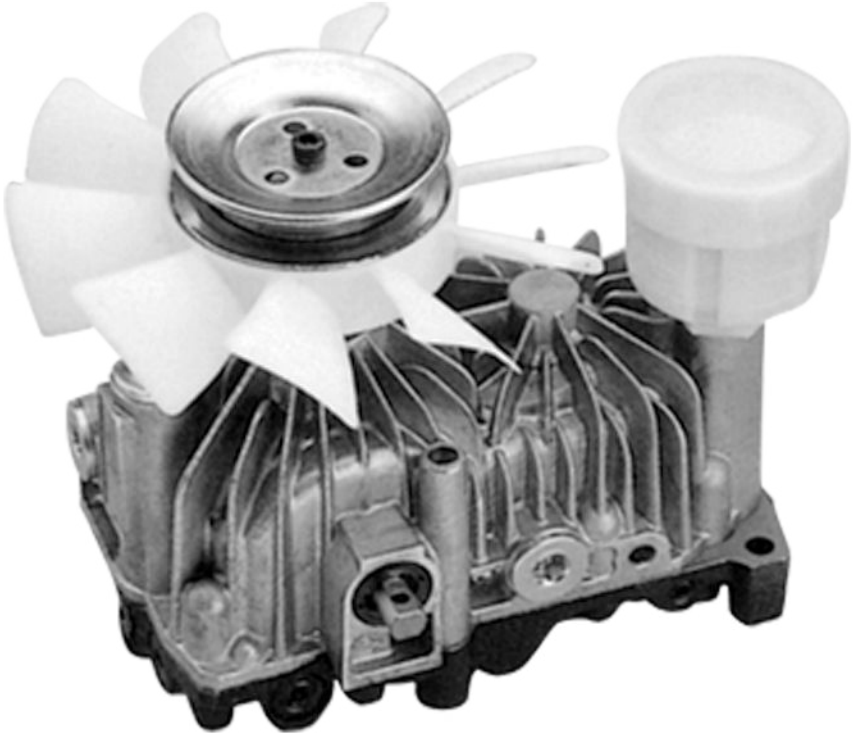
ENGINEERING
TOMORROW

Technical Information

BD Series
Hydrostatic Transmissions



powersolutions.danfoss.com

Revision history

Table of revisions

Date	Changed	Rev
May 2017	Fixed typo	0102
June 2016	Convertd to DITA-CMS	0101
Mar 2010	Correction - Drawing	AC
Jan 2009	Correction - Text	AB
Jan 2006	First edition	AA

Contents

Contents

General Description

BD Series Family

The BD hydrostatic transmission can be applied for the transfer and control of power. It provides an infinitely variable speed range between zero and maximum in both forward and reverse modes of operation.

The BDU transmission is a **" Z" style transmission** with a variable displacement pump and a fixed displacement motor. The **variable displacement pump** features a cradle swashplate with a direct proportional displacement control. Reversing the direction of tilt of the swashplate reverses the flow of oil from the pump and thus reverses the direction of the motor output rotation. The **fixed displacement motor** uses a fixed swashplate. The pump and motor are of the axial piston design and utilize sphericalnosed pistons which are held against a thrust bearing by internal compression springs. The fluid supply for **the BDU-10L/21L/21H transmission** is contained in an external reservoir and passes through an external filter prior to entering the transmission and feeding the fixed displacement gerotor charge pump. Excess fluid in the charge circuit is discharged over the charge relief valve back to the charge pump inlet. Constant flow across a small fixed orifice connecting the charge circuit to the transmission housing supplements the cooling flow.

The BDU-06S/10S transmission has a self-contained fluid supply and an integral filter. The fluid is forced through the filter by positive "head" on the fluid in the housing reservoir with an assist by the negative pressure created in the pump pistons as they create a vacuum. Charge check valves in the center section are used to control the makeup flow of fluid to the low pressure side of the loop. A spool type bypass valve is utilized in the transmission to permit moving the vehicle over short distances at low speeds without starting the engine.

The BDP-10L is a variable displacement pump to utilize the pump kit of the BDU-10L transmission and designed for vehicle application which is for propel or for auxiliary functions where the system pressure requirements and design life can be met within pump rating.

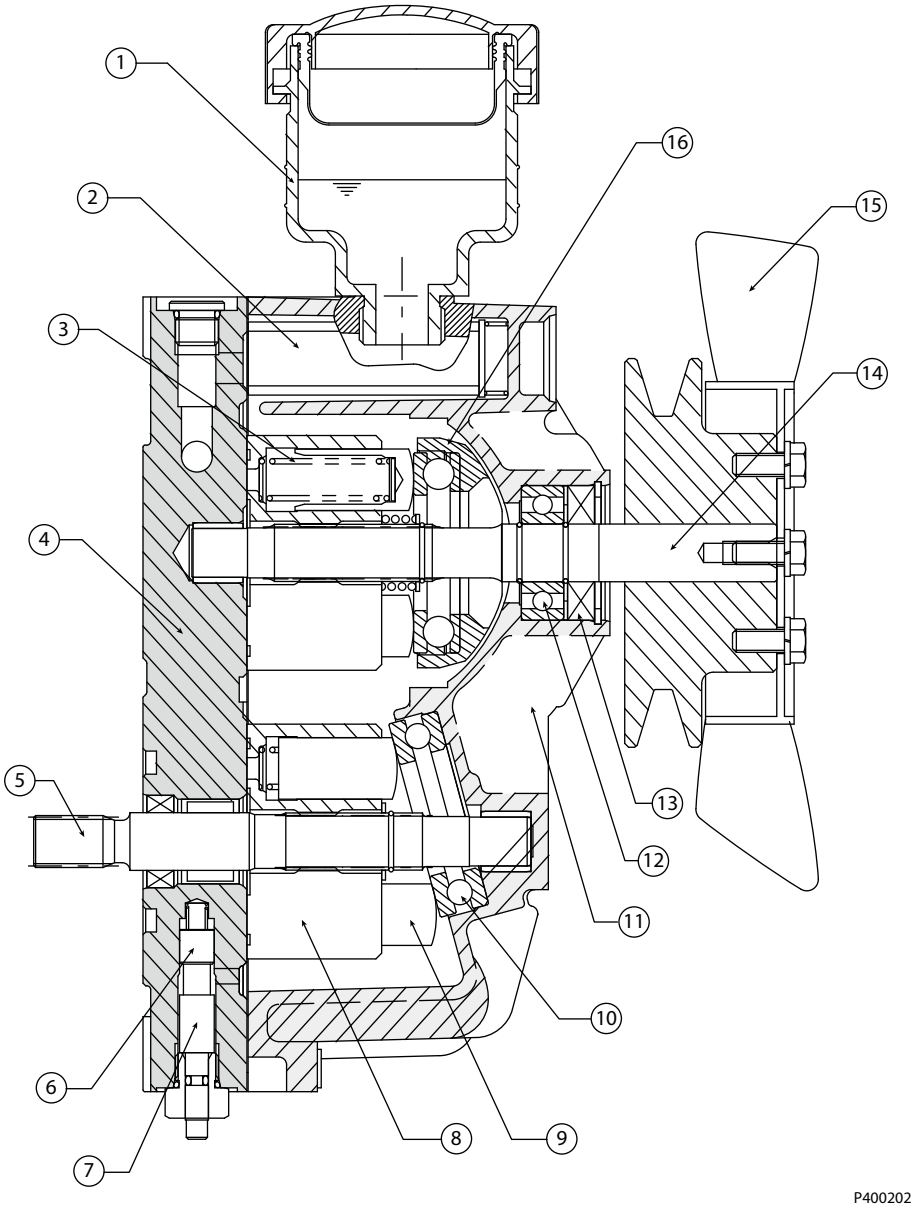
Features and Benefits

- A complete transmission family to meet the needs of small vehicle application.
- 3 Transmission Frame Sizes: 6, 10, 21
- PTO Capability on "Z" Style Transmission
- Variable Pump Version of 10 Frame Size Available ($10cm^3$)
- Cost Effective, Compact, Lightweight Design
- Low Noise
- High Efficiency
- Worldwide Sales and Service

General Description

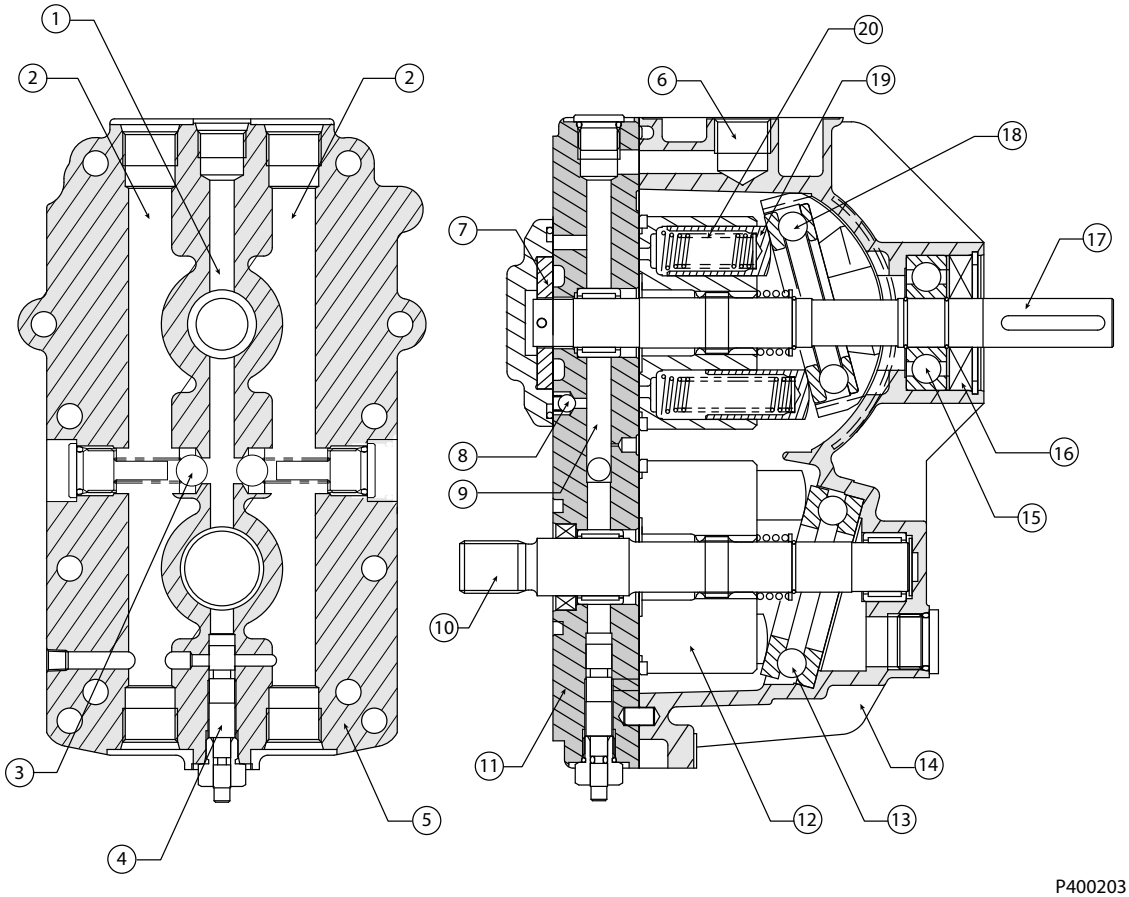
Design

BD Series Cross-Section (BDU-10S)



