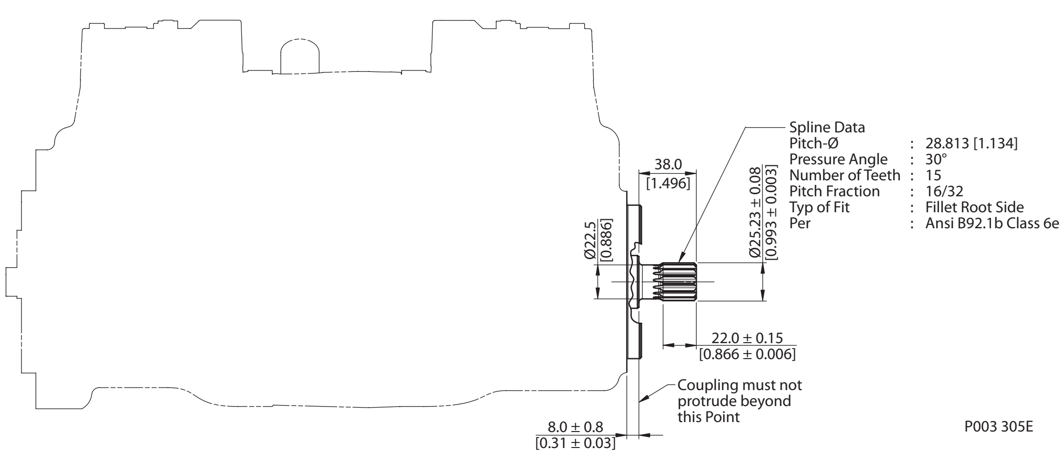


Specifications

Option	Spline	Min. active Spline Length mm [in]	Torque Rating[1] N•m [lbf•in]	
			Rated Torque	Maximum Torque
G1	14 teeth, 12/24 pitch	30.6 [1.205]	534 [4720]	592 [5240]

1) For definitions of maximum and continuous torque values, refer to *Shaft torque ratings and spline lubrication*.

Option G5

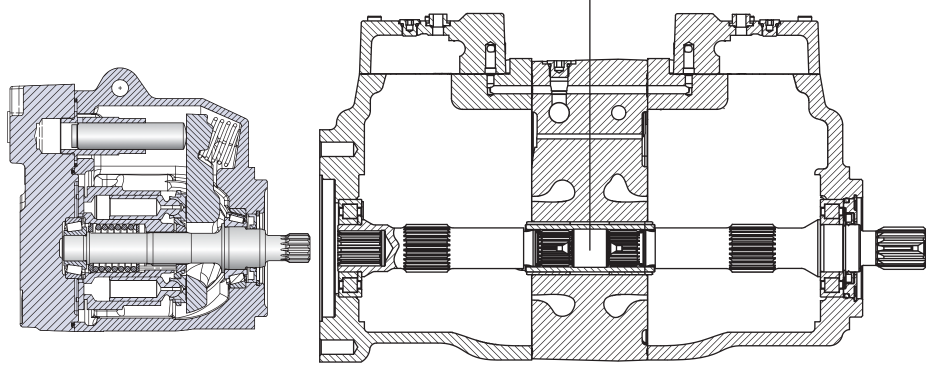


Specifications

Option	Spline	Min. active Spline Length mm [in]	Torque Rating[1] N•m [lbf•in]	
			Rated Torque	Maximum Torque
G5	15 teeth, 16/32 pitch	22.0 [0.866]	277 [2450]	395 [3490]

1) For definitions of maximum and continuous torque values, refer to *Shaft torque ratings and spline lubrication*.

Torque Rating for Center Section Coupling



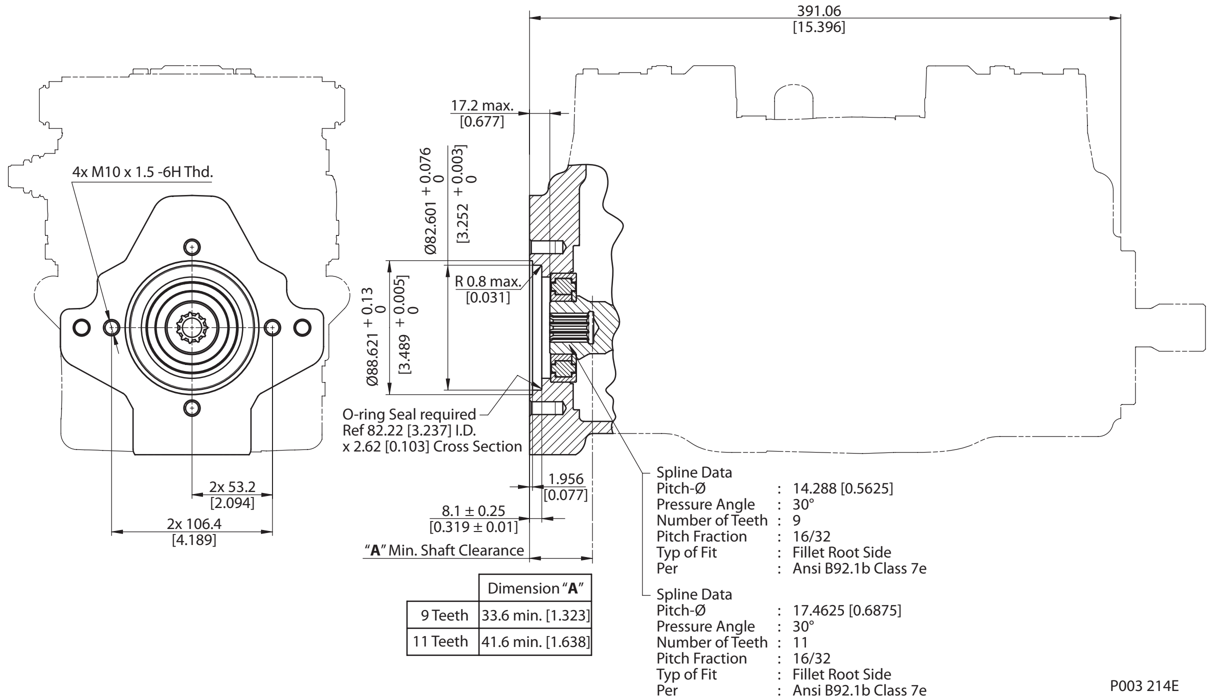
Torque Rating

	Torque Rating[1] N•m [lbf•in]	
	Continuous	**Maximum**
Center Coupling	336 [2970]	405 [3580]

1) For definitions of maximum and continuous torque values, refer to *Shaft torque ratings and spline lubrication*.

Auxiliary Mounting Pads

Option H1 (SAE "A-A") and H2 (SAE "A")



Standard pad cover shipped with the pump can also be used as a running cover.

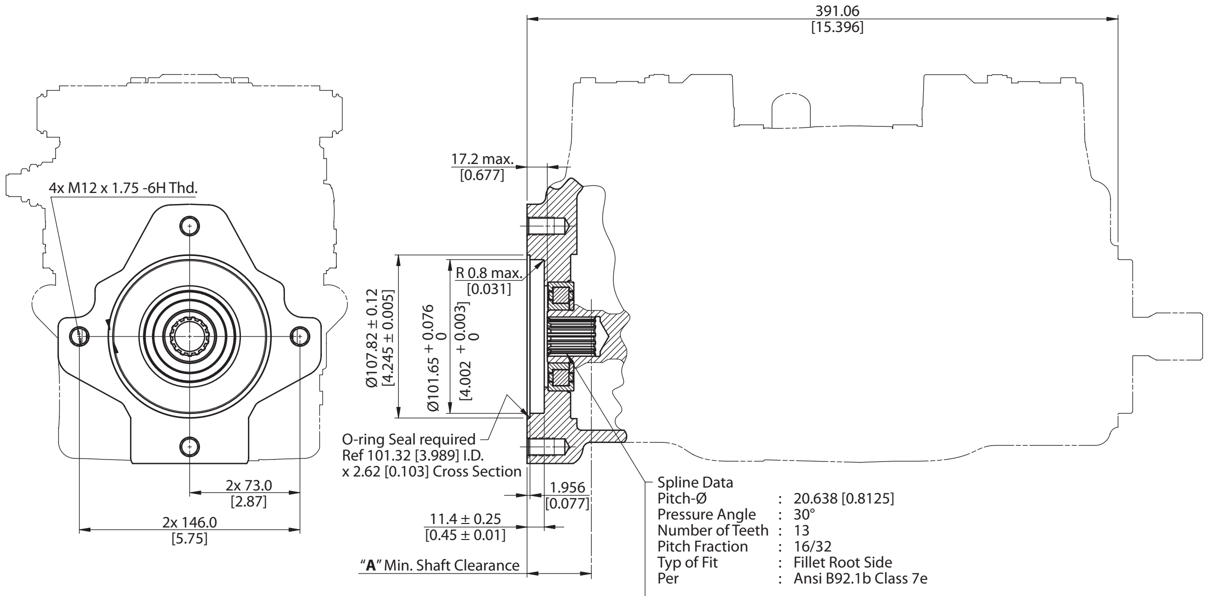
Specifications

Option	Spline	Min. active Spline Length mm [in]	Torque Rating[1] N•m [lbf•in]	
			Rated Torque	Maximum Torque
H2	9 teeth, 16/32 pitch	8.6 [0.34]	60 [529]	162 [1430]
H1	11 teeth, 16/32 pitch	10.5 [0.41]	109 [967]	296 [2620]

1) For definitions of maximum and continuous torque values, refer to *Shaft torque ratings and spline lubrication*.

Auxiliary Mounting Pads (continued)

Option H3 (SAE "B") and H5 (SAE "B-B")



	Dimension "A"
13 Teeth	42.6 min. [1.677]
15 Teeth	47.6 min. [1.874]

Standard pad cover shipped with the pump can also be used as a running cover.

Specifications

Option	Spline	Min. active Spline Length mm [in]	Torque Rating[1] N•m [lbf•in] Rated Torque	Maximum Torque
H3	13 teeth, 16/32 pitch	12.4 [0.49]	180 [1600]	395 [3500]
H5	15 teeth, 16/32 pitch	14.3 [0.56]	277 [2450]	693 [6130]

1) For definitions of maximum and continuous torque values, refer to *Shaft torque ratings and spline lubrication*.

Charge Pump

Charge Pump Sizing/Selection

In most applications a general guideline is that the charge pump displacement should be at least 10% of the total displacement of all components in the system. Unusual application conditions may require a more detailed review of charge flow requirements. Please refer to BLN-9985, Selection of Drive line Components, for a detailed procedure.

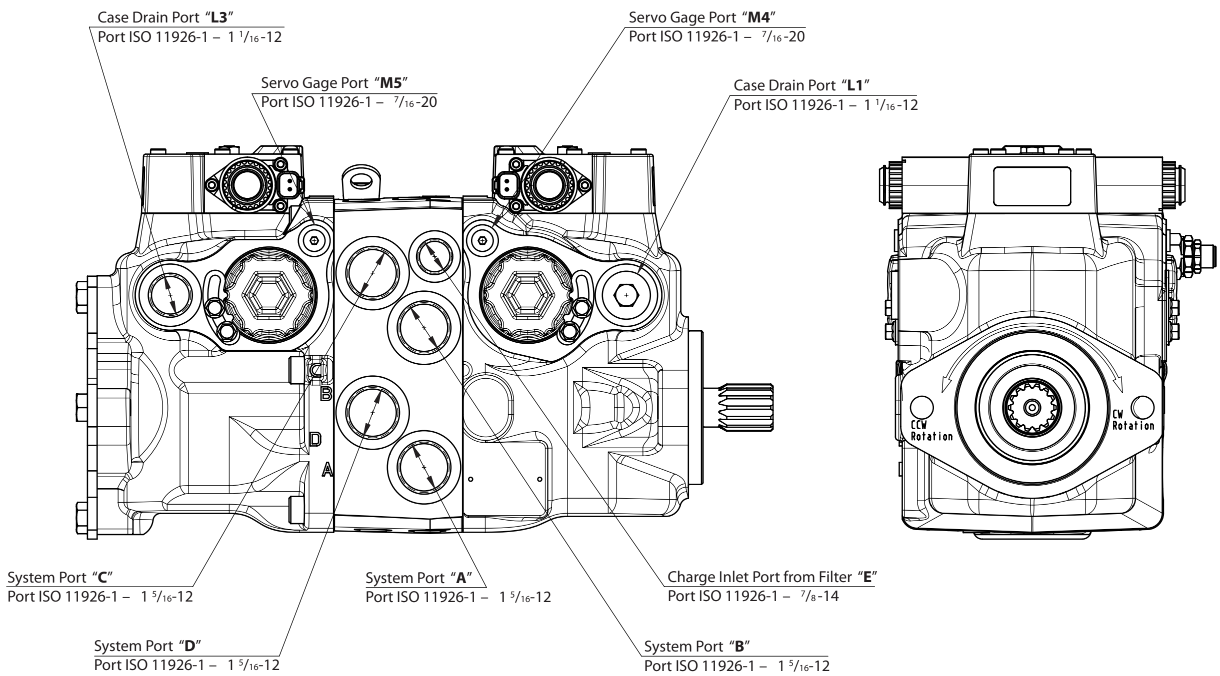
System features and conditions which may invalidate the 10 % guideline include (but are not limited to):

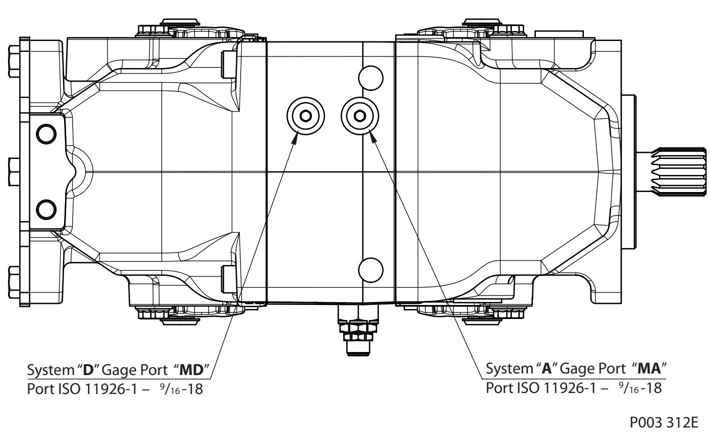
- Continuous operation at low input speeds (< 1500 min^{-1} (rpm))
- High shock loading and/or long loop lines
- High flushing flow requirements
- Multiple Low Speed High Torque motors
- High input shaft speeds

Contact your Sauer-Danfoss representative for application assistance if your application includes any of these conditions.