1. Tank
2. Built-in filter
3. Spring
4. Center section
5. Output shaft
6. Spring
7. Spool type bypass valve
8. Cylinder block
9. Piston
10. Thrust bearing
11. Housing
12. Ball bearing
13. Shaft seal
14. Input shaft
15. Cooling fan
16. Cradle swash plate

General Description



P400203

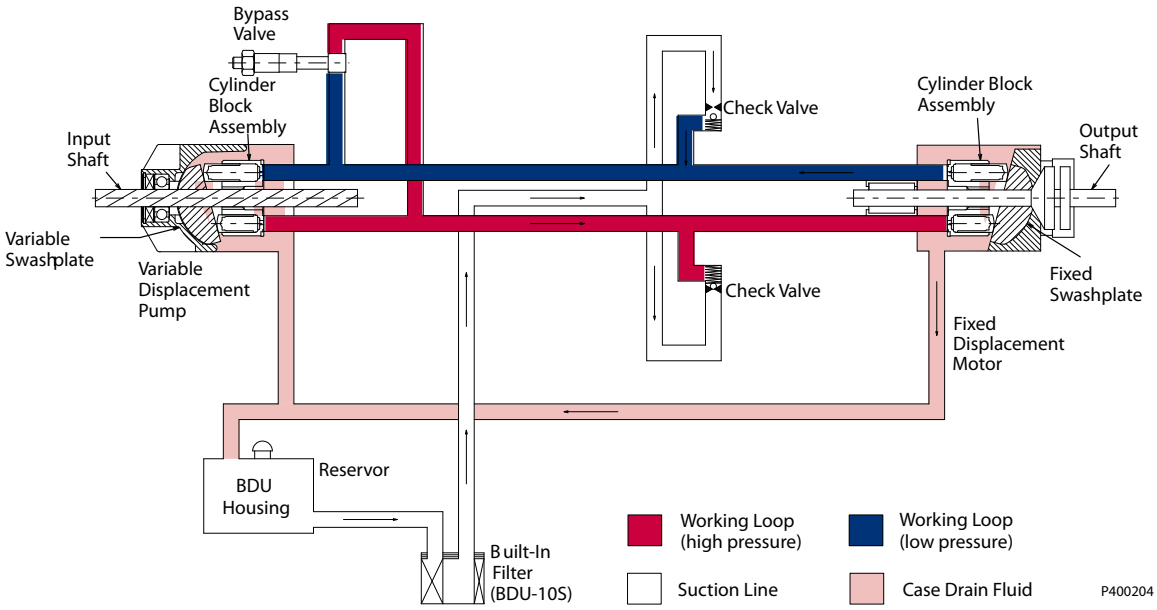
1. Suction Circuit
2. Working Loop
3. Charge Check Valve
4. Spool Type Bypass Valve
5. Center Section
6. Suction Port
7. Charge Pump
8. Charge Relief
9. Charge Circuit
10. Output Shaft
11. Center Section
12. Cylinder Block
13. Thrust Bearing
14. Housing
15. Ball Bearing
16. Shaft Seal
17. Input Shaft
18. Cradle Swash Plate
19. Piston
20. Spring

General Description

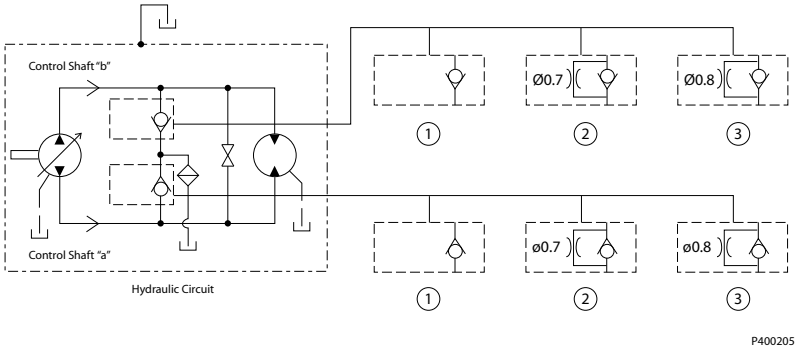
BDU-06/10S

Pictorial Diagram

BDU-06S, BDU-10S



System Schematic



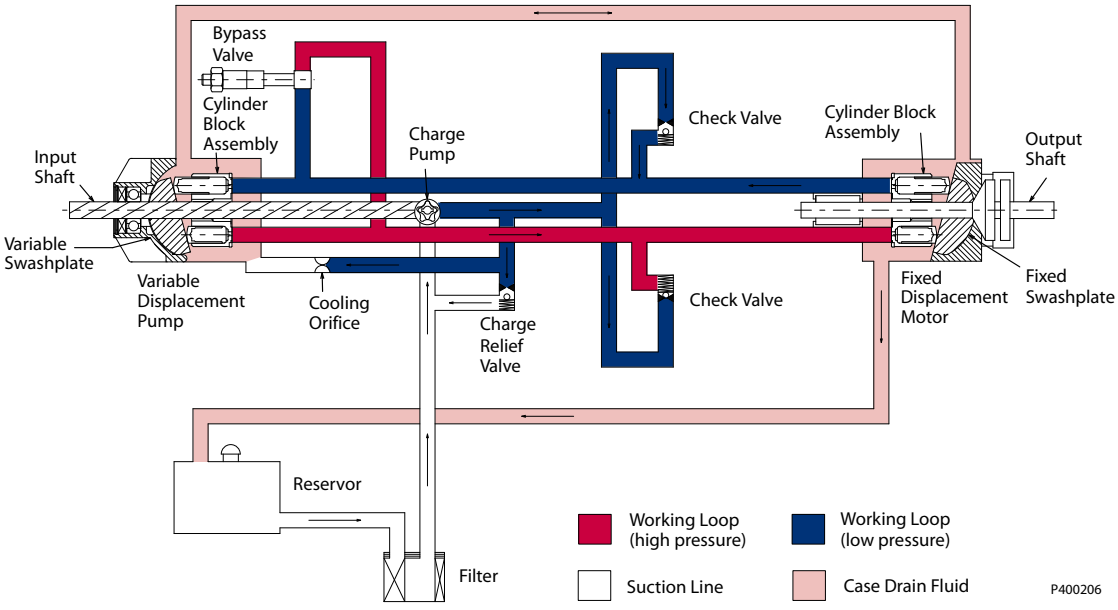
1. Ball Check Valve, Option Code. : BB
2. Check Valve with Ø0.7 Orifice, Option Code : 07
3. Check Valve with Ø0.8 Orifice, Option Code : 08

General Description

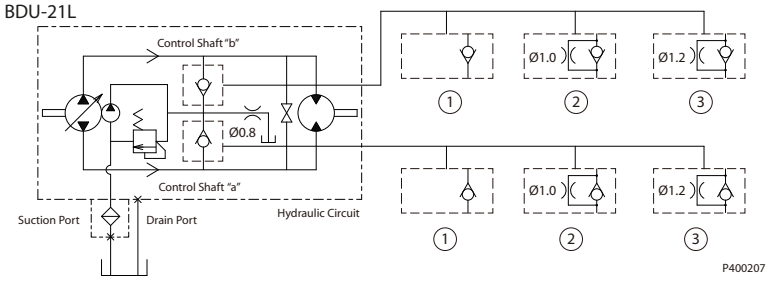
BDU-10L/21L/21H

Pictorial Diagram

BDU-10L, BDU-21L, BDU-21H, BDP-10L (part of pump)



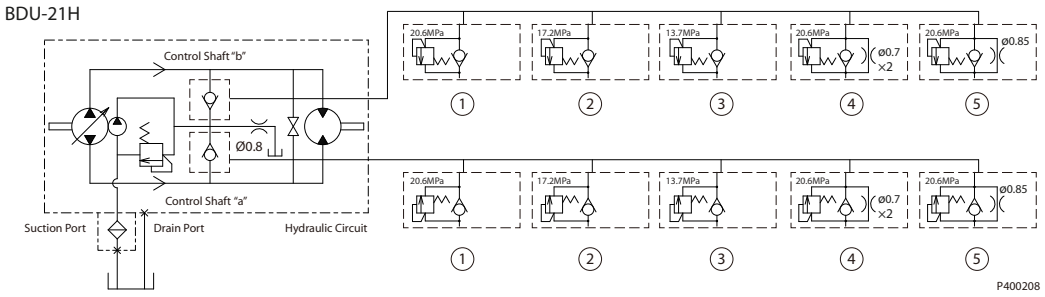
System Schematic: BDU-21L



1. Ball Check Valve, Option Code. : BB
2. Check Valve with Ø1.0 Orifice, Option Code : 10
3. Check Valve with Ø1.2 Orifice, Option Code : 12

General Description

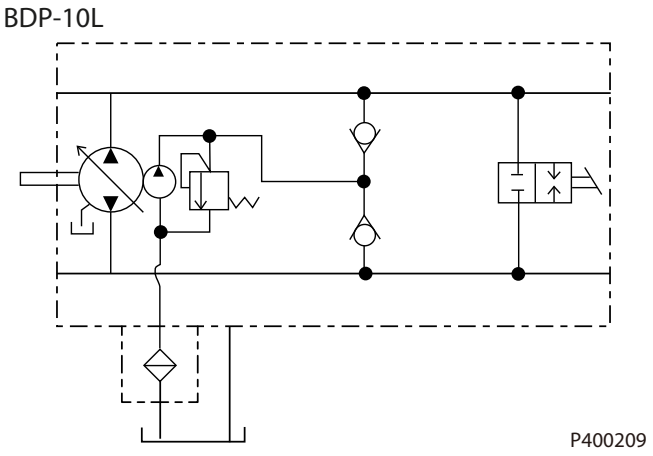
System Schematic: BDU-21H



1. Check Valve with Relief Valve, Option Code. : R0
2. Check Valve with Relief Valve, Option Code. : R1
3. Check Valve with Relief Valve, Option Code. : R2
4. Check Valve with Relief Valve and Ø0.7 Twin Orifice, Option Code. : RA
5. Check Valve with Relief Valve and Ø0.85 Orifice, Option Code. : RB

BDP-10L

System Schematic



Technical Specifications

Features and Options

Features		Unit	Product Type & Frame					
			BDU-06S	BDU-10S	BDU-10L	BDU-21L	BDU-21H	BDP-10L
Pump	Displacement	cm^3 [in^3]	6 [0.37]	10 [0.61]	10 [0.61]	21 [1.28]	21 [1.28]	10 [0.61]
	Swashplate Angle	degree	15	15	15	15	15	15
	Control Shaft	degree	15	21	21	22	22	21
Motor	Displacement	cm^3 [in^3]	6 [0.37]	10 [0.61]	10 [0.61]	21 [1.28]	21 [1.28]	-
	Swashplate Angle	degree	15	15	15	15	15	-
Charge Pump Displacement		cm^3 [in^3]	NA	NA	1.9 [0.12]	2.1 [0.13]	3.0 [0.18]	1.9 [0.12]
Output Speed	Rated	min^{-1}	3000	3000	3600	3600	3600	3600
	Maximum (intermittent)		3200	3200	3800	3800	3800	3800
Maximum Output Torque (Theoretical)		Nm [lbf•in]	9.8 [87]	23.4 [208]	23.4 [208]	49.2 [436]	72.1 [639]	-
Input Power (Maximum)		kW [ps]	1.1 [1.5]	2.2 [3.0]	3.7 [5.0]	7.4 [10.0]	11.0 [15.0]	3.7 [5.0]
Weight		kgf [lbs]	4 [9]	6.3 [14]	6.5 [14]	10 [22]	10 [22]	4.6 [10]
Control Torque Required to Stroke Pump (Maximum)		Nm [lbf•in]	8.8 [78]	19.6 [174]	19.6 [174]	22.5 [200]	24.5 [217]	19.6 [174]
Mounting			See *Installation Drawings*					
Rotation			Clockwise or Counterclockwise					
Suction/Oil Tank Port (SAE O-ring Boss)			7/8-14 UNF		7/16-20 UNF	9/16-18 UNF		7/16-20 UNF
Other ports			See *Installation Drawings*					
Shaft			See *Installation Drawings*					
Bypass Valve			OP	STD	STD	STD	STD	STD
Neutral Valve/Orifice			NA/NA	NA/OP	NA/OP	OP/OP	OP/OP	NA/OP
High Pressure Relief Valve			NA	NA	NA	NA	STD	NA
Filtration			W/O	built-in	External	External (Option, Integrated)		External
Reservoir			Integrated	Integrated	External	External		External
Space for the oil in the housing		cm^3	450	550	550	700	700	250

SAE J1926-1 / ISO 11926-1

Operating Parameters

Parameter	Unit	Product Type & Frame					
		BDU-06S	BDU-10S	BDU-10L	BDU-21L	BDU-21H	BDP-10L
Input Speed							
Minimum	min^{-1}	1000	600				
Rated		3000		3600			
Maximum		3200		3800			
System Pressure							

Technical Specifications

Parameter	Unit	Product Type & Frame					
		BDU-06S	BDU-10S	BDU-10L	BDU-21L	BDU-21H	BDP-10L
Rated	bar [psi]	105 [1530]	150 [2185]			210 [3059]	150 [2185]
Maximum		105 [1530]	175 [2549]		210 [3059]	245 [3569]	175 [2549]
Charge Pressure	bar [psi]	NA		3 [44] - 5 [73]			
Charge Inlet Pressure	bar [psi]	NA		0.8 [12] abs			
Case Pressure							
Rated	bar [psi]	0.3 [4]					
Maximum (Cold Start)		0.7 [10]					

Fluid Specifications

Features		Units	BD Series
Viscosity	Minimum	$mm^2/sec.$ [SUS]	7 [49]
	Continuous		12-60 [66-280]
	Maximum		1600 [7500]
Temperature	Minimum	°C [°F]	-10 [14]
	Maximum Continuous		82 [180]
	Maximum		104 [219]

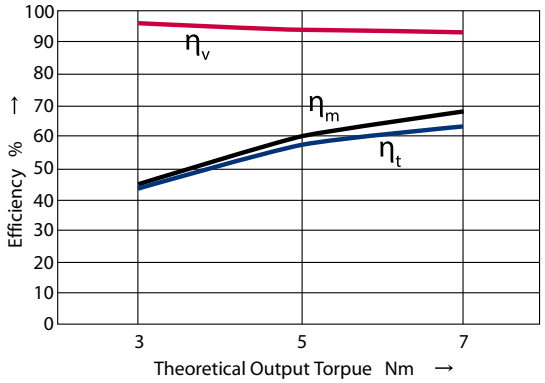
Technical Specifications

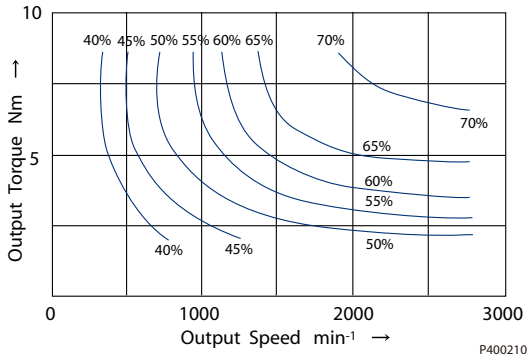
Efficiency

Input speed: 3000 min^{-1}, Oil temperature: 50 °C, Full Displacement

BDU-06S

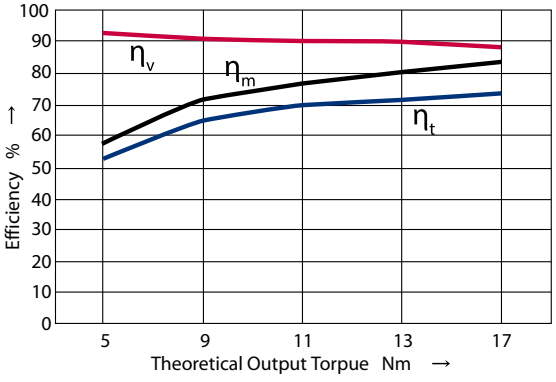
Efficiency (η_v:Volumetric, η_m:Mechanial, η_t:Overall)

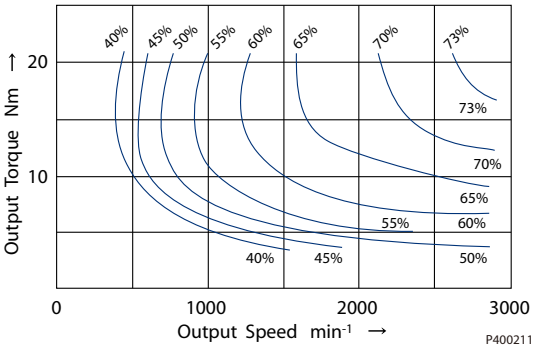




BDU-10S

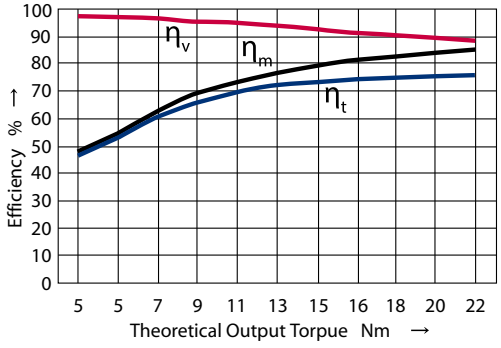
Efficiency (η_v:Volumetric, η_m:Mechanial, η_t:Overall)

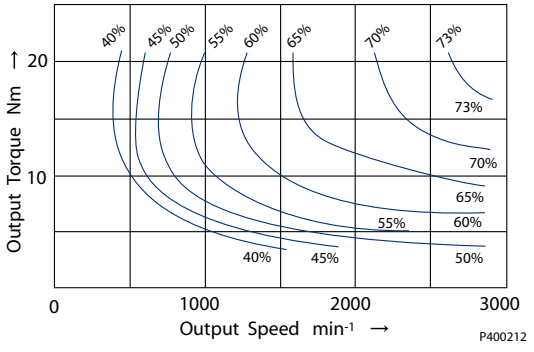




BDU-10L

Efficiency (η_v:Volumetric, η_m:Mechanial, η_t:Overall)

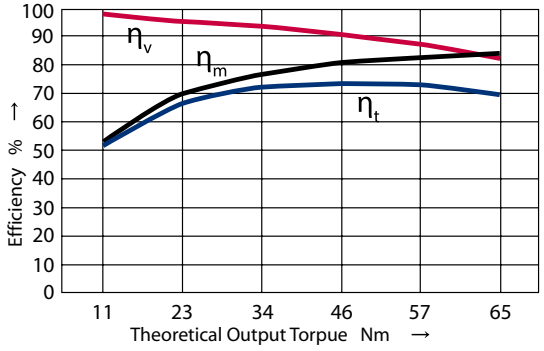


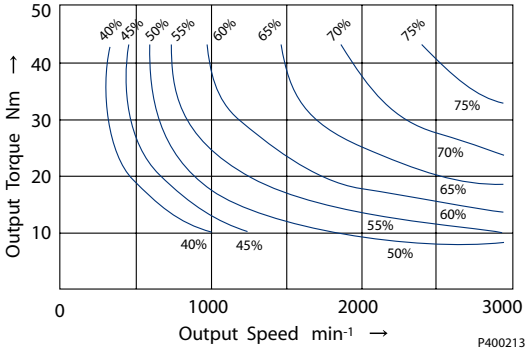


Technical Specifications

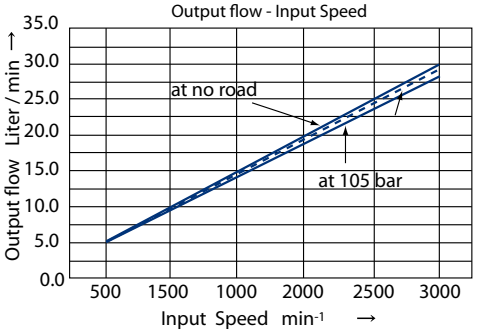
BDU-21L/21H

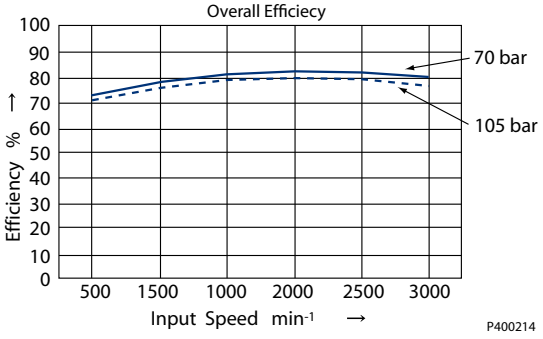
Efficiency (η_v:Volumetric, η_m:Mechanial, η_t:Overall)





BDP-10L





Operating Parameters

Overview

Maintain operating parameters within prescribed limits during all operating conditions. This section defines operating limits given in the table *Operating Parameters*.

Input Speed

Minimum speed is the lowest input speed recommended during engine idle condition. Operating below minimum speed limits 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.

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 speed and normal operating—or weighted average—pressure that you can only determine from a duty cycle analysis.

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

Maximum pressure (peak) is the highest intermittent pressure allowed under any circumstances. Applications with applied pressures between rated and maximum require factory approval with complete application, duty cycle, and life expectancy analysis.

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

Charge Pressure

The charge pressure setting listed in the technical specifications is based on the charge flow across the charge pressure relief valve at fluid temperature at 50˚C [120˚F].