Installation Drawings

Port Description





Port Description

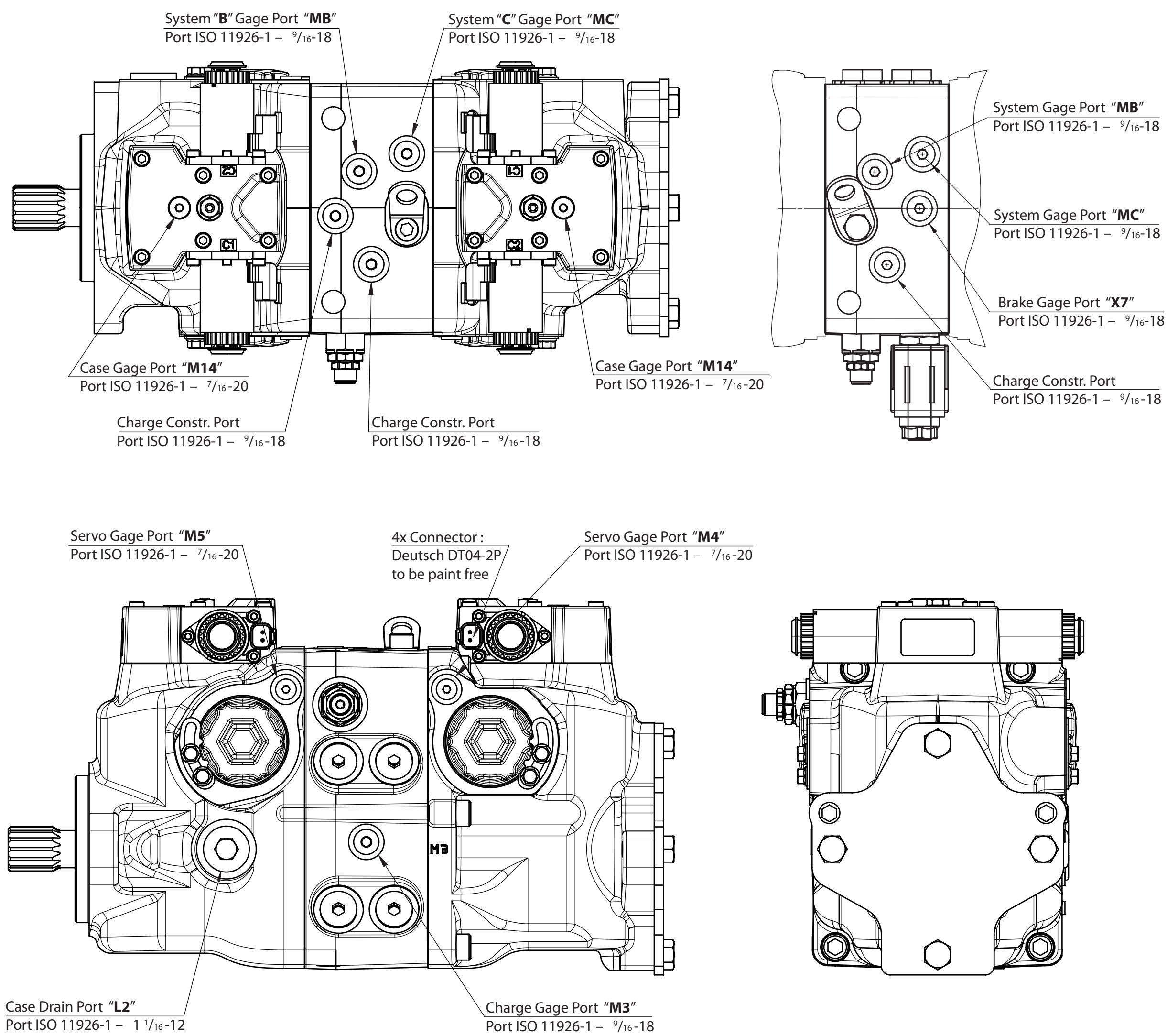
Port	Description	Sizes
A	System Port "**A**"	1 5/16-12
B	System Port "**B**"	1 5/16-12
C	System Port "**C**"	1 5/16-12
D	System Port "**D**"	1 5/16-12
E	Charge Filtration Port from Filter	7/8-14
L1	Case Drain Port	1 1/16-12
L2	Case Drain Port	1 1/16-12
L3	Case Drain Port	1 1/16-12
MA	System "**A**" Gage Port	9/16-18
MB	System "**B**" Gage Port	9/16-18
MC	System "**C**" Gage Port	9/16-18
MD	System "**D**" Gage Port	9/16-18
M3	Charge Gage Port	9/16-18
M4	Servo Gage Port	7/16-20
M5	Gage Port	7/16-20
M14	Case Gage Port	7/16-20
X7	Brake Gage Port	9/16-18

Please contact Sauer-Danfoss for specific installation drawings.

Installation Drawings (continued)

Port Description

Without CCO (Control Cut Off) *With CCO (Control Cut Off)*

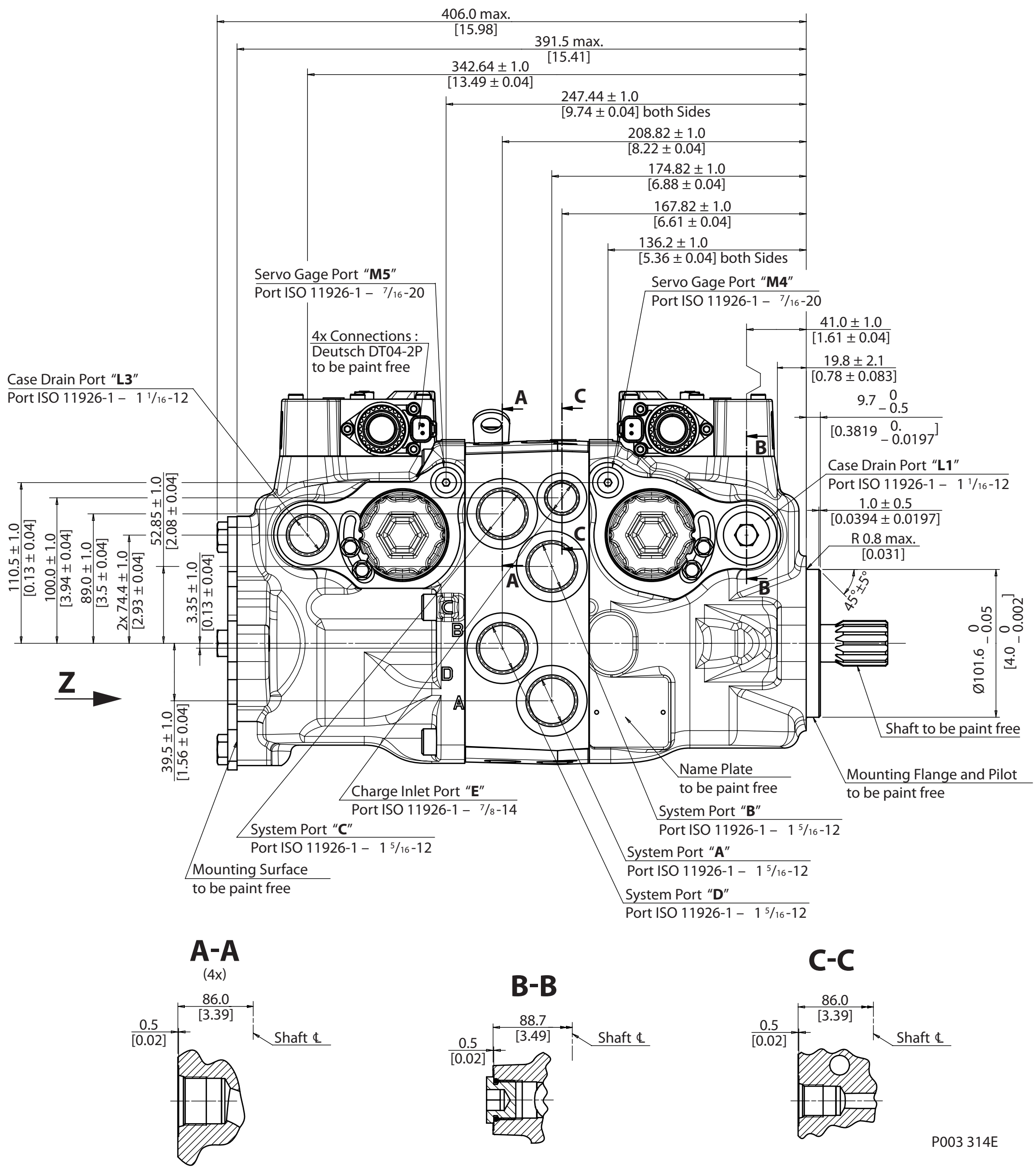


P003 313E

Please contact Sauer-Danfoss for specific installation drawings.

Installation Drawings (continued)

Dimensions

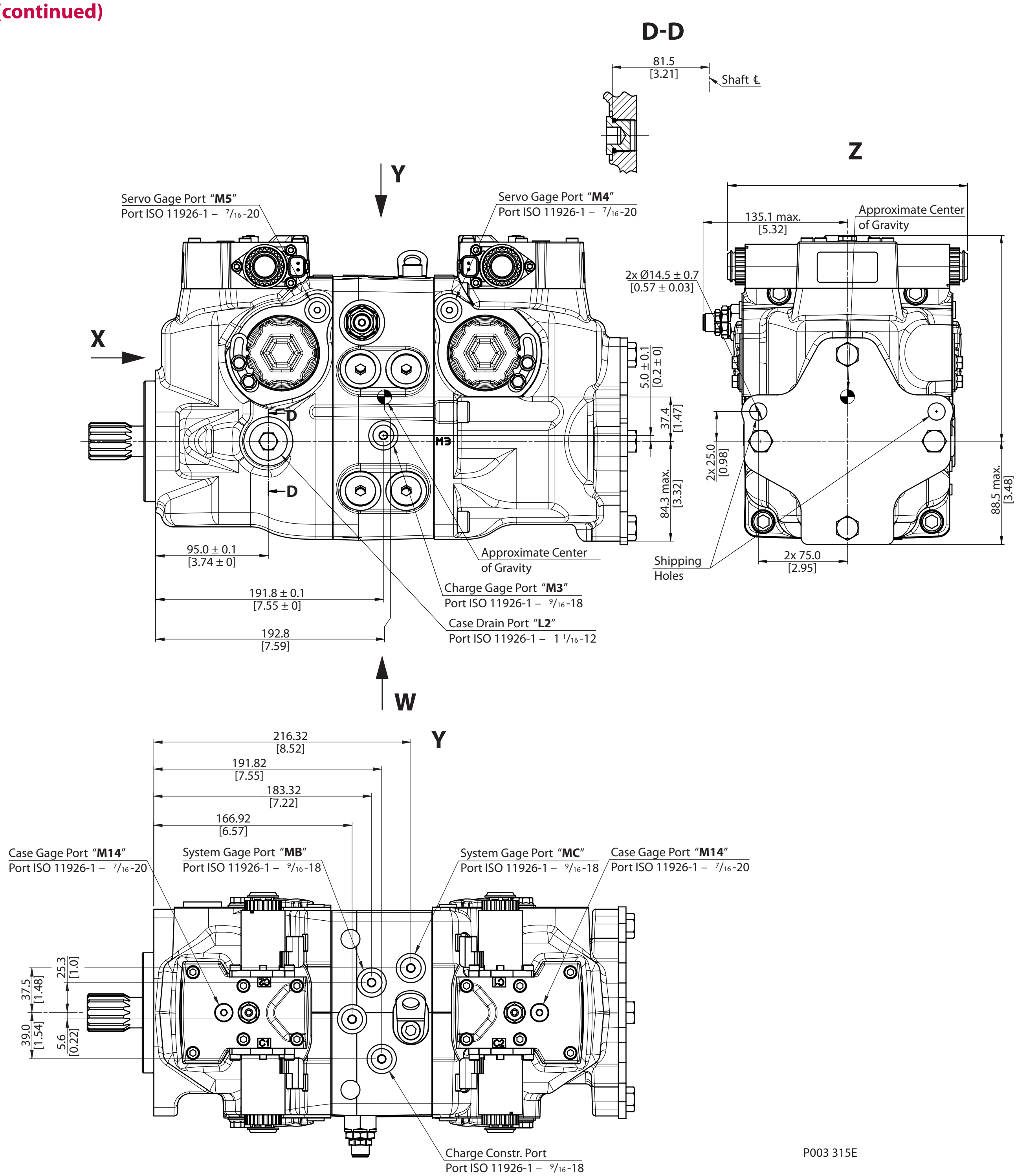


"L3" case drain port must be used (see case drain section for more details).

Please contact Sauer-Danfoss for specific installation drawings.

Installation Drawings (continued)

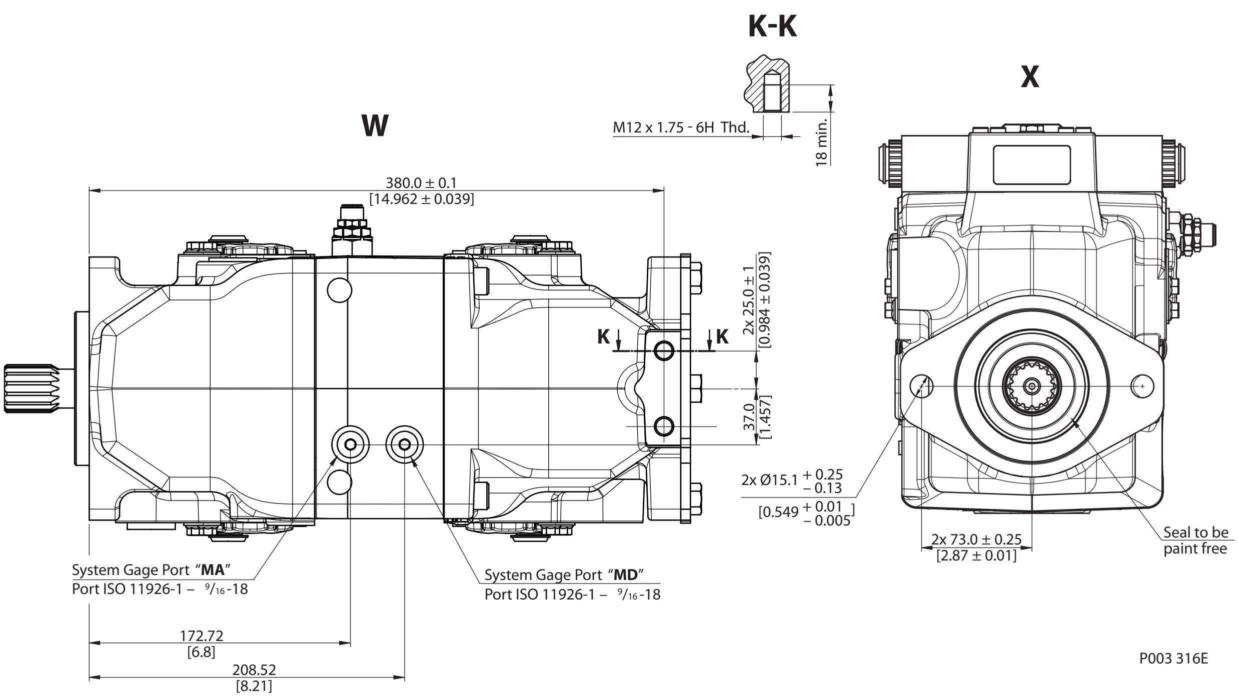
Dimensions



Please contact Sauer-Danfoss for specific installation drawings.