Charge Inlet Pressure

Charge pump inlet conditions must be controlled in order to achieve expected life and performance. A continuous inlet vacuum of no less than 0.8 abs bar is recommended. Normal vacuums less than 0.7 abs bar would indicate inadequate inlet design or stricted filter.

Operating Parameters

Case Pressure

Under normal operating conditions, the maximum continuous case pressure must not exceed 0.3 bar (4PSI). Maximum allowable intermittent case pressure during cold start must not exceed 0.7 bar (10PSI).

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. This condition may also affect performance since charge and system pressure are referenced to case pressure.

Hydraulic Fluids

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

The following hydraulic fluids are suitable:

Hydraulic fluid type	Standard, name/type	Note
Hydraulic Oil	ISO 11 158 – HM	seal compatibility and vane pump wear resistance per DIN 51 524-2 must be met
	ISO 11 158 - HV	seal compatibility and vane pump wear resistance per DIN 51 524-3 must be met
	DIN 51 524-2 - HLP	
	DIN 51 524-3 - HVLP	
Engine oil	API Classification SL, SJ	for gasoline engines
	CI-4, CH-4, CG-4, CF-4 and CF	for diesel engines

Temperature and Viscosity

Temperature and viscosity requirements must be concurrently satisfied. The data shown in the table *Fluid Specifications* on page 12, assume petroleum-based fluids are used.

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 **rated temperature**. The **maximum 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.

For maximum unit efficiency and bearing life the fluid viscosity should remain in the **recommended operating 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.

Heat exchangers should be sized to keep the fluid within these limits. Testing to verify that these temperature limits are not exceeded is recommended.

System Design Parameters

Fluid and Filtration

To prevent premature wear, it is imperative that only clean fluid enters the hydrostatic transmission circuit. Therefore an inlet filter better than β20=1.4 is required in the charge pump inlet line. This filter should not have a bypass and should be changed regularly to ensure system reliability. The BD series hydrostatic transmission requires system filtration capable of maintaining fluid cleanliness at ISO 4406-1999 class 22/18/15 or better.

Reservoir

The BDU-06S and BDU-10S are designed with optional integrated reservoir. A reservoir for BDU-10L and BDP-10L larger than the 2 liter tank size is recommended. A reservoir for BDU-21L/H larger than the 5 liter tank size is recommended. The hoses or piping size is recommended to be larger than 3/8 inch normal tube OD.

Control Shaft Force

The BDU transmission is designed with direct displacement control (DDC). DDC can be located at either side of the housing. It provides a simple, positive method of control. Movement of the control shaft causes a proportional swashplate movement, thus varying the pump's displacement from full displacement in one direction to full displacement in the opposite direction.

The approximate maximum control torque necessary to rotate the control shaft is shown in the table of technical specifications. A stopper to prevent over-stroke is required at the end of maximum angle of control shaft. The control shaft force should be kept at or below the force in the table below.

Features	Unit	Product type & Frame		
		BDU-06S	BDU-10S	BDU-21L
Allowable maximum force for control shaft	Nm	10	20	25

Independent Braking System

Vehicle propel applications may require a provision for non-linear control input to reduce control sensitivity near neutral. Damping or frictional forces may be necessary to produce the desired control feeling.

These units do not include any neutral centering device for the swashplate. It is necessary to provide a force in the machine's control system that will hold the swashplate at the desired angle. A " fail safe " which will return the swashplate to the neutral in the event of linkage failure is recommended.

Warning

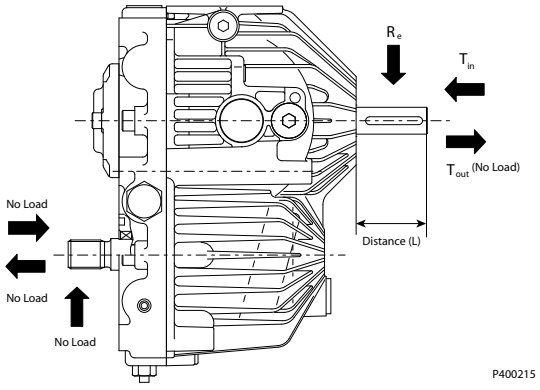
Unintended vehicle or machine movement hazard.

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.

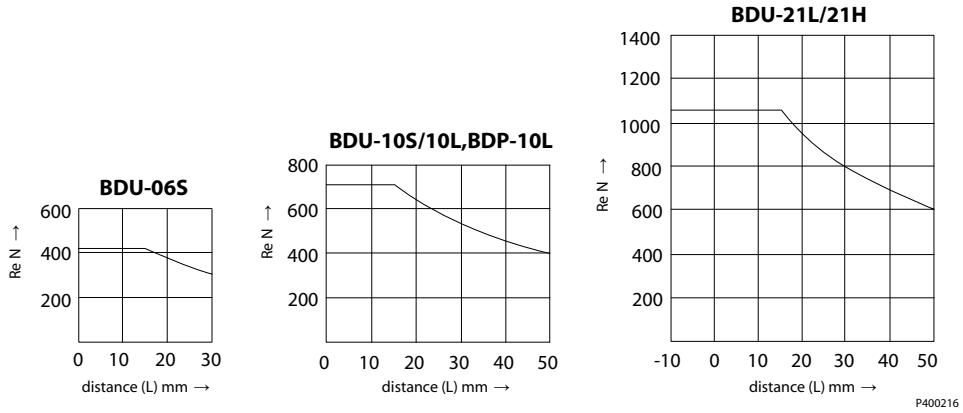
Features and Options

Shaft Load

The maximum allowable radial road of input shaft (Re) is based on the maximum external moment and the distance from the housing surface to the input shaft. The limit of radial load of input shaft is shown the figure below:



The maximum shaft thrust in (**Tin**) of input shaft is 18% of allowable radial road (**Re**) of the input shaft. The shaft thrust out (**Tout**) of the input shaft should be no load. The radial and thrust load of the output shaft should be no load.

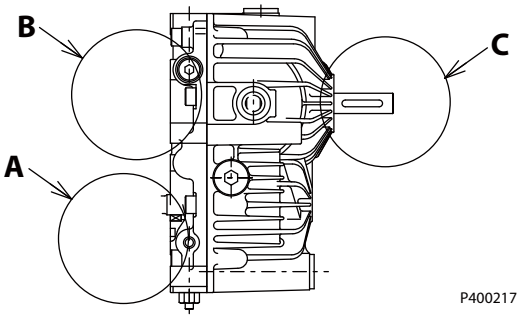


Shaft Options

The BDU transmissions are available with a variety of straight key, JIS Spline, JIS Serration, SAE Spline shaft for input shaft, PTO shaft and output shaft. Details are shown in the *Installation Drawings* on page 35.

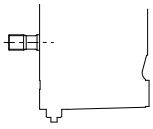
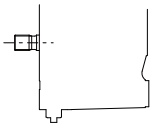
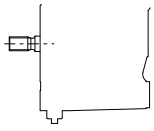
Features and Options

Shaft Options : BDU-06S/10S/10L

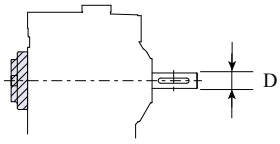
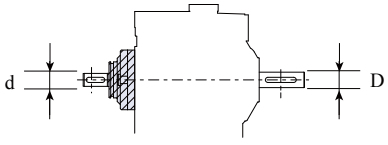
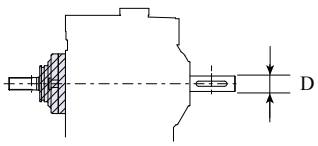


Shafts:
A = Output Shaft
B = PTO Shaft
C = Input Shaft

Output Shaft Options

	Output Shaft		Code	BDU-06S	BDU-10S	BDU-10L
	JIS Spline	15 x 13 x 1.0	J13	●	●	●
		20 x 18 x 1.0	K18		●	●
	SAE Spline	32/64-16T	S16	●	●	●

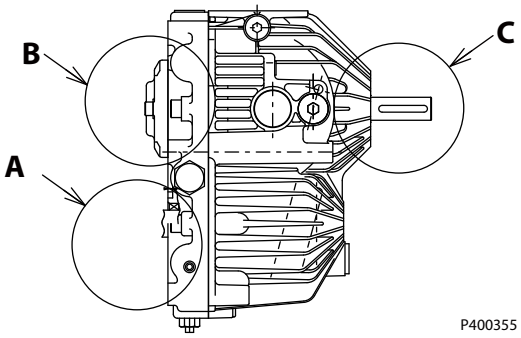
PTO Shaft / Input Shaft Options

PTO Shaft		Input Shaft	Code	BDU-06S	BDU-10S	BDU-10L
None		Straight-Keyed D = 15 mm	KA0	●		
			KB0		●	
			KB1			●
Straight d = 12.7 mm		Straight-Keyed D = 15 mm	PB1		●	
			PB3			●
JIS Serration 12 x 23 x 0.5		Straight-Keyed D = 15 mm	PB2		●	
			PB4			●

This charge pump housing is applied only for BDU-10L.

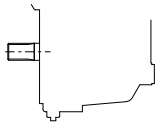
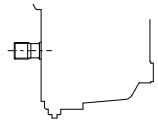
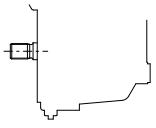
Features and Options

Shaft Options : BDU-21L/21H

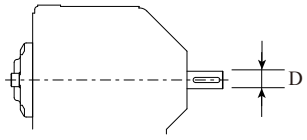
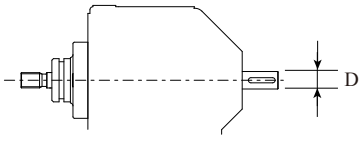
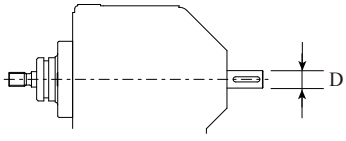


Shafts:
A = Output Shaft
B = PTO Shaft
C = Input Shaft

Output Shaft Options

	Output Shaft		Code	BDU-21L	BDU-21H
	JIS Spline	20 x 14 x 1.25	J14	●	●
		20 x 18 x 1.0	J18	●	●
	SAE Spline	32/64-22T	S22	●	●

PTO Shaft / Input Shaft Options

PTO Shaft		Input Shaft	Code	BDU-21L	BDU-21H
None		Straight-Keyed D = 17 mm	KC1	●	
			KC2		●
JIS Spline 15 x 13 x 1.0		Straight-Keyed D = 17 mm	PC1	●	
			PC2		●
SAE Spline 32/64-16T		Straight-Keyed D = 17 mm	PC3	●	
			PC5		●

Features and Options

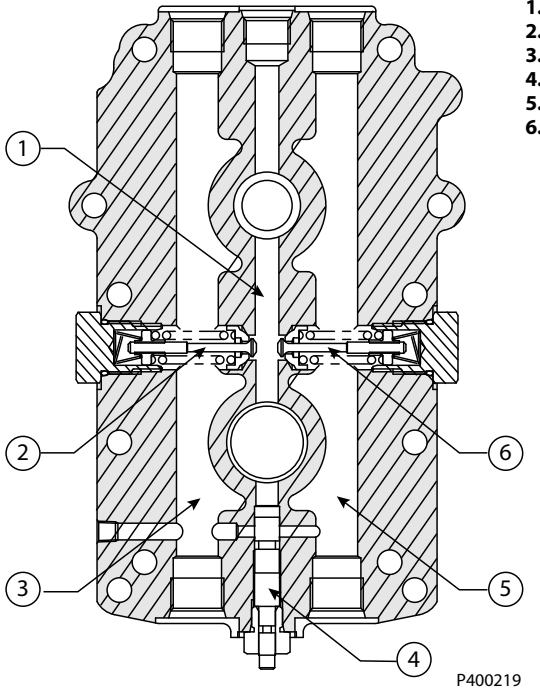
Bypass Valve

In some applications, it is desirable to move the vehicle over short distances at low speed without starting the engine. A bypass valve allows oil to be routed from one side of the pump/motor circuit to the other, thus allowing the motor to turn. The bypass valve must be fully closed during normal vehicle operation. BDU series transmissions utilize a spool-type bypass valve. The bypass valve plunger must be depressed manually to open the valve. This connects both sides of the main hydraulic circuit to the housing case and allows fluid to circulate without rotating the pump, prime mover and motor. A spring closes this valve on the 6S, 10L and 10S transmissions, while charge pressure closes the valve on the 21L and 21H transmissions. The BDP-10L pump utilizes a screw-type bypass valve.

High Pressure Relief Valve (hprv) and Charge Check (Overpressure Protection)

The BDU-21H transmission is available with a combination charge check and high pressure relief valve assembly. High pressure relief valves are available in a range of settings as shown in the *Model Code* on page 29. Individual port pressure settings may be specified. The high pressure relief valve settings are a differential pressure (referenced to charge pressure).

Check and Relief Valve for BDU-21H		
Option Code	Pressure setting	Orifice
	bar [psi]	
R0	210	-
R1	175	-
R2	140	-
RA	210	0.7 Twin
RB	210	0.85

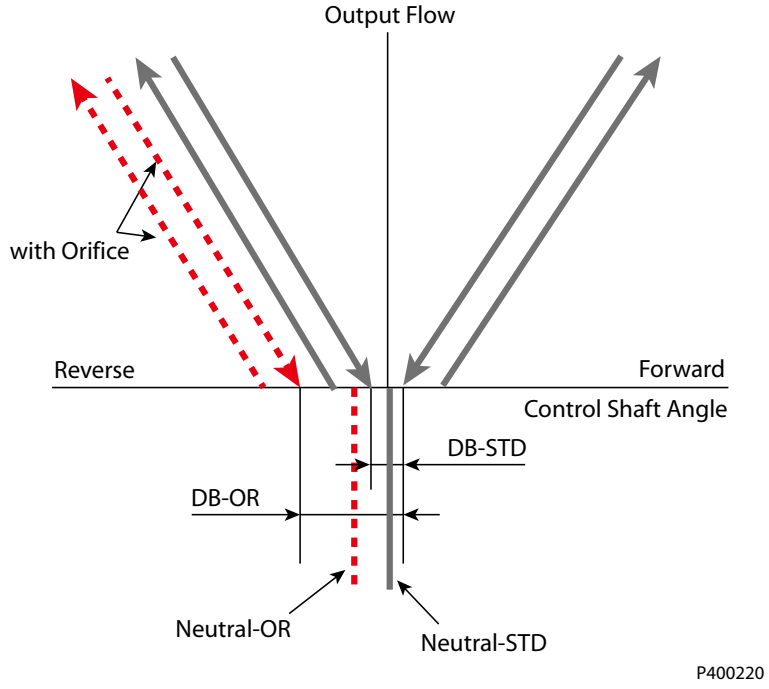


1. Charge circuit
2. Check and relief valve
3. Working loop (Main hydraulic circuit
4. Bypass valve
5. Working loop (Main hydraulic circuit)
6. Check and relief valve

Features and Options

Charge Check Valve with Orifice

The BDU transmissions are equipped with charge check valves. In some applications, it is desirable to use charge check valve with orifice for expanding null dead band, giving both the safety measure to prevent the vehicle movement in the neutral position of the control shaft and easy adjustment of neutral position when connected to vehicle linkage. The orifice connects the working loop, which is a main hydraulic circuit, to a charge circuit. It always allows some internal leakage to ensure the expanding null dead band around neutral position of control shaft. However, it decreases the volumetric efficiency, particularly at high system pressure in the working loop. It is recommended to install the orifice in a specific working loop, which is pressurized when the vehicle moves in reverse. The orifice diameter improves the null dead band but decreases the volumetric efficiency. A cross section and characteristics are shown below. The charge check valves with orifice are available in a range of orifice diameters as shown in the *Model Code* on page 29.



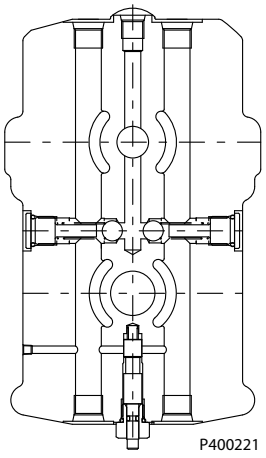
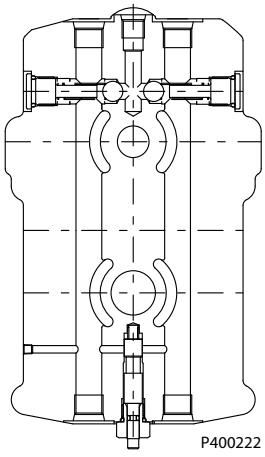
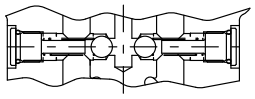
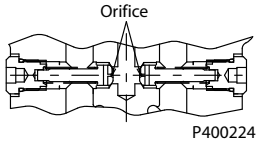
Input Speed: 3000min^{-1}, Oil Temp: 50 °C , No Load

Features	Unit	BDU-10S/10L/21L/21H
		Without Orifice
Deadband of Control Shaft Angle (DB-STD)	[degree]	Approx. 0.1

Features	Unit	BDU-10S/10L		BDU-21L		BDU-21H	
		Orifice diameter [mm]					
		Ø 0.7	Ø 0.8	Ø 1.0	Ø 1.2	Ø 0.85	Ø 0.7 twin
Deadband of Control Shaft Angle (DB-OR)	[degree]	Approx. 0.5	Approx. 0.7	Approx. 0.5	Approx. 0.7	Approx. 0.35	Approx. 0.5

Features and Options

Charge Check with Orifice

<table>
<tr>
<td>BDU-10S
BDU-10L</td>
<td>BDU-10L Check Valve
 
P400221</td>
<td>BDU-10S Check Valve
 
P400222</td>
<td>Check Valve (Ball) without Orifice
 
P400223
Check Valve with Orifice
 

P400224</td>
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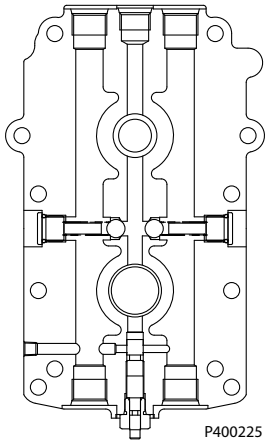
<tr>
<td>BDU-21L</td>
<td colspan="2"> 
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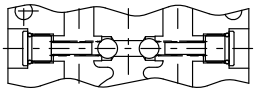
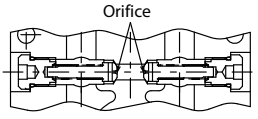
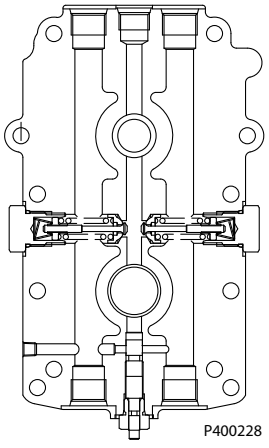
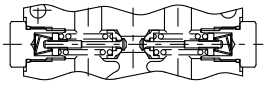
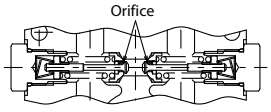
 
P400226
Check Valve with Orifice
 

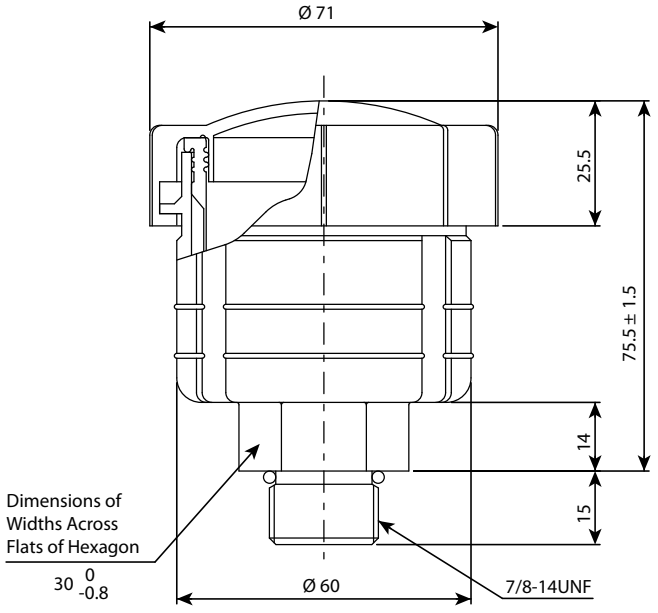
P400227</td>
</tr>
<tr>
<td>BDU-21H</td>
<td colspan="2"> 
P400228</td>
<td>Check & Relief without Orifice
 
P400229
Check & Relief with Orifice
 

P400230</td>
</tr>
</table>

Features and Options

Optional Integrated Reservoir

The BDU-06S and BDU-10S are designed with optional integrated reservoir. The optional Integrated reservoir is shown in the figure on the right.

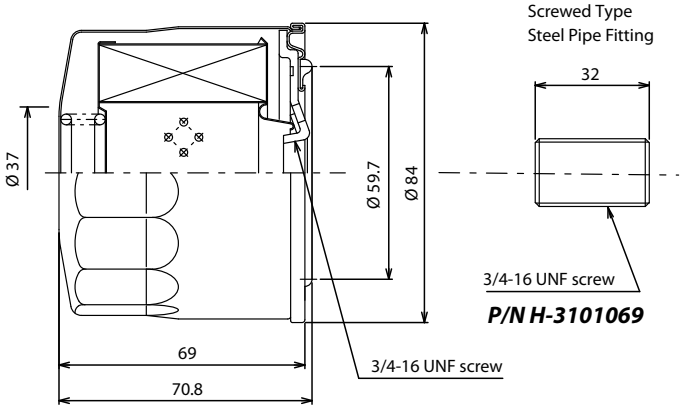


P/N BDU-10S-TANK

P400231

Filter

The BDU-10S is designed with Built-in filter. BDU-21L/H is designed with optional Integrated filter, which is shown in the figure on the right. The filter connection is designed with consideration given to the screwed type steel pipe fitting that is an option. An external filter is required in the charge pump inlet line for BDU- 10L and BDP-10L. This filter should not have a bypass and should be changed regularly to ensure system reliability.