Installation Drawings (continued)

Dimensions



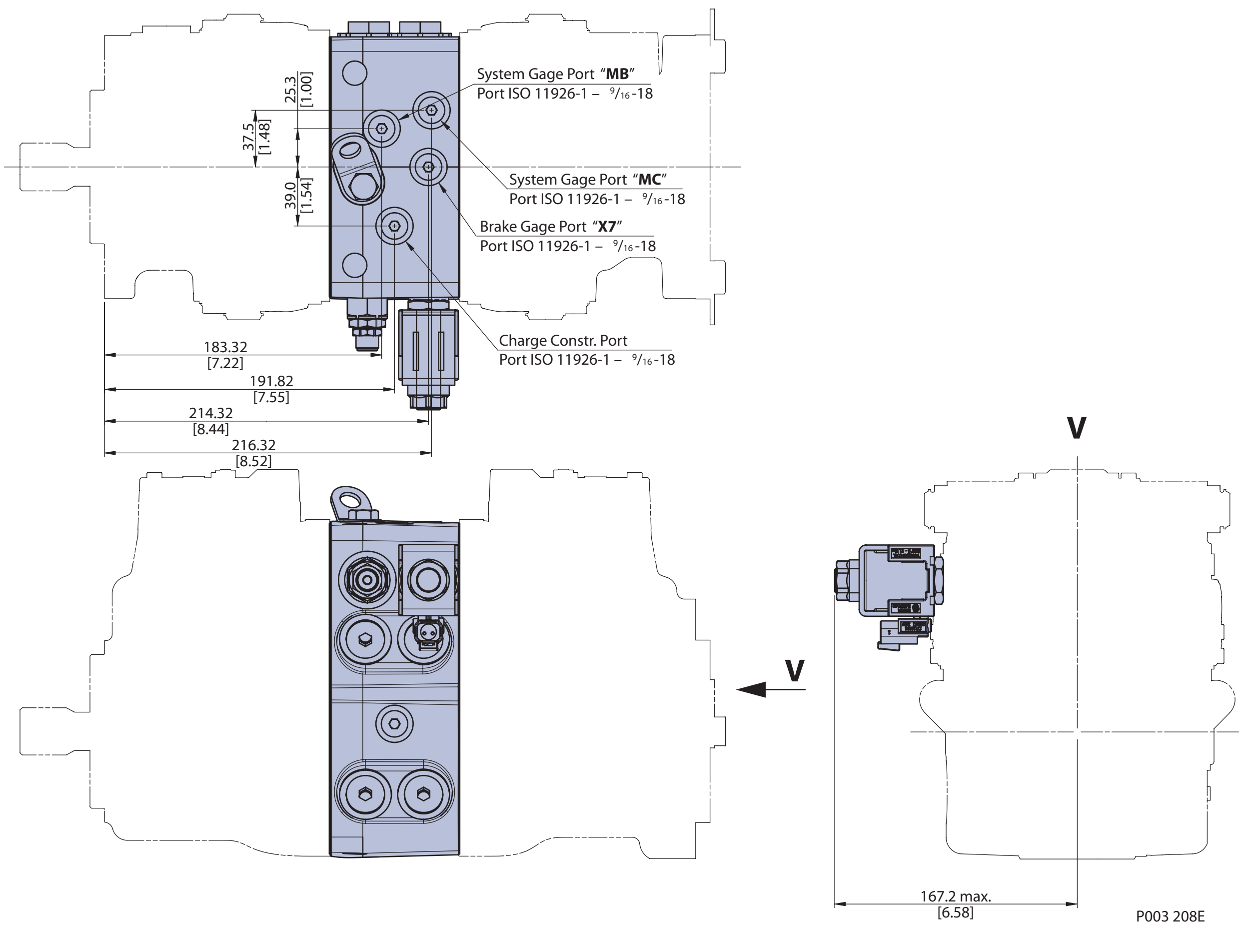
Mounting bolt holes are sized for 14 mm fasteners. M12 or ½ inch can be used, but require a hardened washer.

Please contact Sauer-Danfoss for specific installation drawings.

Installation Drawings (continued)

Controls

Control Cut Off (CCO)



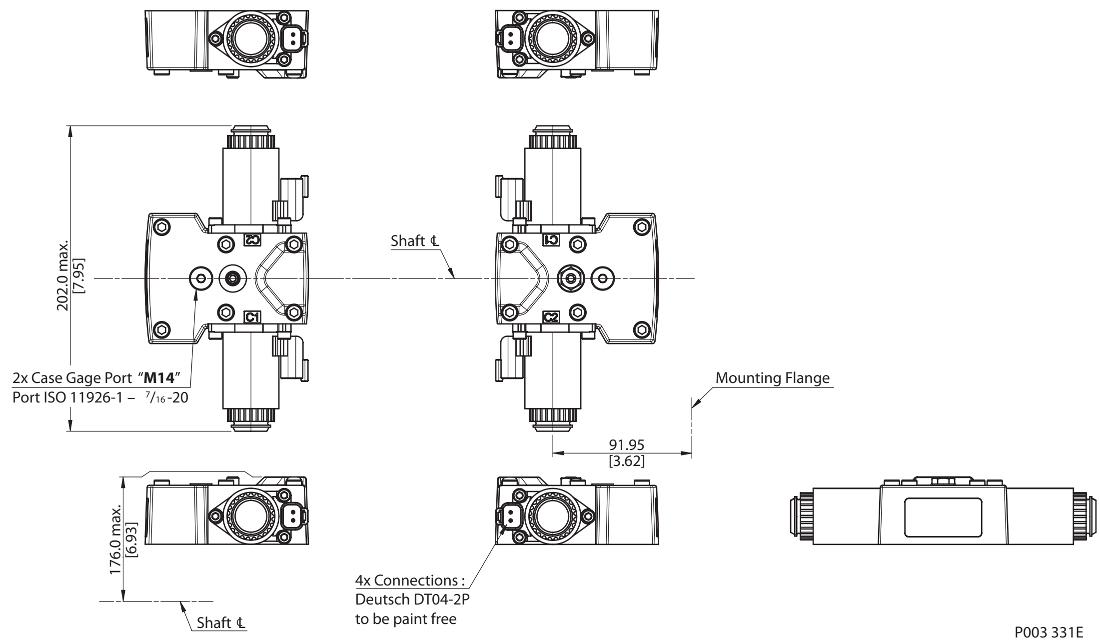
P003 208E

Please contact Sauer-Danfoss for specific installation drawings.

Installation Drawings (continued)

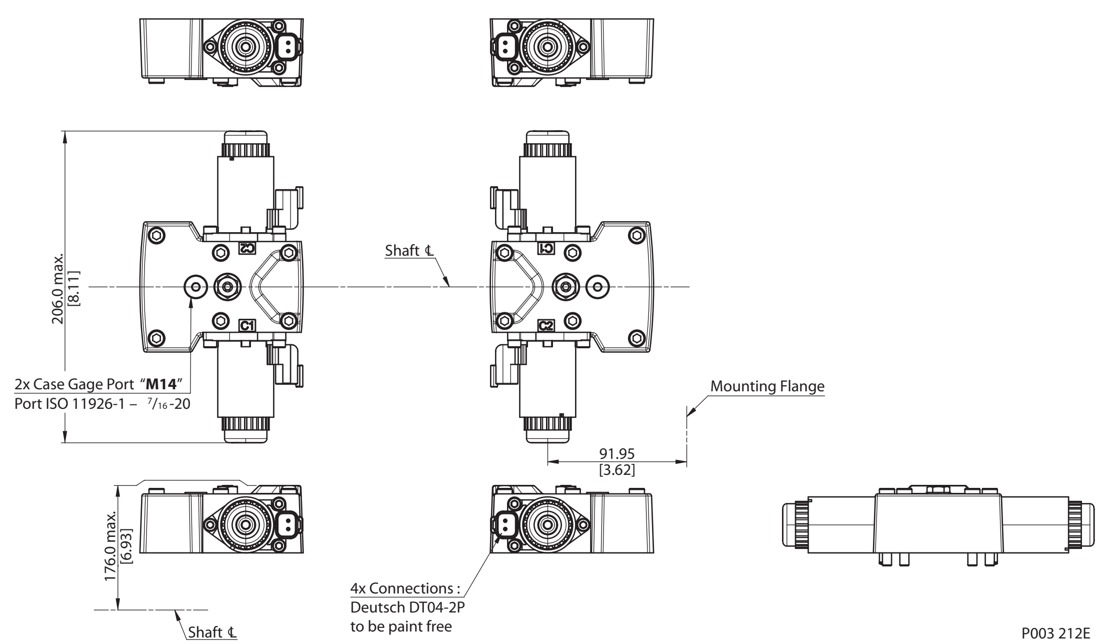
Controls

Electric Displacement Control (EDC)
*Option **A2** (12 V)/**A3** (24 V)*



P003 331E

Electric Displacement Control (EDC) with Manual Override
*Option **A4** (12 V)/**A5** (24 V)*



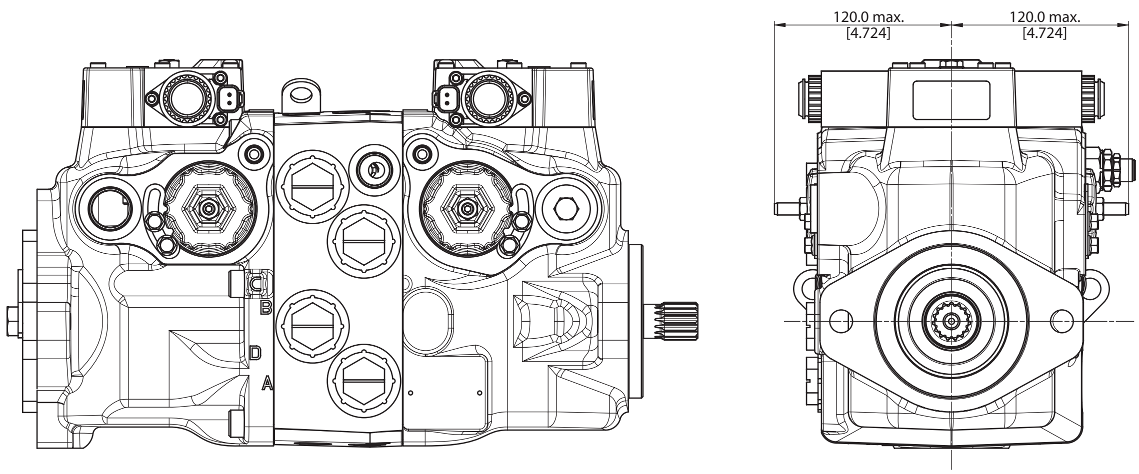
P003 212E

Please contact Sauer-Danfoss for specific installation drawings.

Installation Drawings (continued)

Displacement Limiters

Displacement Limiter
*Option **B** and **D***



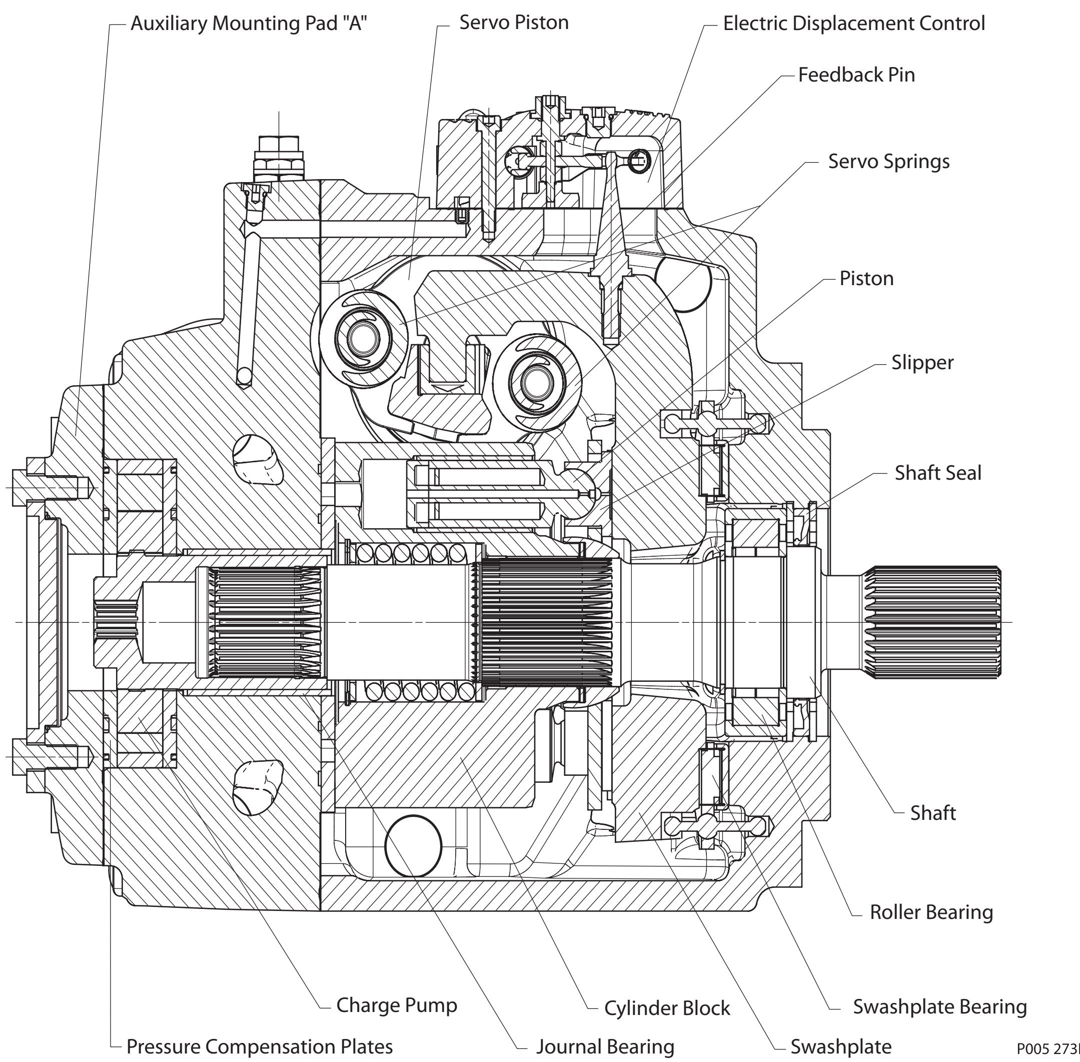
Please contact Sauer-Danfoss for specific installation drawings.

Contents

Design 59
Technical Specifications 60
Bearing Life 62
Mounting Flange Loads 63
Model Code 64
Electrical Displacement Control (EDC) 66
Manual Over Ride (MOR) 68
Displacement Limiter 69
Input Shafts 70
  Option G3 70
  Option G2 70
Auxiliary Mounting Pads 71
  Option H2 SAE "A" 71
  Option H1 SAE "A-A" 72
  Option H3 SAE "B" 73
  Option H5 SAE "B-B" 74
  Option H6 SAE "C" 75
  Option H4 SAE "D" 76
Charge Pump 77
Installation Drawings 78
  Port Description 78
  Dimensions 80
  Controls 83
    Electric Displacement Control (EDC) Option ***A2*** (12 V)/***A3*** (24 V) 83
    Electric Displacement Control (EDC) with Manual Override, Option ***A4*** (12 V)/***A5*** (24 V) 83
  Displacement Limiter 84
    Displacement Limiter Option ***B*** 84
  Filtration 85
    Suction Filtration Option ***L*** 85
    Integral Full Flow Charge Pressure Filtration with Filter Bypass Sensor Option ***M*** 86

Design

Cross Section H1 147/165 cm³ Pump



Technical Specifications

For definitions of the following specifications, see *Operating parameters*.

General Specifications

Design	Axial piston pump of cradle swashplate design with variable displacement
Direction of Rotation	Clockwise, counterclockwise
Pipe Connections	Main pressure ports: SAE flange twin ports
	Remaining ports: SAE straight thread O-ring boss
Recommended Installation Position	Pump installation recommended with control position on the top or side. Consult Sauer-Danfoss for non conformance to these guidelines. The housing must always be filled with hydraulic fluid.
Auxiliary Cavity Pressure	Will see inlet pressure with internal charge pump. Will be case pressure with external charge supply. Please verify mating pump shaft seal capability.