P/N H-3101069

P/N 05EL-BD

P400232

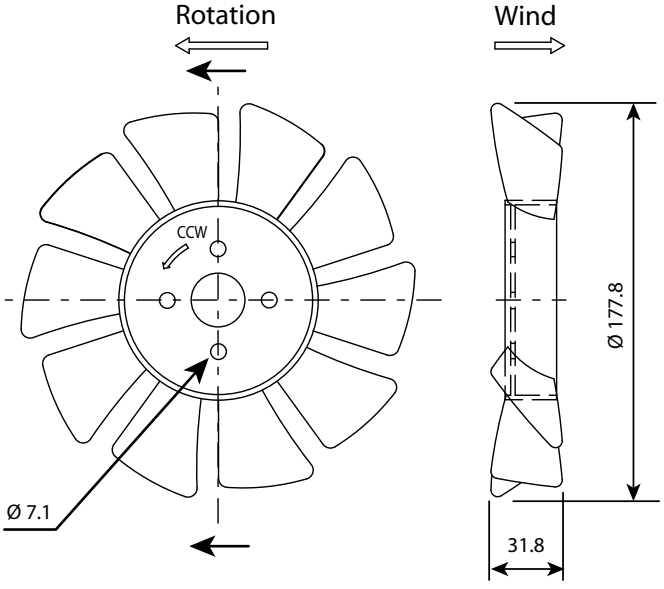
Features and Options

Fan

The operating temperature of the BDU transmission becomes hot when operated at a heavy load for long, continuous time. To avoid a reduction in the life of the BDU transmission or risking immediate failure, a cooling fan may be installed on the input shaft or external reservoir to be effective as heat exchanger may be installed. The BDU transmission is available with optional fan integrated with the belt drive device for the input shaft. The detailed outlines are shown in the *Installation Drawings* on page 35.

Optional Fan for Cooling

P/N	Rotation
H-1030826	CW
H-1030827E	CCW



Optional Fan for Cooling

P/N	Rotation
H-1030826	CW
H-1030827E	CCW

Component Selection

Selecting the proper transmission for a vehicle begins with determining the maximum system pressure by using tractive effort of the vehicle and the maximum vehicle speed required. The transmission selected must meet both requirements.

Maximum System Pressure

Maximum operating system pressure should be calculated at maximum tractive effort condition. Maximum tractive effort condition is assumed at vehicle with maximum weight transfer from pushing or pulling implements at maximum grade of slope. First, calculate BDU motor torque by using the following equation:

Equation-1

$$MTQ\_ME = \frac{PR\_ME \times VW\_ML \times LR \times 9.8}{FDR \times EFF\_FD}$$

- MTQ_ME = Output torque of BDU motor at maximum tractive effort condition in Nm
- PR_ME = Pull Ratio at maximum tractive effort (See below)
- VW_ML = Gross vehicle weight with maximum loaded weight in kgf
- LR = Tire Radius in meters
- FDR = Transaxle Final Drive Ratio
- EFF_FD = Transaxle Final Drive Efficiency

The hydrostatic transmissions in many applications are used in conjunction with readily available transaxles. In order to meet both requirements of high output torque at operating mode and high speed at traveling mode, the transaxles with two kinds of shifts, Hi and Lo are used in some applications. In such transaxles, use Lo shift ratio as FDR in equation-1 and -4 to calculate maximum system pressure.

A useful parameter for determining tractive effort is "**Pull Ratio**". Pull Ratio is a dimensionless term that is the ratio of tractive effort to gross vehicle weight. It is generally constant for each class of vehicle. These values may be used when actual vehicle tractive efforts are not known. In a typical agriculture application for BDU application, Pull Ratio for the highest load mode can be calculated from the primary components of pull ratio: rolling resistance, grade motion resistance by a function of slope, machine function motion resistance and drive configuration motion resistance. In such cases, pull ratio is determined by using the following equation:

Equation-2

$$PR\_ME = RR + GR + MF + DC$$

- RR = Rolling resistance. See SD Application manual
- GR = Motion resistance of Grade. See SD Application manual
- MF = Machine function motion resistance, See SD Application manual
- DC = Drive configuration motion resistance, See SD Application manual

Then, **maximum system pressure** can be calculated by using MTQ_ME and the following quation:

Equation-3

$$SPR\_ME = \frac{MTQ\_ME \times 62.87}{DP \times MEF\_MO}$$

- SPR_ME = Maximum BDU system pressure operated at Maximum tractive effort mode in bar
- DP = Motor Displacement of selected BDU transmissions in cm^3
- MEF_MO = Motor Mechanical Efficiency of BDU transmission in this mode

Select **appropriate BDU** size which will give SPR_ME, not to exceed the value of maximum system pressure allowed in the technical specification, because BDU is generally applied without system pressure relief valves.

Component Selection

If appropriate BDU size satisfies maximum system pressure, determine the BDU output speed at maximum tractive effort mode by using the following equation:

Equation-4

$$MSP\_ME = \frac{VSP\_ME \times FDR \times 9.55}{LR}$$

- MSP_ME = The BDU output speed at maximum tractive effort condition in min^{-1} (rpm)
- VSP_ME = The vehicle speed requested for maximum tractive effort mode in m/s

Confirm the BDU output speed calculated to satisfy the maximum output speed (intermittent) in the technical specification.

Input Power

Calculate required input power of BDU by using the following equation:

Equation-5

$$PW\_ME = MTQ\_ME \times MSP\_ME \times 0.000105 / OEF\_BDU$$

- PW_ME = BDU Input power required for maximum tractive effort mode in kW
- OEF_BDU = BDU unit overall efficiency for this mode

If PW_ME is larger than Input power (Maximum) of selected BDU, VSP_ME should be limited to satisfy maximum BDU input power. If the calculated speed exceeds the technical specification, the transaxle final drive ratio or tire size may need to be changed.

Maximum vehicle speed is generally recommended in traveling mode. Calculate maximum BDU speed by using the following equation:

Equation-6

$$MSP\_TR = \frac{VSP\_TR \times FDR \times 9.55}{LR}$$

- MSP_TR = The BDU output speed for traveling mode in min^{-1} (rpm)
- VSP_TR = The vehicle speed requested for traveling mode in m/s

Use Hi shift ratio as FDR in Equation-6 if the Transaxle Final Drive has two shifts.

Confirm MSP_TR to satisfy the maximum output speed (intermittent) in the technical specification. If MSP_TR is not satisfied, FDR (Hi shift) may need to be changed. It is also necessary to determine the system pressure for traveling mode (SPR_TR) to satisfy maximum system pressure (intermittent) allowed in the technical specification. SPR_TR is calculated by using equation -1, -2 and -3 with parameters of traveling mode.

Calculate the required BDU input shaft speed to satisfy maximum BDU output shaft speed by using the following equation:

Equation-7

$$PSP\_RIN = MSP\_TR / VEF\_BDU$$

- PSP_RIN = required BDU input shaft speed in min^{-1} (rpm)
- VEF_BDU = BDU volumetric efficiency for this mode

Confirm BDU input shaft speed is larger than PSP_RIN.

Component Selection

Unit Life

The **unit life** of selected BDU transmissions should be determined by using average system pressure under overall operating modes, because vehicles generally operate in their maximum tractive effort mode for a small percentage of their life. If a duty cycle for a transmission is known, weighted average system pressure can be calculated and can estimate the life expectancy of the transmission selected. The duty cycle can be assumed for instances including several modes. Calculate weighted average system pressure by using the following equation:

Equation-8

$$SPR\_AV = \sqrt[3]{\frac{((SPR\_ME)^3 \times T\_ME + (SPR\_NE)^3 \times T\_NE + (SPR\_TR)^3 \times T\_TR + - - -)}{(T\_ME + T\_NE + T\_TR + - - -)}}$$

- SPR_AV = weighted average system pressure. This is the mean pressure of the duty cycle in bar
- SPR_ME = the system pressure for maximum tractive effort mode and T_ME is its time in the duty cycle
- SPR_NE = the system pressure at the normal tractive effort which means with normal weight and at 0% Grade and T_NE is its time in the duty cycle
- SPR_TR = the system pressure for traveling mode and T_TR is its time in the duty cycle

If needed, define other system pressures at other operating conditions and add them to the equation.

The BDU Unit Life hours at weighted average pressure is determined by using the following equation:

Equation-9

$$LH = RH \times \left(\frac{SPR\_RH}{SPR\_AV} \right)^3 \times \left(\frac{3000}{PSP\_IN} \right)$$

- LH = Unit Life hours of selected BDU at the duty cycle estimated
- SPR_RH = The system pressure at Rated Unit Life (See table A)
- PSP_IN = The input shaft speed of BDU unit. Normally, input shaft speed of BDU is constant

Confirm LH of selected BDU to satisfy the Life requirement. If LH is shorter than the requested specification, the next larger size transmission may be needed and the repeat the calculation for Component Selection on other BDU using Equation -1 through -9. Contact Danfoss for assistance in correct transmission selection.

Table A

Parameter	Unit	Frame				
		BDU-06S	BDU-10S	BDU-10L	BDU-21L	BDU-21H
RH	hour	300	300	1000	1600	2500
SPR_RH	bar	55	70	70	70	70
BSP_OP	min^{-1}	3000	3000	3000	3000	3000

Model Code

BDU : Model Code (A - B - C - D - E)

A - Displacement

Code	Description	06S	10S	10L	21L	21H
06	6 cm^3	●				
10	10 cm^3		●	●		
21	21 cm^3				●	●

B - Design

Code	Description	06S	10S	10L	21L	21H
S	Standard	●	●			
L	Long Life			●	●	
H	High Pressure					●

C - Rotation

Code	Description	06S	10S	10L	21L	21H
W	Bi-directional rotation	●	●			
R	Clockwise rotation			●	●	●
L	Counter-Clockwise rotation			●	●	●

D - Contrl Arm Location

Code	Description	06S	10S	10L	21L	21H
R	Right-hand side viewing from input shaft (pump located upside)	●	●	●	●	●
L	Left-hand side viewing from input shaft (pump located upside)	●	●	●	●	●

E - Output Shaft

Code	Description	06S	10S	10L	21L	21H
J13	JIS Spline 15×13×1.0	●	●	●		
J14	JIS Spline 20×14×1.25				●	●
J18	JIS Spline 20×18×1.0				●	●
K18	JIS Spline 15×18×0.75		●	●		
S16	SAE Spline 32/64 - 16T	●	●	●		
S22	SAE Spline 32/64 - 22T				●	●

Model Code

BDU : Model Code (F - G)

F - Check & Relief Valve (Left-hand side viewing from Housing)