Physical Properties

Feature	Unit	Frame Size	
		147	165
Displacement	cm^3 [in^3]	147 [8.97]	165 [10.07]
Flow at Rated (continuous) Speed	l/min [US gal/min]	441 [117]	495 [131]
Torque at Maximum Displacement (theoretical)	N•m/bar [lbf•in/1000psi]	2.34 [1430]	2.63 [1605]
Mass Moment of Inertia of Rotating Components	kg•m^2 [slug•ft^2]	0.027 [0.00199]	
Weight Dry (without PTO and Filter)	kg [lb]	96 [211]	
Oil Volume	liter [US gal]	3.0 [0.8]	
Mounting Flange		SAE flange, size D (SAE J 744) mounting pad	
Auxiliary Mounting		SAE A, SAE B, SAE B-B, SAE C, SAE D	
Shafts		Splined: 27-teeth 16/32, 13-teeth 8/16	
Suction Ports		1.625-12UN-2B [1 5/8 -12UN-2B]	
Main Port Configuration		Radial Twin Ports, SAE 4-bolt, 1 1/4 - Code 62, M12	
Case Drain Ports L1, L3 (SAE O-ring boss) Case Drain Ports L2, L4 (SAE O-ring boss) prefered usage		1.0625-12UNF-2B [1 1/16 -12UNF-2B] 1.3175-12UNF-2B [1 5/16 -12UNF-2B]	
Other Ports		SAE O-ring boss. See *Installation drawings*.	
Customer Interface Threads		Metric fastener	

Operating Parameters

Feature		Unit	Frame Size	
			147	165
Input Speed	Minimum	min^{-1} (rpm)	500*	
	Minimum for full performance		1200	
	Rated		3000	
	Maximum		3100	
System Pressure	Rated	bar [psi]	450 [6530]	400 [5800]
	Maximum		480 [6960]	450 [6530]
	Minimum low loop		10 [150]	
Charge Pressure	Minimum	bar [psi]	16 [232]	
	Maximum		34 [493]	
Control Pressure	Minimum (at corner power)	bar [psi]	17 [247]	
	Maximum		40 [580]	
Charge Pump Inlet Pressure	Rated	bar (absolute) [in Hg vaccum]	0.7 [9]	
	Minimum (cold start)		0.2 [24]	
	Maximum	bar [psi]	4.0 [58]	
Case Pressure	Rated	bar [psi]	3.0 [40]	
	Maximum		5.0 [75]	

* Not for internal charge pump, 1200 min^{-1} with external charge at ½ displacement for full performance.

Technical Specifications (continued)

Fluid Specifications

Feature		Unit	Frame Size 147	Frame Size 165
Viscosity	Minimum	mm²/s [SUS]	7 [49]	
	Recommended range		12-80 [66-370]	
	Maximum		*1600 [7500]*	
Temperature Range [1]	Minimum	°C [°F]	-40 [-40]	
	Rated		104 [220]	
	Maximum intermittent		*115 [240]*	
Filtration (recommended minimum)	Cleanliness per ISO 4406		22/18/13	
	Efficiency (charge pressure filtration)	β-ratio	$\beta_{15\text{-}20} = 75$ ($\beta_{10} \geq 10$)	
	Efficiency (suction and return line filtration)		$\beta_{35\text{-}45} = 75$ ($\beta_{10} \geq 2$)	
	Recommended inlet screen mesh size	µm	100 – 125	

[1] At the hottest point, normally case drain port.

Bearing Life

Shaft Loads

Normal bearing life in L_{20} hours is shown *in the table below*. The figures reflect a continuous delta pressure, shaft speed, maximum displacement, and no external shaft side load. The data is based on a 50 % forward, 50 % reverse duty cycle, standard charge pump size, and standard charge pressure of 20 bar [290 psi].

Bearing Life with no external Shaft Side Load

Pump Displacement	cm^3 [in^3]	**147 [8.97]**	**165 [10.07]**
Shaft Speed	min^{-1} (rpm)	1800	1800
Delta Pressure – Δp	bar [psi]	240 [3500]	215 [3100]
Bearing Life – L_{20}	hours	28 200	27 100

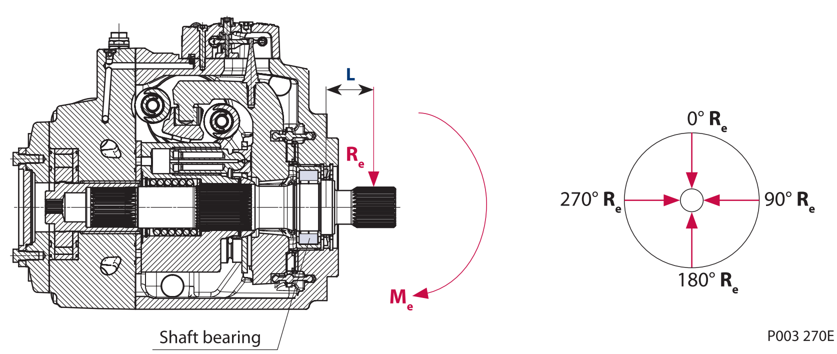
Bearing Life with no external Shaft Side Load

H1 pumps are designed with bearings that can accept some external radial loads. The external radial shaft load limits are a function of the load position and orientation, and the operating conditions of the unit.

The **maximum allowable radial load (R_e)** is based on the maximum external moment (M_e) and the distance (L) from the mounting flange to the load. It may be determined using the following table and formula.

$$R_e = M_e / L$$

Radial Load Position



M_e = Shaft moment
L = Flange distance
R_e = External force to the shaft

Thrust loads should be avoided. Contact factory in the event thrust loads are anticipated.

Bearing Life (continued)

Allowable external Shaft Load:

Displacement		147	165
External Radial Moment – M_e	Nm [lbf•in]	140 [1240]	

All external shaft loads affect bearing life. In applications with external shaft loads, minimize the impact by positioning the load at 0° or 180° as shown *in the figure.*

Sauer-Danfoss recommends clamp-type couplings for applications with radial shaft loads.

Contact your Sauer-Danfoss representative for an evaluation of unit bearing life if you have continuously applied external loads exceeding 25 % of the maximum allowable radial load (R_e) or the pump swashplate is positioned on one side of center all or most of the time.

Mounting Flange Loads

Displacement		147	165
Rated Moment – M_R	Nm [lbf•in]	6500 [57 500]	
Shock Load Moment – M_S		16 300 [144 00]	

For calculation details please see: System Design Parameters section Mounting Flange Loads.

Model Code

		A	B	D	F	E	G	H	J	K	M	N	S	T	V	W	X	Y
H1 P			A					G										

Displacement

147	**147** cm³ [8.97 in³]
165	**165** cm³ [10.06 in³]

A Rotation

L	**L**eft hand (counter clockwise)
R	**R**ight hand (clockwise)

B Product Version

A	Revision code

D Control

A2	Electric Displacement Control (EDC) 12V, Deutsch connector
A3	Electric Displacement Control (EDC) 24V, Deutsch connector
A4	Electric Displacement Control (EDC) 12V, Deutsch connector, Manual override
A5	Electric Displacement Control (EDC) 24V, Deutsch connector, Manual override

F Orifices

C2	Orifices, 1.3 mm in Servo supply for propel applications
C3	No orifice for none propel applications

E Displacement Limiters

N	None
B	Adjustable, factory set to max. displacement

G Endcap Options

	Twin Port, 4-Bolt Split Flange (Code 62)					
Match with below Options (K)	Auxiliary Mounting Pad None, SAE-A, B, B-B, C			Auxiliary Mounting Pad SAE-D		
Match with below Options (T)	Suction Filtration	Integral Full Charge Flow Filtration	Remote Full Charge Flow Filtration	Suction Filtration	Integral Full Charge Flow Filtration	Remote Full Charge Flow Filtration
D3		X				
D5					X	
D6	X					
D7						X
D8			X			
D9				X		

H Mounting

G	SAE D 4-bolt

J Input Shaft

G3	13 teeth splined shaft 8/16 pitch
G2	27 teeth splined shaft 16/32 pitch

K Auxiliary Mounting Pad (align with End Cap Selection, Option G)

NN	None
H2	SAE A pad, 9 teeth 16/32 coupling, shipping cover
H1	SAE A-A pad, 11 teeth 16/32 coupling, shipping cover
H3	SAE B pad, 13 teeth 16/32 coupling, shipping cover
H5	SAE B-B pad, 15 teeth 16/32 coupling, shipping cover
H6	SAE C pad, 14 teeth 12/24 coupling, shipping cover
H4	SAE D pad, 13 teeth 8/16 coupling, shipping cover

Model Code (continued)

H1 P	A	B	D	F	E	G	H	J	K	M	N	S	T	V	W	X	Y
															N N	N N N	N N N

*M Overpressure Protection Type and Setting Side "A" ***

*N Overpressure Protection Type and Setting Side "B" ***

*** Pressure Protection Type must be the same for Side "A" and "B"*

L	K	
L		High pressure relief valve + pressure limiters with bypass
	K	High pressure relief valve with bypass (no pressure limiters)
L15	—	150 bar [2180 psi]
L20	K20	200 bar [2900 psi]
L23	K23	230 bar [3336 psi]
L25	K25	250 bar [3630 psi]
L28	K28	280 bar [4061 psi]
L30	K30	300 bar [4350 psi]
L33	K33	330 bar [4786 psi]
L35	K35	350 bar [5080 psi]
L38	K38	380 bar [5510 psi]
L40	K40	400 bar [5800 psi]
L42	K42	420 bar [6090 psi]
L43	—	430 bar [6237 psi]
L44	—	440 bar [6382 psi] (147 cc only)
L45	K45	450 bar [6960 psi] (147 cc only)

Use to selection for ports "A" and "B"

S Charge Pump

A	26 cm^3/rev [1.57 in^3/rev]
L	34 cm^3/rev [2.07 in^3/rev]

T Filtration Options (align with End Cap Selection, Option G)

L	Suction filtration *(see Basic drawings)*
M	Integral full charge flow filtration with bypass sensor and bypass
P	Remote full charge flow filtration *(see End cap drawings, order remote filter separately)*

V Charge Pressure Relief Setting

20	20 bar [290 psi]
24	24 bar [348 psi]
30	30 bar [435 psi]

W Special Hardware Features

NN	None

X Paint and Nametag

NNN	Black paint and Sauer-Danfoss nametag

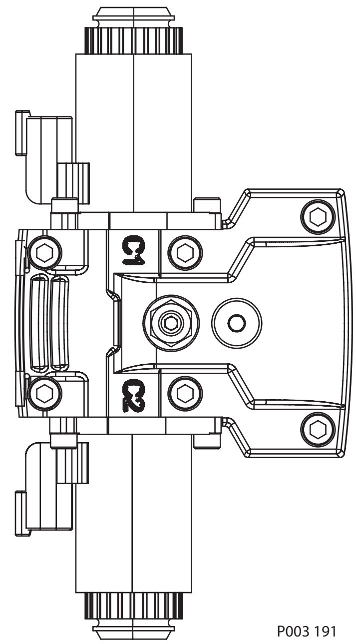
Y Special Settings

NNN	None

Electrical Displacement Control (EDC)

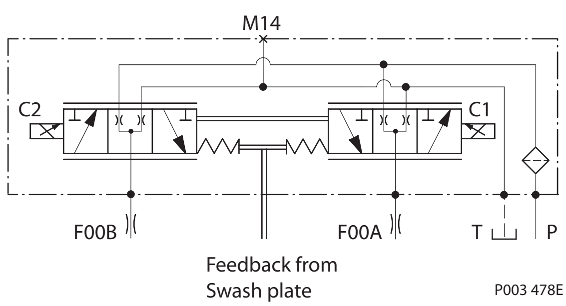
EDC Principle

The Electrical Displacement Control (EDC) consists of a pair of proportional solenoids on each side of a three-position, four-way porting spool. The proportional solenoid applies a force input to the spool, which ports hydraulic pressure to either side of a double acting servo piston. Differential pressure across the servo piston rotates the swashplate, changing the pump's displacement from full displacement in one direction to full displacement in the opposite direction.



P003 191

EDC-Schematic Diagram



P003 478E

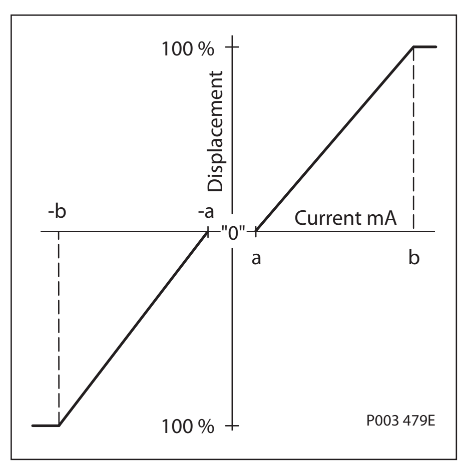
Control Signal Requirements

Control Current

Voltage	a* mA	b mA	Pin Connections
12 V	700	1640	any order
24 V	352	820	

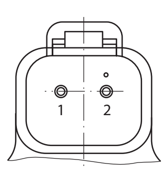
* Factory test current, for vehicle movement or application actuation expect higher value.

Pump Displacement vs. Control Current



P003 479E

Connector



P003 480

Description	Quantity	Ordering Number
Connector	1	Deutsch® DT06-2S
Wedge Lock	1	Deutsch® W2S
Socket Contact (16 and 18 AWG)	2	Deutsch® 0462-201-16141
Sauer-Danfoss Mating Connector Kit	1	K29657

Electrical Displacement Control (EDC) (continued)

Solenoid Data

Voltage	12V	24V
Maximum Current	1800 mA	920 mA
Rated Power	18 W	
Nominal Coil Resistance @ 20 °C [70 °F]	3.66 Ω	14.20 Ω
Nominal Coil Resistance @ 80 °C [176 °F]	4.52 Ω	17.52 Ω
PWM Range	70-200 Hz	
PWM Frequency (preferred)*	100 Hz	
Inductance	33 mH	140 mH
IP Rating (DIN 40 050)	IP 67	
IP Rating (DIN 40 050) with Mating Connector	IP 69K	

* PWM signal required for optimum control performance.

Pump Output Flow Direction vs. Control Signal

Shaft Rotation	CW		CCW	
Coil Energized*	C2	C1	C2	C1
Port A	in	out	out	in
Port B	out	in	in	out
Servo Port Pressurized	M5	M4	M5	M4

* For coil location see installation drawings.

Control Response

H1 controls are available with optional control passage orifices to assist in matching the rate of swashplate response to the application requirements (e.g. in the event of electrical failure). Software ramp or rate limiting should be used to control vehicle response in normal operation. The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure. A swashplate response table is available for each frame indicating available swashplate response times. Testing should be conducted to verify the proper orifice selection for the desired response.

H1 pumps are limited in mechanical orificing combinations. Software is envisioned as the means to control the swashplate response in normal operating conditions.

Mechanical servo orifices are to be used only for fail-safe return to neutral in the event of an electrical failure.
Typical response times shown below at the following conditions:

Δp	=	250 bar	[3626 psi]
Viscosity and temperature	=	30 mm²/s (50 °C)	[141 SUS (122 °F)]
Charge pressure	=	20 bar	[290 psi]
Speed	=	1800 min^{-1} (rpm)	

Response Times

Frame Size	Stroking Direction	1.3 mm [0.05 in] Orifice	No
147/165	Neutral to full flow	2.1 s	1.3 s
	Full flow to neutral	1.6 s	1.2 s

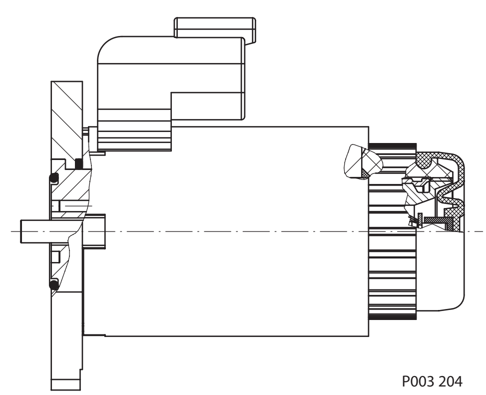
Manual Over Ride (MOR)

All controls are available with a Manual Over Ride (MOR) either standard or as an option for temporary actuation of the control to aid in diagnostics.
FNR controls are always supplied with MOR functionality.

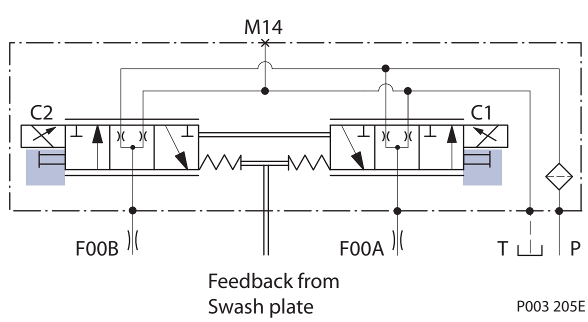
The vehicle or device must always be in a „safe“ condition (i.e. vehicle lifted off the ground) when using the MOR function. The MOR plunger has a 4 mm diameter and must be manually depressed to be engaged. Depressing the plunger mechanically moves the control spool which allows the pump to go on stroke. The MOR should be engaged anticipating a full stroke response from the pump.

An o-ring seal is used to seal the MOR plunger. Initial actuation of the function will require additional force to overcome the o-ring resistance. A threshold force of 45 N is typically required at first actuation. Additional actuations typically require a threshold force of 12 N to move the MOR plunger. Force required to keep the pump at full stroke is typically 51 N. Proportional control of the pump using the MOR should not be expected.

Refer to control flowtable for the relationship of solenoid to direction of flow.



MOR-Schematic Diagram (EDC shown)

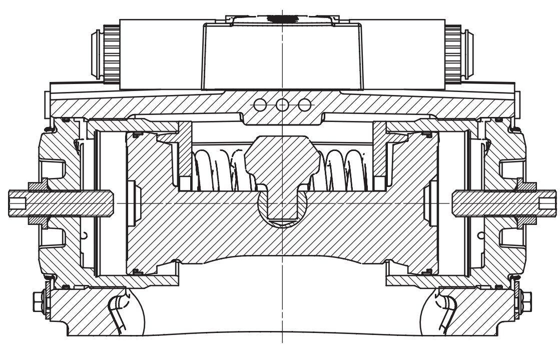


Displacement Limiter

H1 pumps 147/165 are designed with optional mechanical displacement (stroke) limiters factory set to max. displacement.

The maximum displacement of the pump can be set independently to zero displacement for forward and reverse using the two adjustment screws.

Displacement Limiter

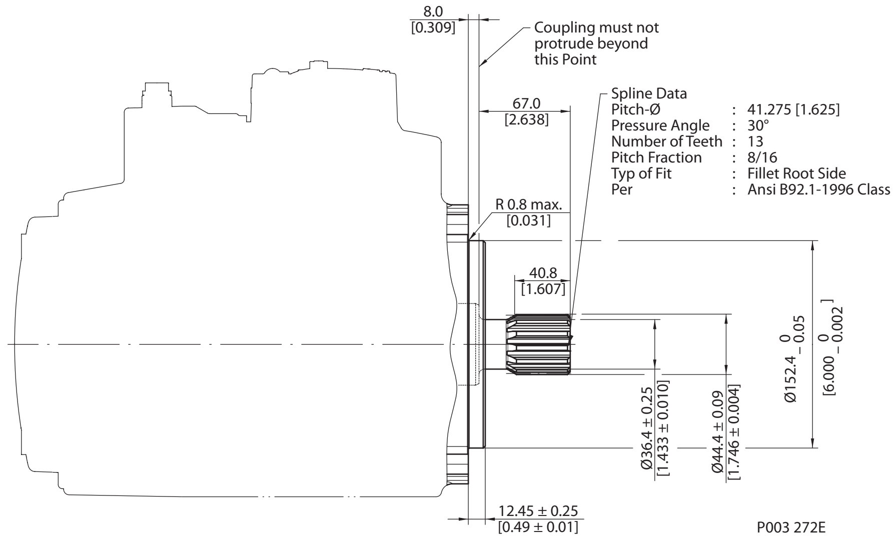

P003 266

Displacement Change (approximately)

Frame Size	1 Turn of Displacement Limiter Screw
147	12.4 cm^3
165	13.9 cm^3

Input Shafts

Option G3

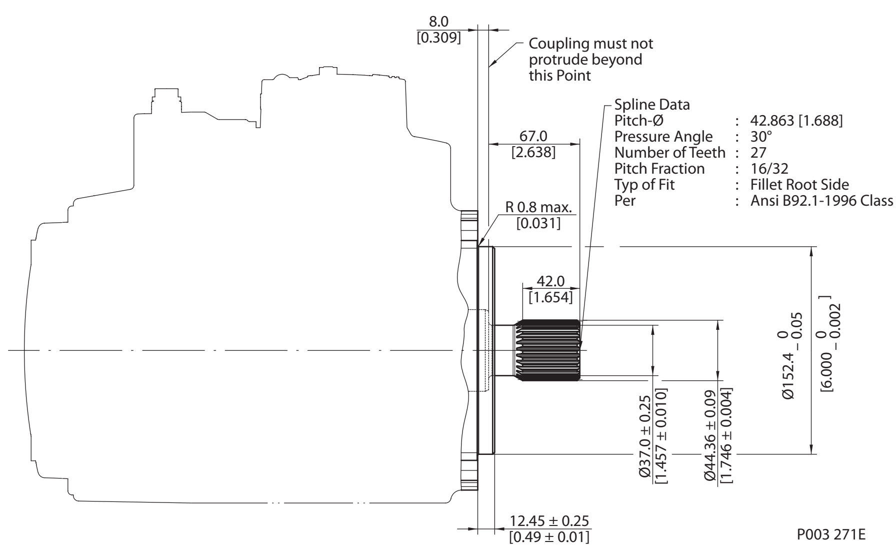


Specifications

Option	Spline	Min. active Spline Length mm [in]	Torque Rating[1] N•m [lbf•in] Rated Torque	Maximum Torque
G3	13 teeth, 8/16 pitch	40.8 [1.607]	1442 [12 800]	2206 [19 500]

1) For definitions of maximum and continuous torque values, refer to *Shaft torque ratings and spline lubrication*.

Option G2



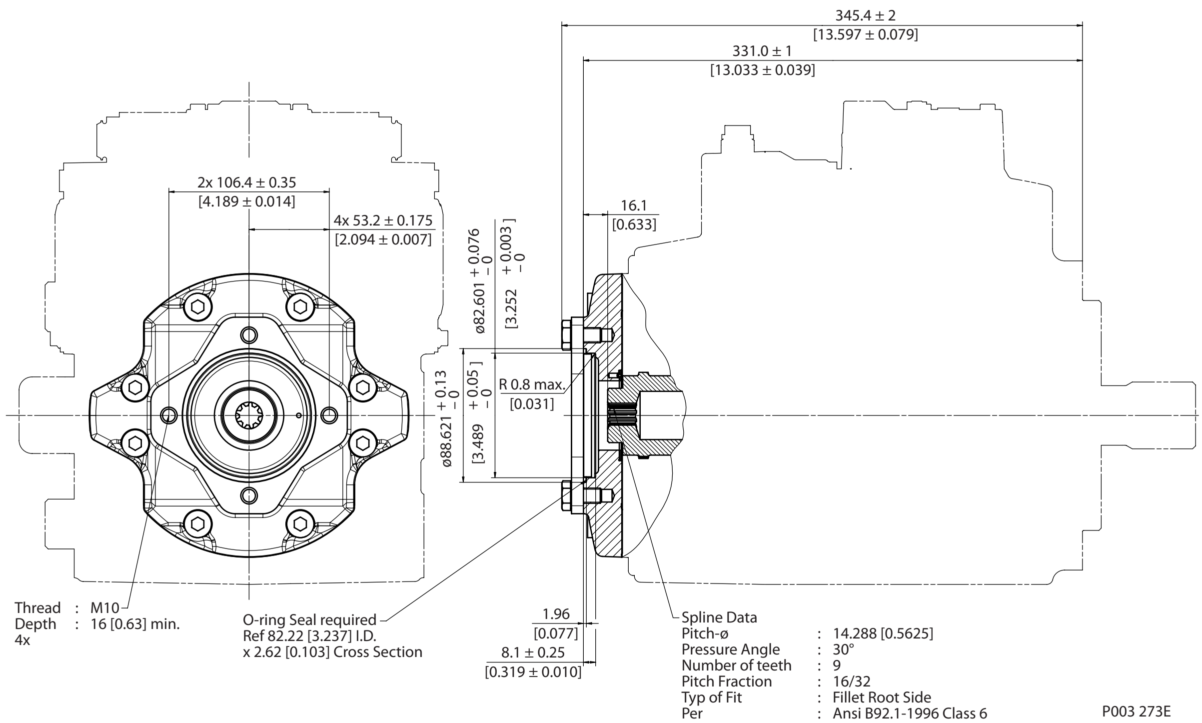
Specifications

Option	Spline	Min. active Spline Length mm [in]	Torque Rating[1] N•m [lbf•in] Rated Torque	Maximum Torque
G2	27 teeth, 16/32 pitch	42.0 [1.654]	1615 [14 300]	2291 [20 300]

1) For definitions of maximum and continuous torque values, refer to *Shaft torque ratings and spline lubrication*.

Auxiliary Mounting Pads

Option H2 SAE "A"



Specifications

Option	Spline	Min. active Spline Length mm [in]	Torque Rating[1] N•m [lbf•in] Rated Torque	Maximum Torque
H2	9 teeth, 16/32 pitch	8.6 [0.34]	60 [529]	162 [1430]

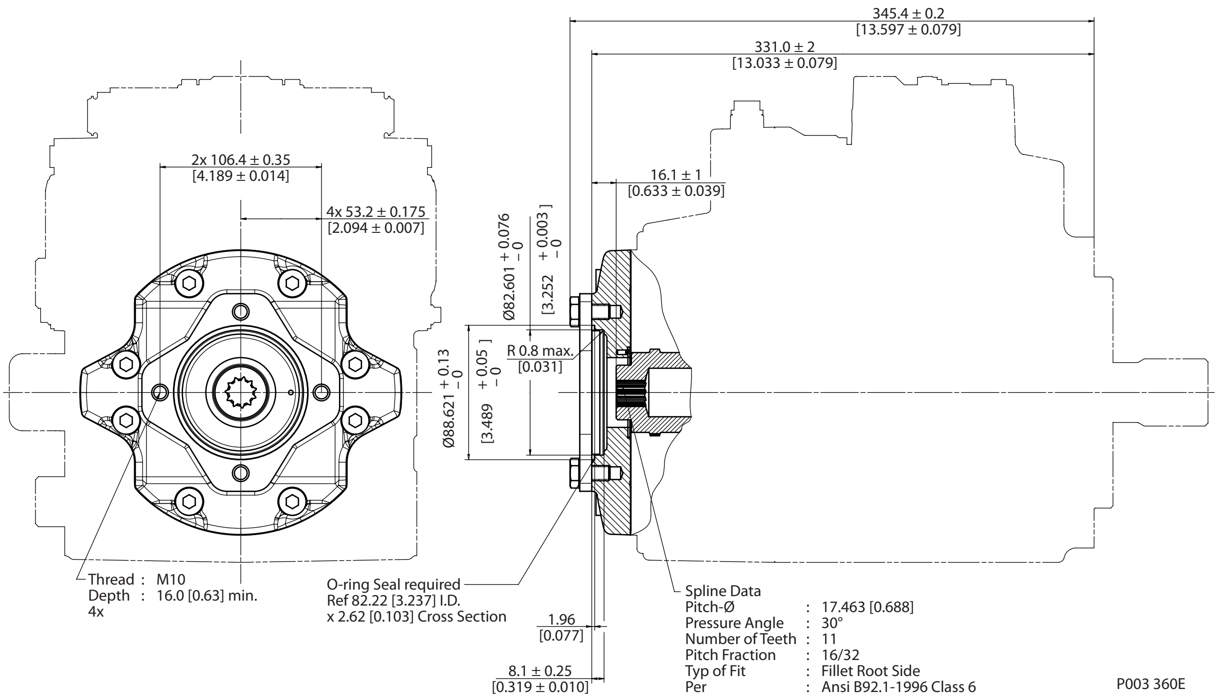
1) For definitions of maximum and continuous torque values, refer to *Shaft torque ratings and spline lubrication*.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Auxiliary Mounting Pads (continued)

Option H1 SAE "A-A"



Specifications

Option	Spline	Min. active Spline Length mm [in]	Torque Rating[1] N•m [lbf•in] Rated Torque	Maximum Torque
H1	11 teeth, 16/32 pitch	10.5 [0.41]	109 [967]	296 [2620]

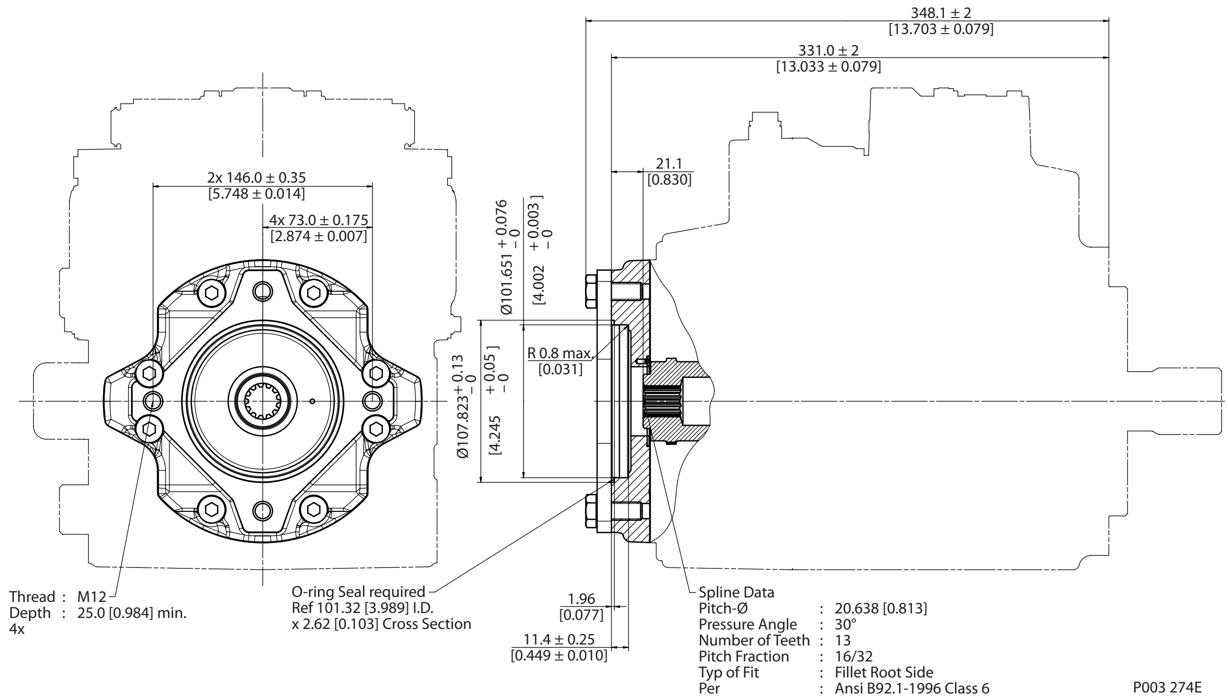
1) For definitions of maximum and continuous torque values, refer to *Shaft torque ratings and spline lubrication*.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Auxiliary Mounting Pads (continued)