Code	Description	06S	10S	10L	21L	21H
BB	Ball Check Valve	●	●	●	●	
00	Poppet-type Check Valve		●	●	●	
07	Check Valve w/dia = 0.7 orifice		●	●		
08	Check Valve w/dia = 0.8 orifice		●	●		
10	Check Valve w/dia = 1.0 orifice				●	
12	Check Valve w/dia = 1.2 orifice				●	
R0	Check and High Pressure Relief Valve 210 bar					●
R1	Check and High Pressure Relief Valve 175 bar					●
R2	Check and High Pressure Relief Valve 140 bar					●
RA	Check and High Pressure Relief Valve 210 bar w/dia=0.7 twin orifice					●
RB	Check and High Pressure Relief Valve 210 bar w/dia=0.85 orifice					●

G - Check & Relief Valve (Right-hand side viewing from Housing)

Code	Description	06S	10S	10L	21L	21H
BB	Ball Check Valve	●	●	●	●	
00	Poppet-type Check Valve		●	●	●	
07	Check Valve w/dia = 0.7 orifice		●	●		
08	Check Valve w/dia = 0.8 orifice		●	●		
10	Check Valve w/dia = 1.0 orifice				●	
12	Check Valve w/dia = 1.2 orifice				●	
R0	Check and High Pressure Relief Valve 210 bar					●
R1	Check and High Pressure Relief Valve 175 bar					●
R2	Check and High Pressure Relief Valve 140 bar					●
RA	Check and High Pressure Relief Valve 210 bar w/dia=0.7 twin orifice					●
RB	Check and High Pressure Relief Valve 210 bar w/dia=0.85 orifice					●

Model Code

BDU : Model Code (H - J - K)

H - Input shaft / PTO shaft Configuration & Charge Pump Displacement

Code	Description	06S	10S	10L	21L	21H
KAO	Straight-keyed D=15mm shaft / None & w/o Charge Pump	●	●	●	●	
KBO	Straight-keyed D=15mm shaft / None & w/o Charge Pump		●	●	●	
KB1	Straight-keyed D=15mm shaft / None & w/1.9cm^3 Charge Pump		●	●		
KC1	Straight-keyed D=17mm shaft / None & w/2.1cm^3 Charge Pump		●	●		
KC2	Straight-keyed D=17mm shaft / None & w/3.1cm^3 Charge Pump				●	
PB1	Straight-keyed D=15mm shaft /Straight 12.7 mm shaft & w/o Charge Pump				●	
PB2	Straight-keyed D=15mm shaft /JIS Serration 12 x 23 x 0.5 shaft & w/o Charge Pump					●
PB3	Straigt-keyed D=15mm shaft /Straight 12.6 mm shaft & w/2.4cm^3 Charge Pump					● PB4
PB4	Straight-keyed D=15mm shaft /JIS Serration 12 x 23 x 0.5 shaft & w/ 2.4cm^3 Charge Pump					●
PC1	Straight-keyed D=17mm shaft /JIS Spline 15 x 13 x 1.0 shaft & w/2.1cm^3 Charge Pump					●
PC2	Straight-keyed D=17mm shaft /JIS Spline 15 x 13 x 1.0 shaft & w/3.1cm^3 Charge Pump					●
PC5	Straight-Keyed D=17mm shaft /SAE Spline 32/64 -16T & w/2.1cm^3 Charge Pump					
PC6	Straight-Keyed D=17mm shaft /SAE Spline 32/64 -16T & w/3.1cm^3 Charge Pump					

J - Bypass & Nuetral Valve

Code	Description	06S	10S	10L	21L	21H
N	None	●				
A	w/Nuetral Valve Pressure 35 bar w/dia=1.0 orifice				●	●
B	w/Bypass Valve	●	●	●	●	●

K - Special Hardware

Code	Description	06S	10S	10L	21L	21H
NNN	None	●	●	●	●	●
WOL	Oil-filled in case	●	●			

Model Code

BDP : Model Code

	A	B	C	D	E			F		G		H			J	K		
BDP -	1	0	L		R	N	N	N				K	B	1		N	N	N

***A** - Displacement*

Code	Description	10L
10	10 cm^3	●

***B** - Design*

Code	Description	10L
L	Long Life	●

***C** - Rotation*

Code	Description	10L
R	Clockwise rotation	●
L	Counter-Clockwise rotation	●

***D** - Control Arm Location*

Code	Description	10L
R	Right-hand side viewing from input shaft (main port located upside)	●

***E** - Output Shaft*

Code	Description	10L
N	None	●

***F** - Check & Relief Valve (Left-hand side viewing from Housing)*

Code	Description	10L
BB	Ball Check Valve	●
00	Poppet-type Check Valve	●
07	Check Valve w/dia=0.7 orifice	●
08	Check Valve w/dia=0.8 orifice	●

***G** - Check & Relief Valve (Right-hand side viewing from Housing)*

Code	Description	10L
BB	Ball Check Valve	●
00	Poppet-type Check Valve	●
07	Check Valve w/dia=0.7 orifice	●
08	Check Valve w/dia=0.8 orifice	●

***H** - Input / PTO shaft Configuration & Charge Pump Displacement*

Code	Description	10L
KB1	Straight 15mm shaft/None & w/1.9cm^3 Charge Pump	●

Model Code

J *- Bypass Valve*

Code	Description	10L
B	w/Bypass Valve	●
C	w/Bypass Valve w/orifice dia=0.5	

K *- Special Hardware*

Code	Description	10L
NNN	None	●

Recommended Installation and Maintenance

Housing Installation

The center section of BDU transmission has 4 holes for fixing screws. The screws should be inserted in the holes and tightened to specifications.

*Fitting Torque 1569 ~ 2058 N·cm

Shaft Installation

The input shaft of the BDU transmission should be connected to the prime mover by a belt drive device, sheave or coupling. When using a belt drive device, the radial load on the input shaft should not exceed the maximum allowable load shown in *Shaft Load* on page 18.

When installing the BDU motor shaft to the gearbox or to other devices directly, utilize the groove on the center section of the BDU transmission, which is located concentric to the motor shaft, to ensure the accuracy of concentricity. When using the coupling for connection of the shaft, ensure the accuracy of concentricity is kept in the region of ±0.025mm. Do not beat the coupling strongly into the shaft with a hammer.

It is recommended the shaft to be lubricated when using a spline shaft.

Start Up Procedure

After installing the BDU transmission and corresponding pipeline connection, remove the case drain port plug from the housing. Fill the BDU transmission case with the recommended oil through the drain port.

BDU-10S is filled with oil at the plant shipment.

Make sure the control shaft of the BDU transmission is set to the neutral position. The BDU transmission pump must be at zero position. Depress the bypass valve plunger manually to connect both side of the main hydraulic circuit to housing case. Allow the prime mover to turn at idling speed. Turn the control shaft and oil fills into main circuits. Stop depressing the bypass valve plunger. Then, the output shaft will start to turn. Check the oil tank or reservoir level and refill the oil to the proper level if necessary. Repeat the control shaft movement from full displacement in one direction to full displacement in the opposite direction. Oil should not contain air trapped in the oil during the initial operation.

Operation

Check all joints and connections for leaks, and check that the oil tank or reservoir level is proper at the time of first operation and every day.

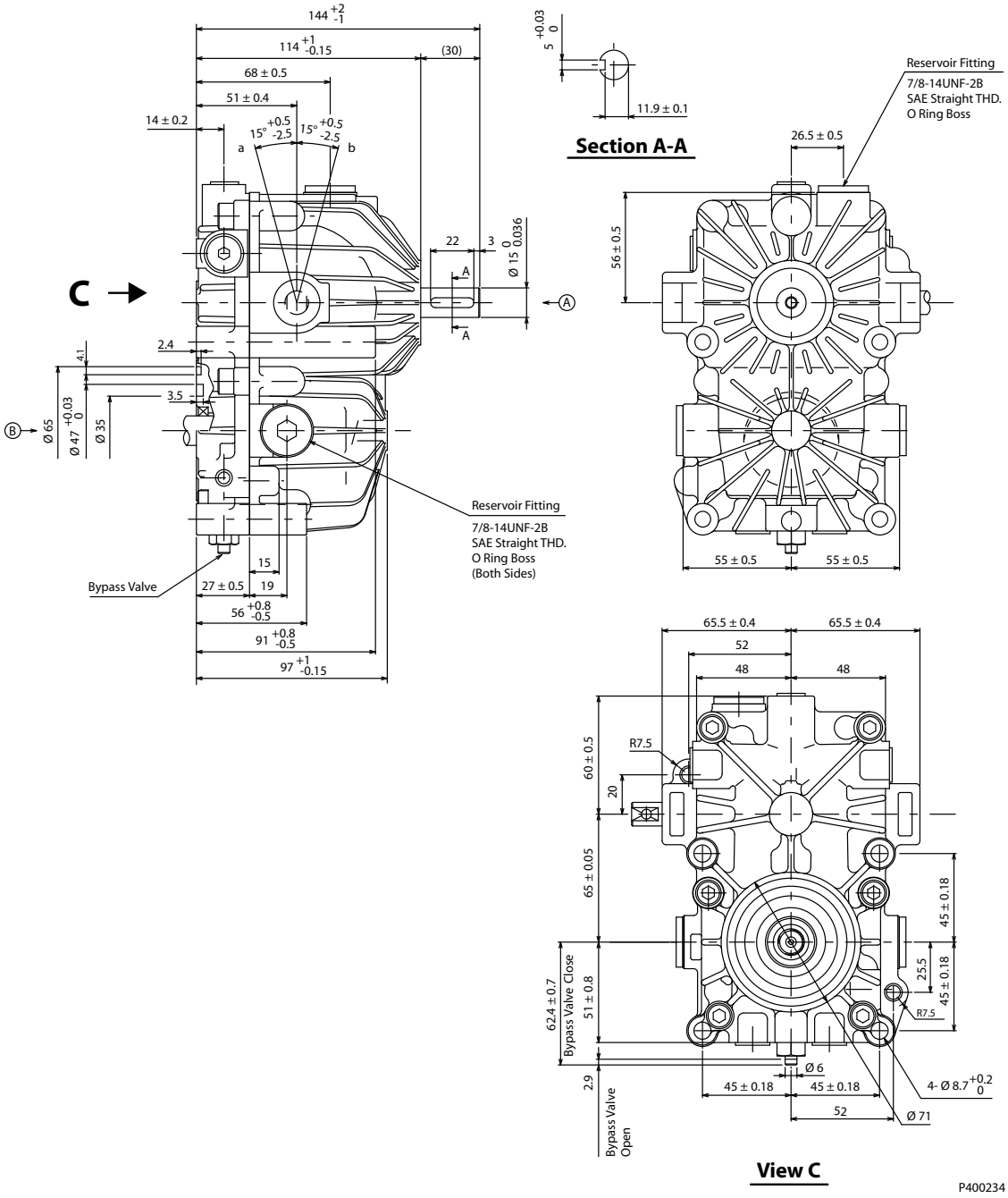
Start the prime mover turning in the neutral position of the control shaft of the BDU transmission.