Option H3 SAE "B"



Specifications

Option	Spline	Min. active Spline Length mm [in]	Torque Rating[1] N•m [lbf•in]	
			Rated Torque	Maximum Torque
H3	13 teeth, 16/32 pitch	12.4 [0.49]	180 [1600]	395 [3500]

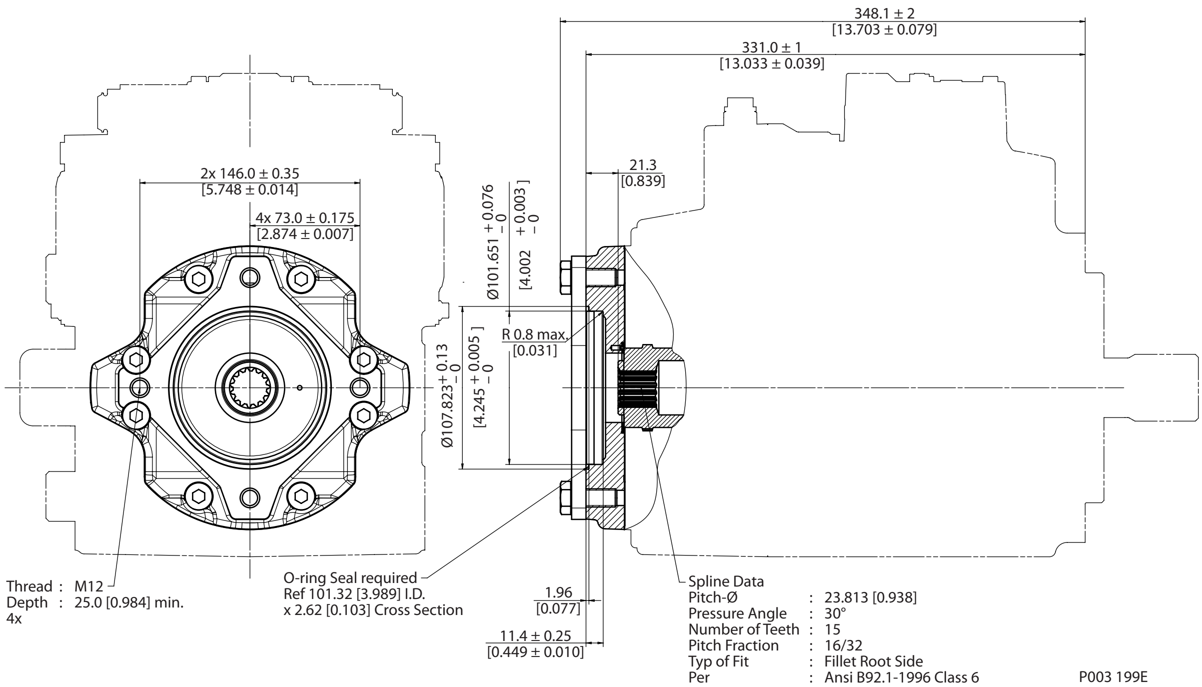
1) For definitions of maximum and continuous torque values, refer to *Shaft torque ratings and spline lubrication*.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Auxiliary Mounting Pads (continued)

Option H5 SAE "B-B"



Specifications

Option	Spline	Min. active Spline Length mm [in]	Torque Rating[1] N•m [lbf•in] Rated Torque	Maximum Torque
H5	15 teeth, 16/32 pitch	14.3 [0.56]	277 [2450]	693 [6130]

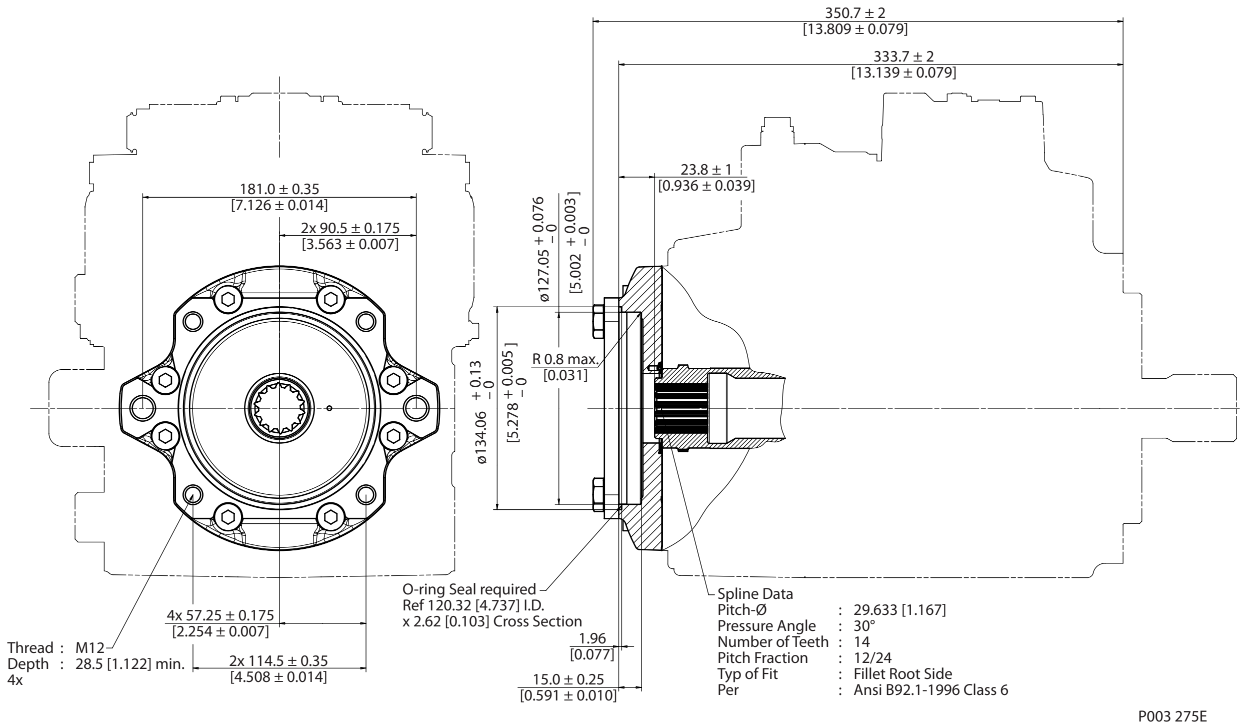
1) For definitions of maximum and continuous torque values, refer to *Shaft torque ratings and spline lubrication*.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Auxiliary Mounting Pads (continued)

Option H6 SAE "C"



Specifications

Option	Spline	Min. active Spline Length mm [in]	Torque Rating[1] N•m [lbf•in] Rated Torque	Maximum Torque
H6	14 teeth, 12/24 pitch	15.2 [0.60]	534 [4720]	816 [7220]

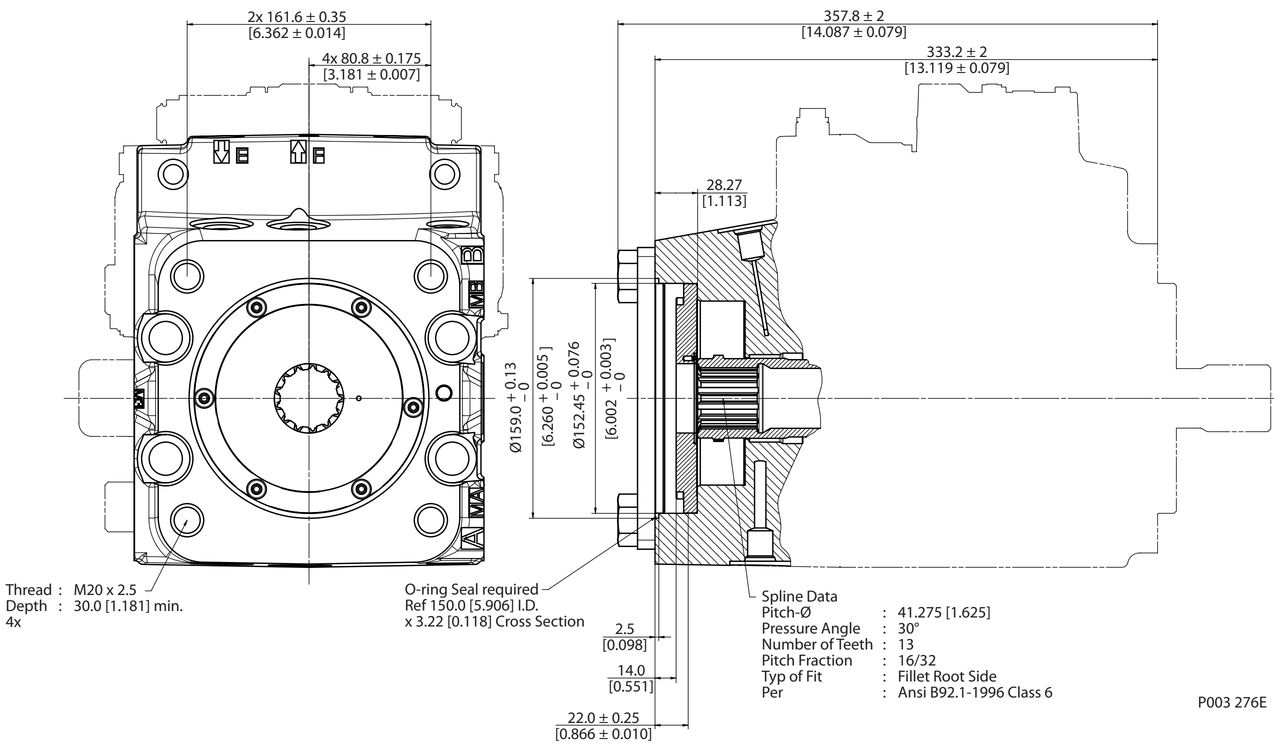
1) For definitions of maximum and continuous torque values, refer to *Shaft torque ratings and spline lubrication*.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Auxiliary Mounting Pads (continued)

Option H4 SAE "D"



Specifications

Option	Spline	Min. active Spline Length mm [in]	Torque Rating[1] N•m [lbf•in] Rated Torque	Maximum Torque
H4	13 teeth, 8/16 pitch	20.3 [0.40]	1442 [12 800]	2206 [19 500]

1) For definitions of maximum and continuous torque values, refer to *Shaft torque ratings and spline lubrication*.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Charge Pump

Charge Pump Sizing/Selection

In most applications a general guideline is that the charge pump displacement should be at least 10% of the total displacement of all components in the system. Unusual application conditions may require a more detailed review of charge flow requirements. Please refer to BLN-9985, Selection of Drive line Components, for a detailed procedure.

System features and conditions which may invalidate the 10 % guideline include (but are not limited to):

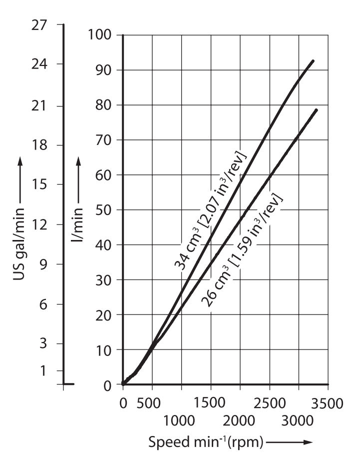
- Continuous operation at low input speeds (< 1500 min^{-1} (rpm))
- High shock loading and/or long loop lines
- High flushing flow requirements
- Multiple Low Speed High Torque motors
- High input shaft speeds

Contact your Sauer-Danfoss representative for application assistance if your application includes any of these conditions.

Charge pump flow and power curves

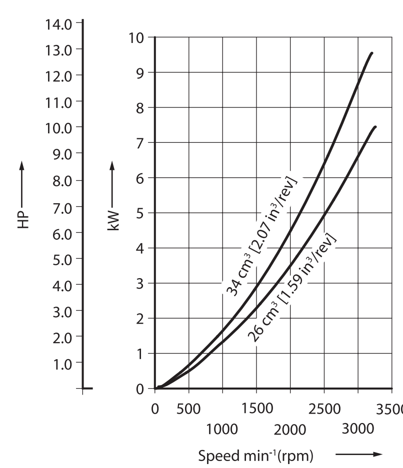
Charge pressure:	20 bar	[290 psi]
Case drain:	80 °C (8.2 mm^2/s)	[180 °F (53 SUS)]
Reservoir temperature:	70 °C (11 mm^2/s)	[160 °F (63 SUS)]

Charge Pump Flow



P003 335E

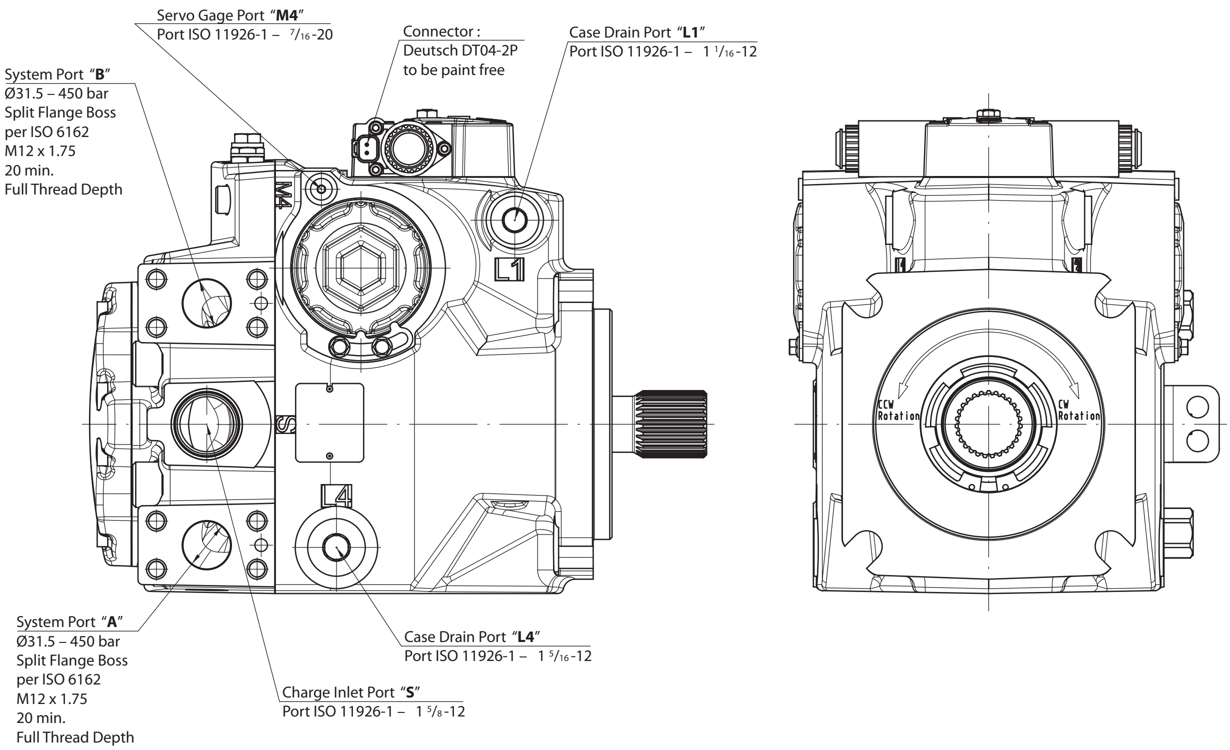
Charge Pump Power Requirements

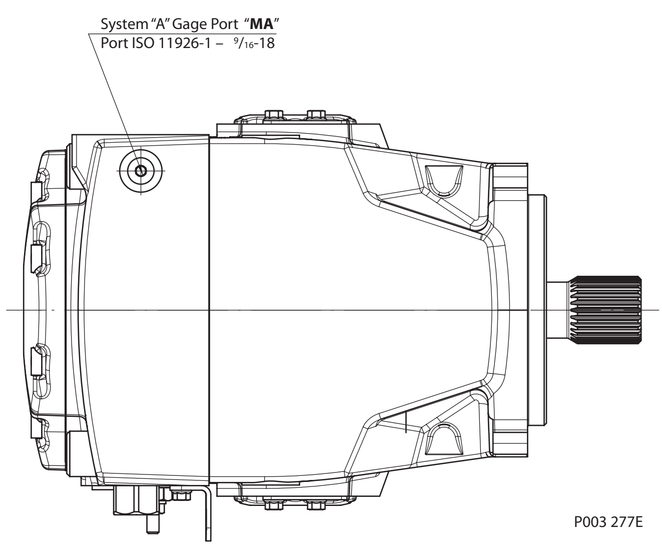


P003 337E

Installation Drawings

Port Description





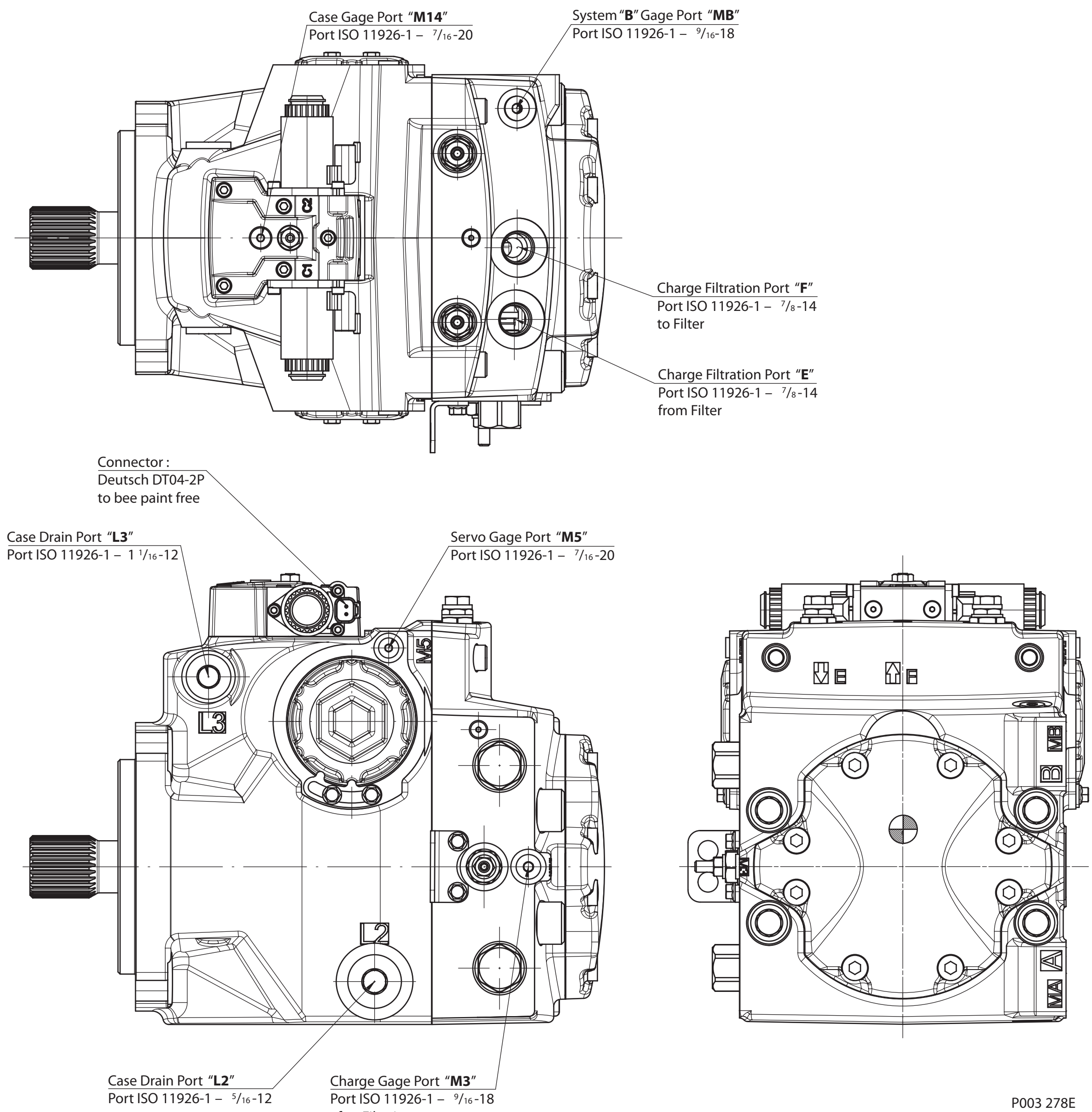
Port Description

Port	Description	Sizes
A	System Port "**A**"	Ø 31.5
B	System Port "**B**"	Ø 31.5
E	Charge Filtration Port, from Filter	7/8-14
F	Charge Filtration Port, to Filter	7/8-14
L1	Case Drain Port	1 1/16-12
L2	Case Drain Port	1 5/16-12
L3	Case Drain Port	1 1/16-12
L4	Case Drain Port	1 5/16-12
MA	System "**A**" Gage Port	9/16-18
MB	System "**B**" Gage Port	9/16-18
M3	Charge Gage Port, after Filtering	9/16-18
M4	Servo Gage Port	7/16-20
M5	Servo Gage Port	7/16-20
M14	Case Gage Port	7/16-20
S	Charge Inlet Port	1 5/8-12

Please contact Sauer-Danfoss for specific installation drawings.

Installation Drawings (continued)

Port Description

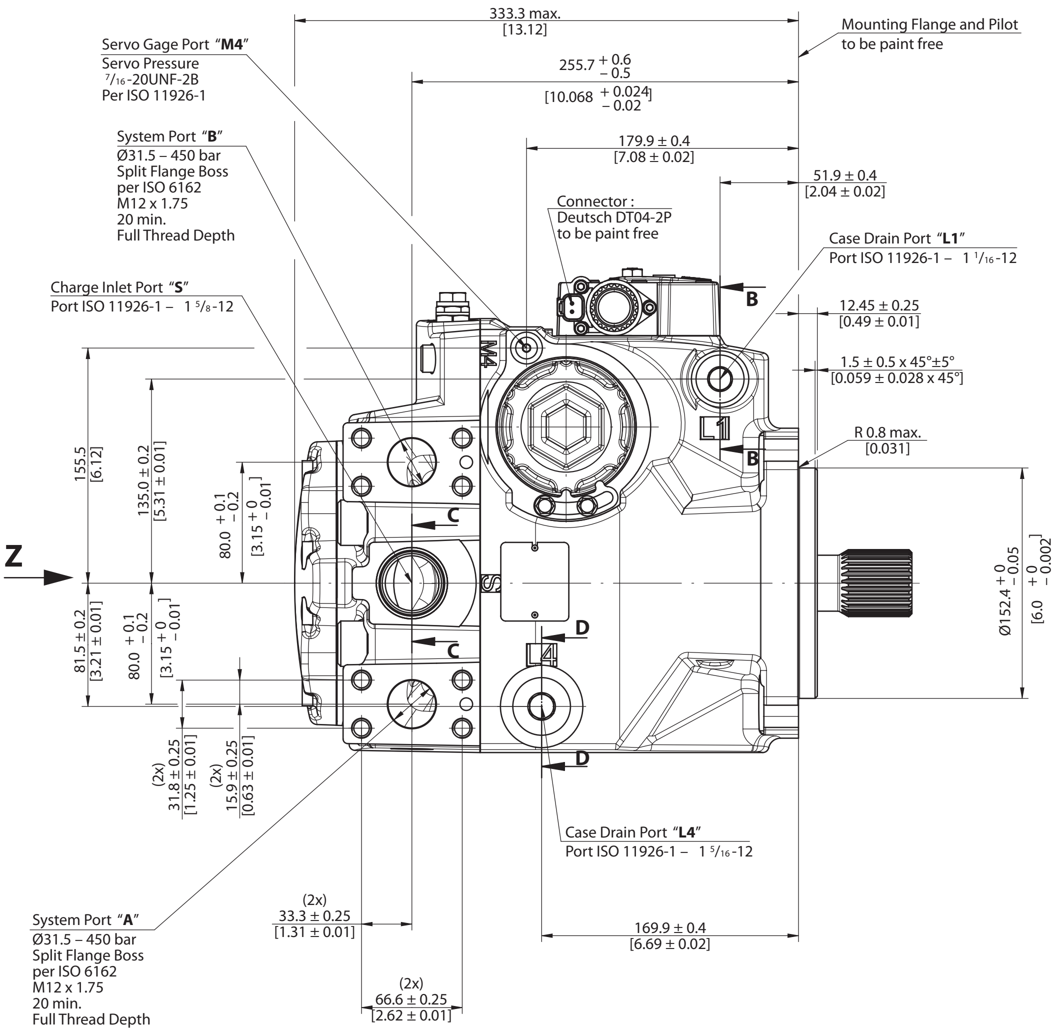


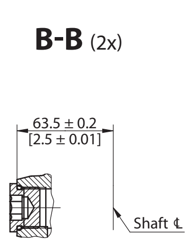
P003 278E

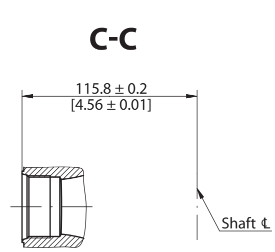
Please contact Sauer-Danfoss for specific installation drawings.

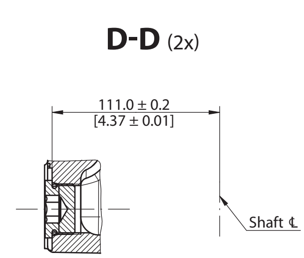
Installation Drawings (continued)

Dimensions







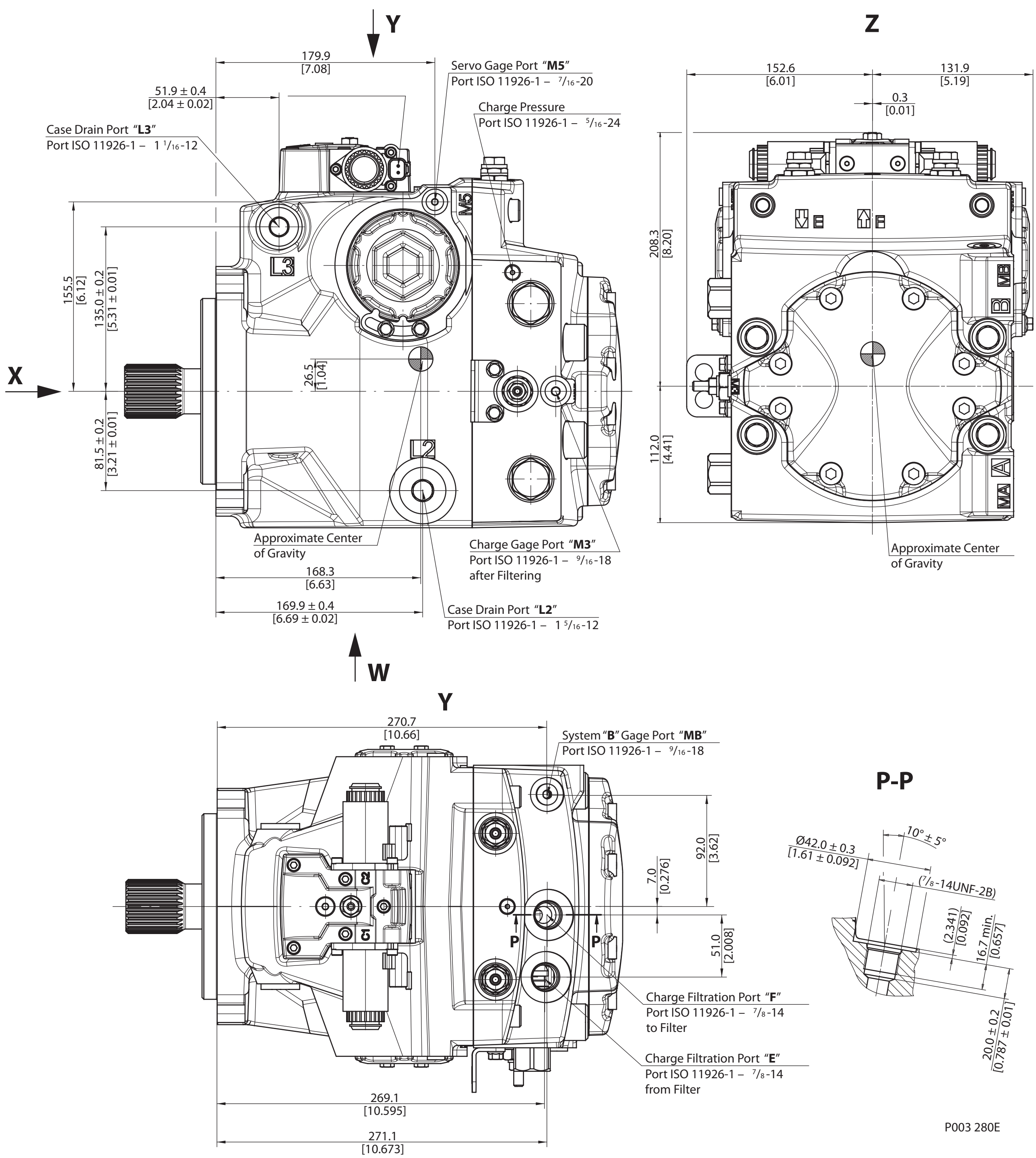


P003 279E

Please contact Sauer-Danfoss for specific installation drawings.

Installation Drawings (continued)

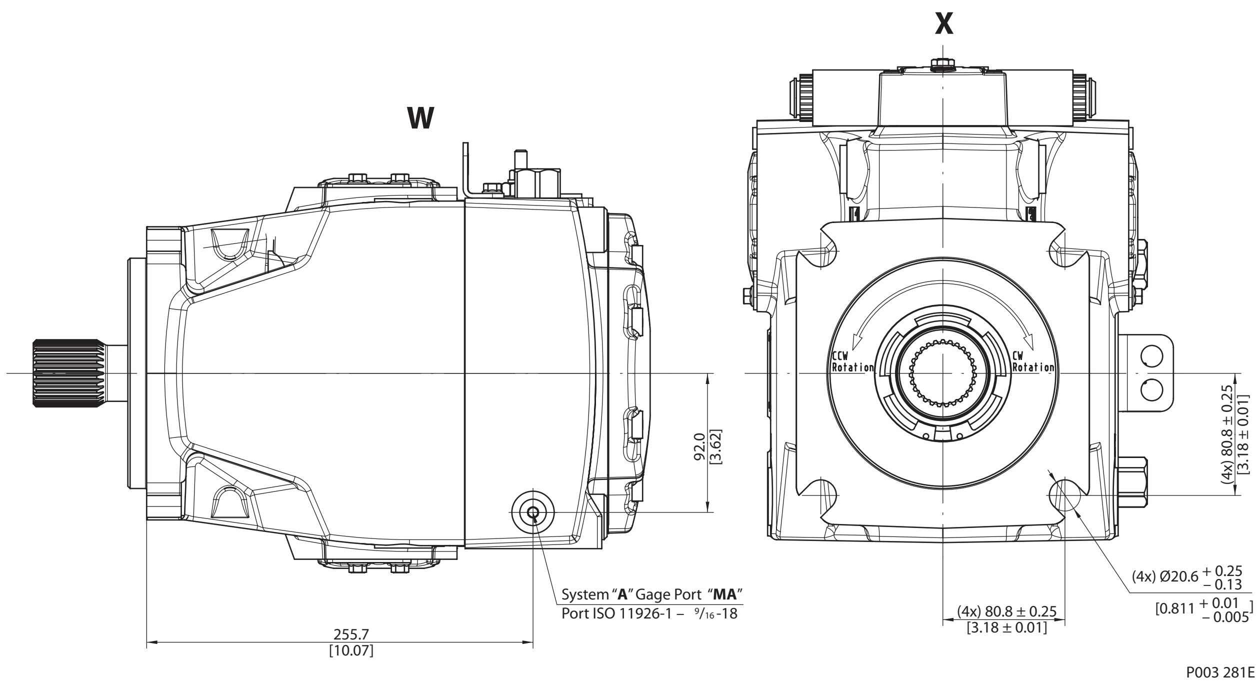
Dimensions



Use always highest case drain port. Please contact Sauer-Danfoss for specific installation drawings.

Installation Drawings (continued)

Dimensions

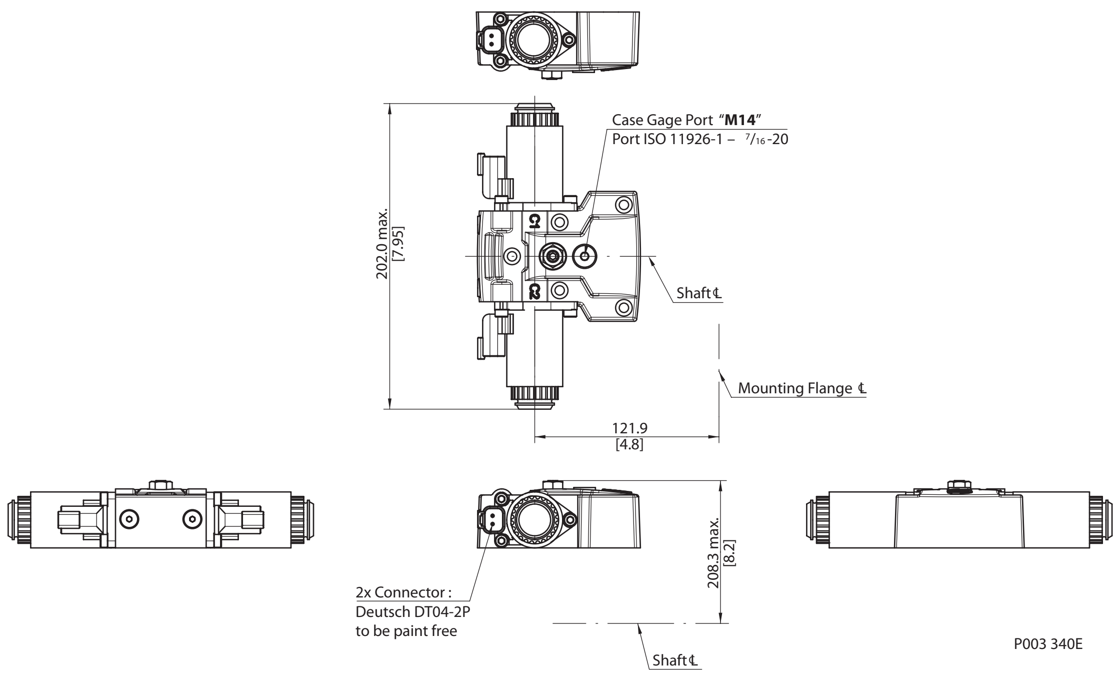


Please contact Sauer-Danfoss for specific installation drawings.

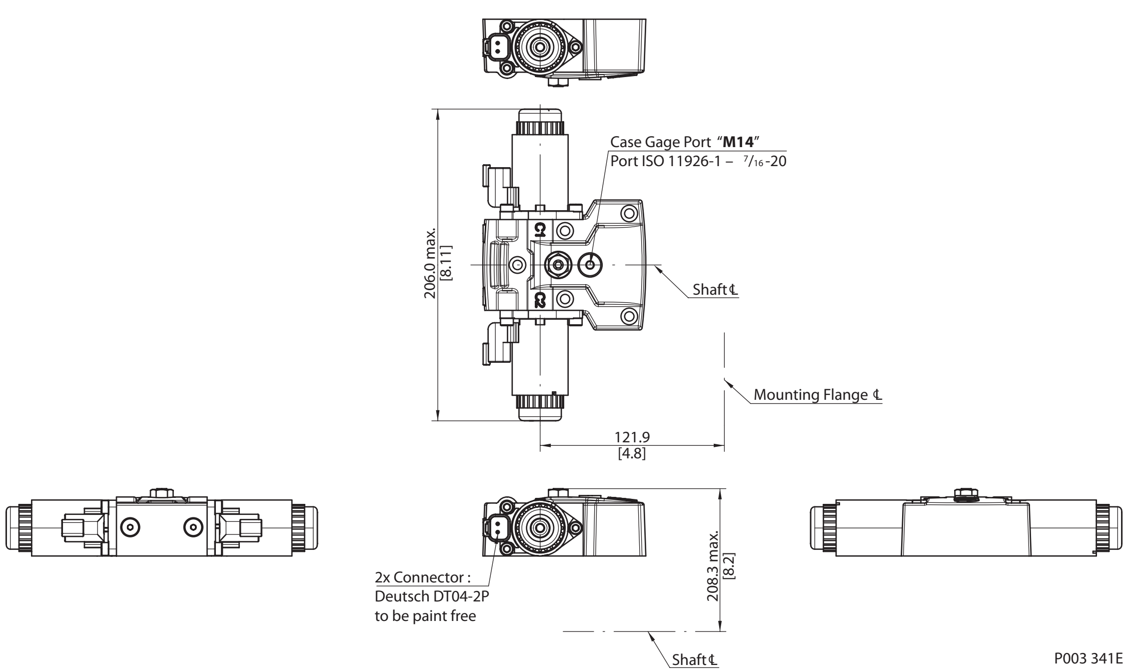
Installation Drawings (continued)

Controls

Electric Displacement Control (EDC)
*Option **A2** (12 V)/**A3** (24 V)*



Electric Displacement Control (EDC) with Manual Override,
*Option **A4** (12 V)/**A5** (24 V)*

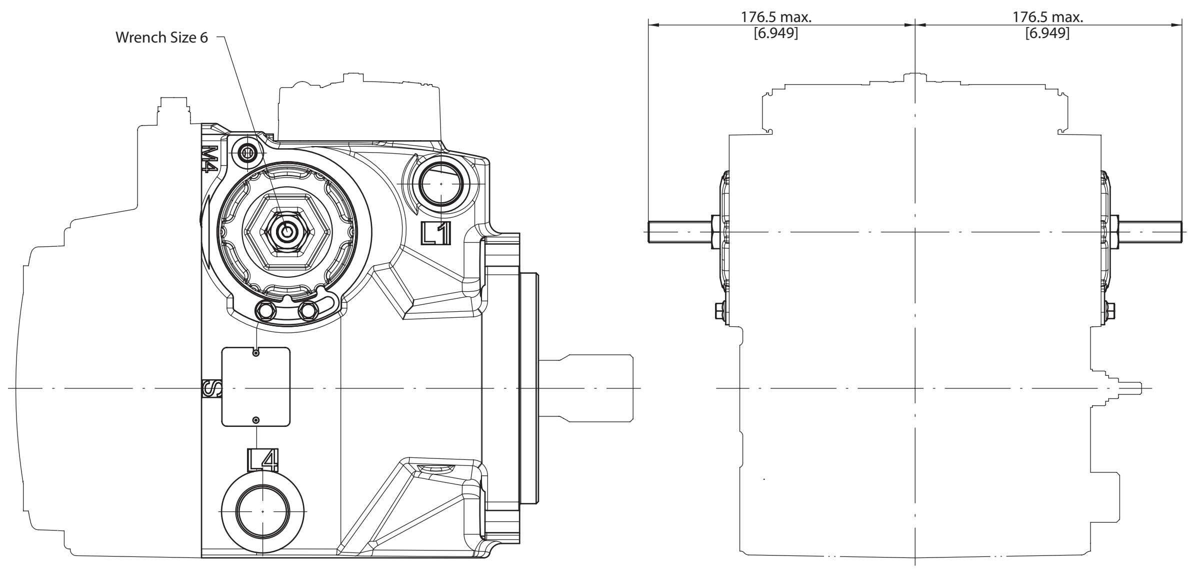


Please contact Sauer-Danfoss for specific installation drawings.

Installation Drawings (continued)

Displacement Limiter

Displacement Limiter
*Option **B***



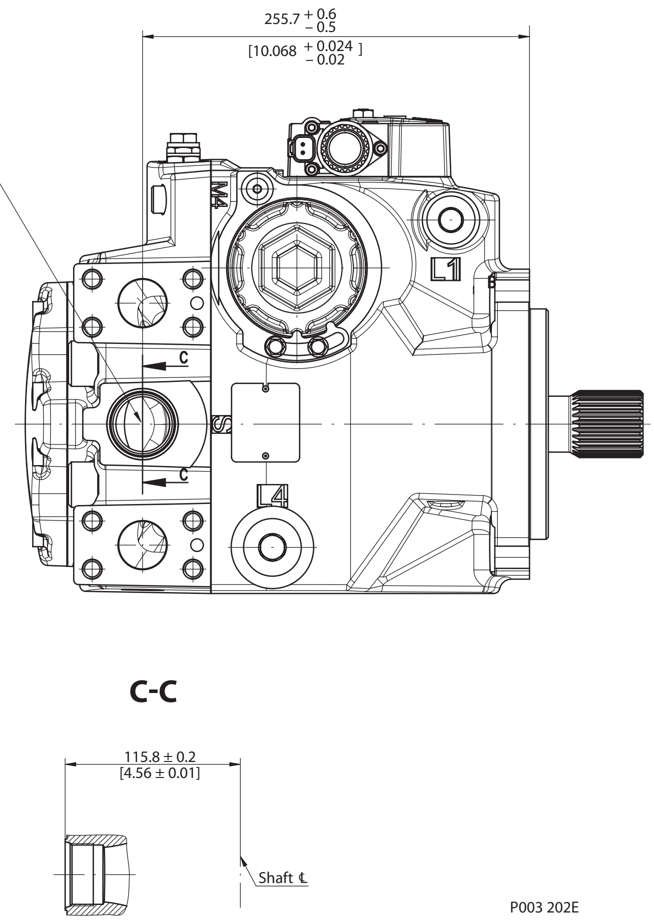
P003 344E

Please contact Sauer-Danfoss for specific installation drawings.

Installation Drawings (continued)

Filtration

Suction Filtration
*Option **L***

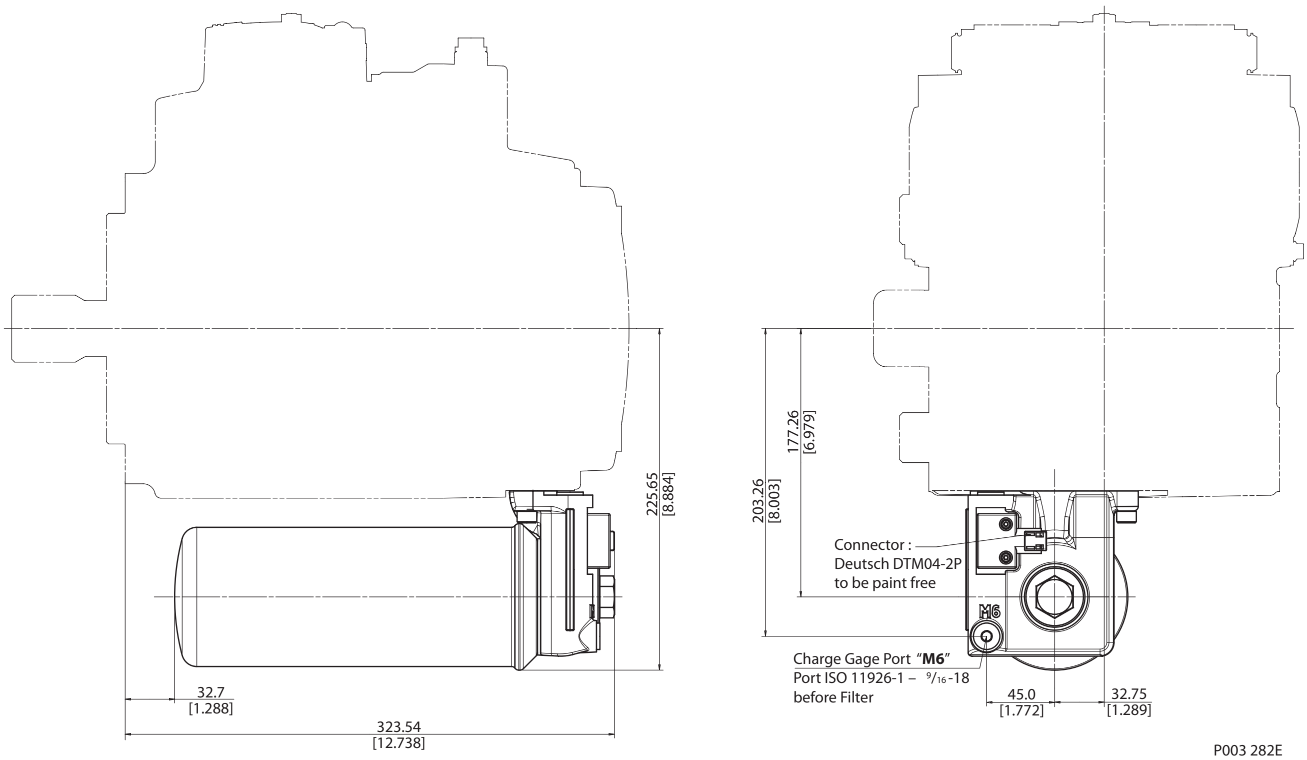


Please contact Sauer-Danfoss for specific installation drawings.

Installation Drawings (continued)

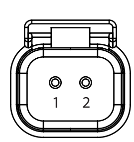
Filtration

*Integral Full Flow Charge Pressure Filtration with Filter Bypass Sensor Option **M***



P003 282E

Connector



P003 186

Description	Quantity	Ordering Number
Connector	1	Deutsch DTM06-2S
Secondary Wedge Lock	1	Deutsch WM-2S
Socket Terminal	2	Deutsch 0462-201-20141

Please contact Sauer-Danfoss for specific installation drawings.

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