Maintenance

If some water, dust or grease are mixed in, with the transmission oil, change to new recommended oil. Always keep at less than 0.1 % water in the transmission oil. It is recommended to change oil and filter every year or at the every 500 operating hours.

Installation Drawings

BDU-06S : Ports and Dimensions

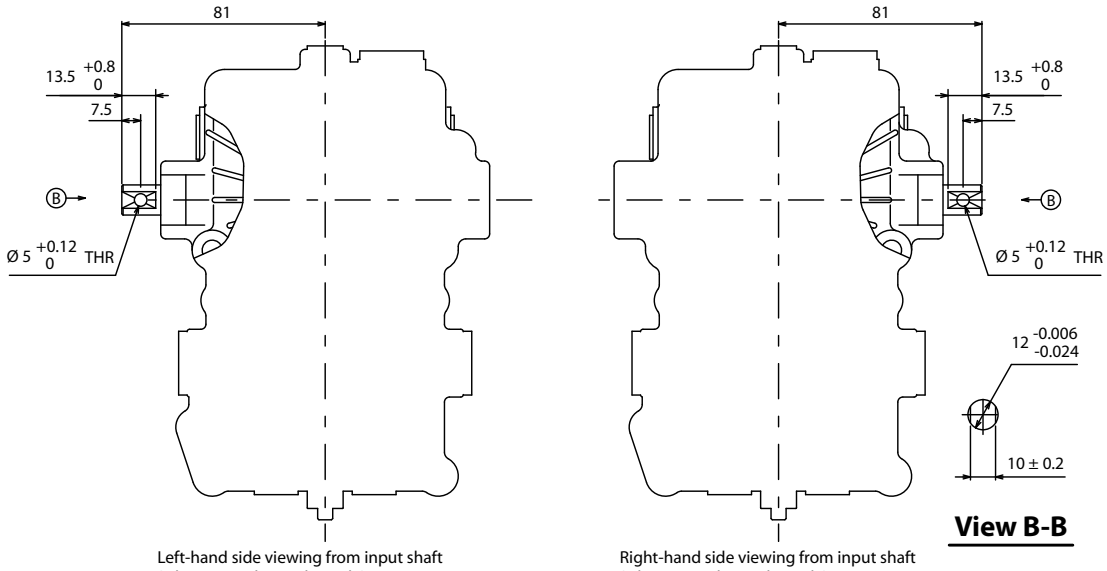


Option Code	R		L	
Input Rotation as Seen From A Direction	CW		CCW	
Control Shaft Rotation	a	b	a	b
Output Rotation as Seen From B Direction	CCW	CW	CW	CCW

The tightening torque to install HST is 1569 to 2058 N·cm.

Installation Drawings

BDU-06S : Control Arm Location

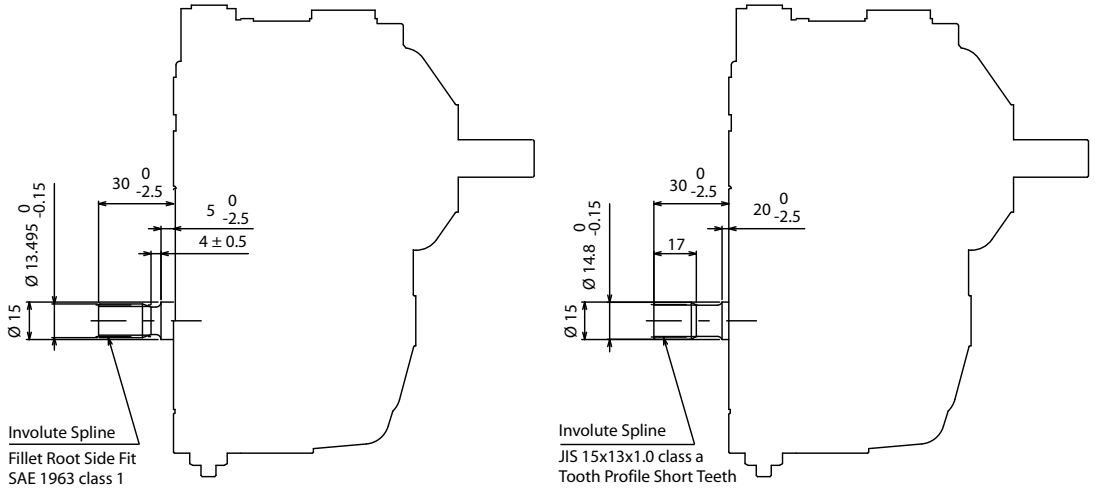


Left-hand side viewing from input shaft
(when pump located upside)
Option Code : L

Right-hand side viewing from input shaft
(when pump located upside)
Option Code : R

P400235

BDU-06S : Motor Shaft



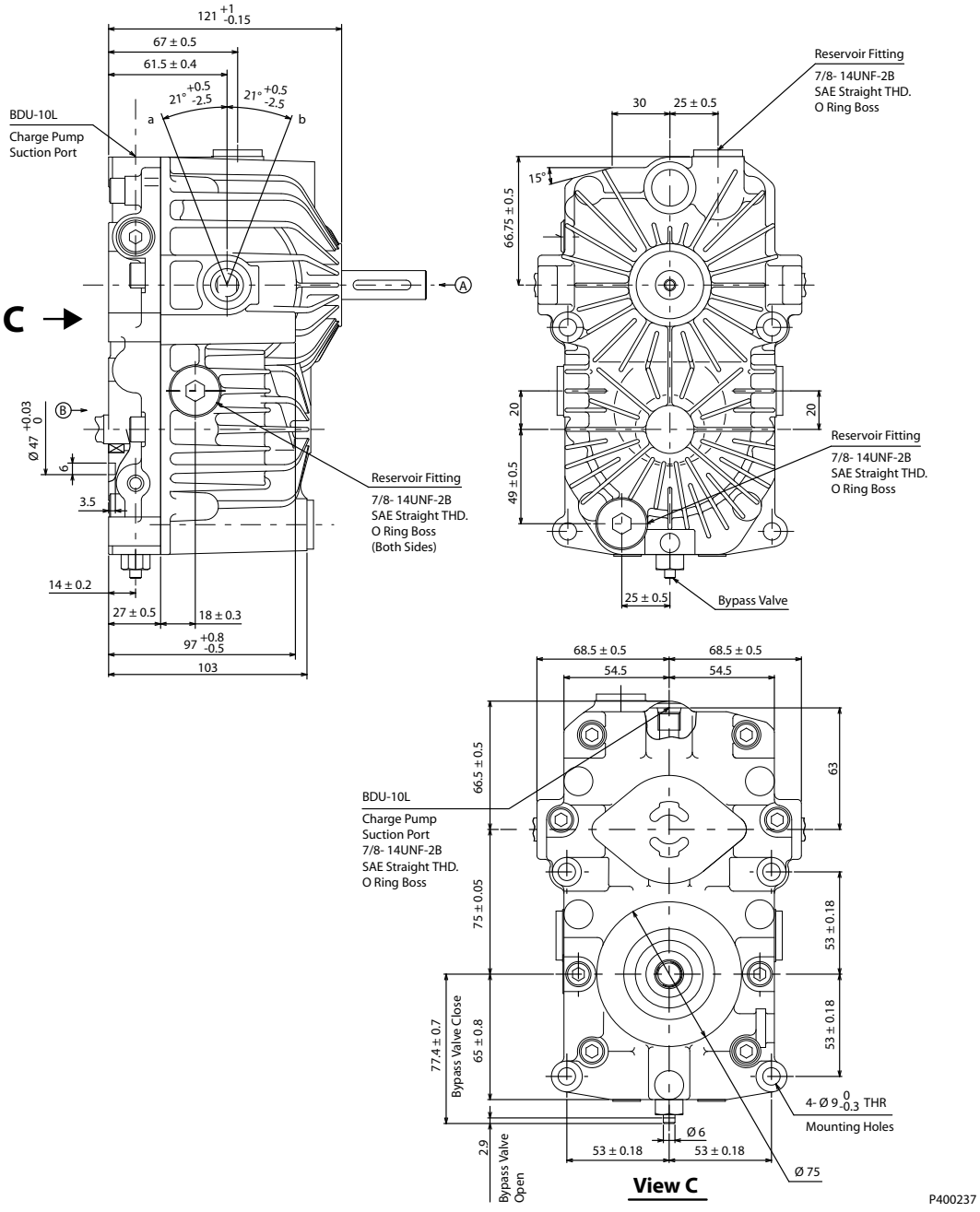
Involute Spline
Fillet Root Side Fit
SAE 1963 class 1
Pitch Diameter = 12.7
Pressure Angle = 30°
Number of Teeth = 16
Spline Pitch = 32/64

Involute Spline
JIS 15x13x1.0 class a
Tooth Profile Short Teeth
Module = 1.0
Pressure Angle = 20°
Number of Teeth = 13
Pitch Diameter = Ø13.0
Addendum Modification Coefficient = 0.8

P400236

Installation Drawings

BDU-10S/10L : Ports and Dimensions

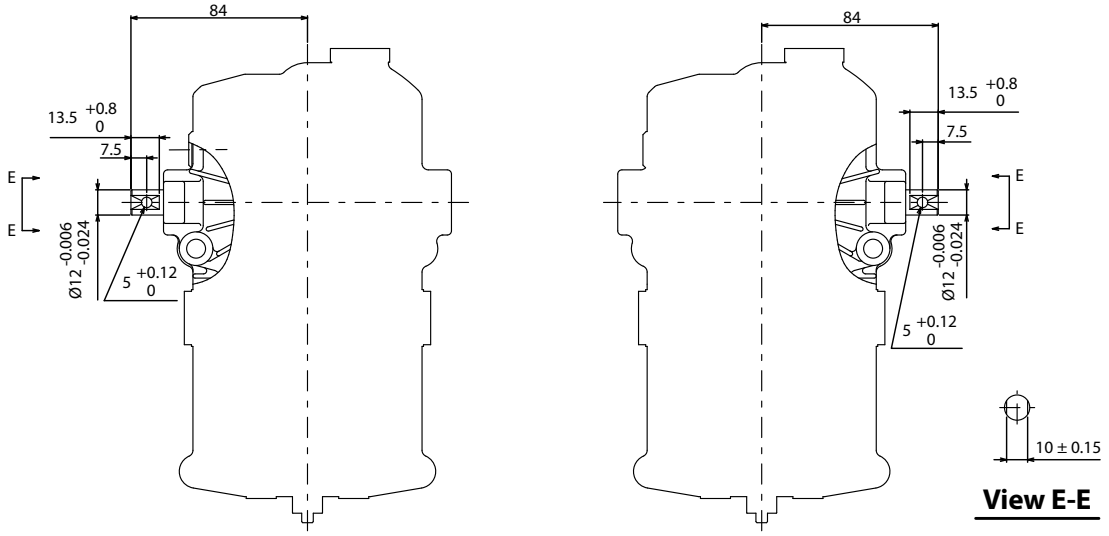


Option Code	R		L	
Input Rotation as Seen From A Direction	CW		CCW	
Control Shaft Rotation	a	b	a	b
Output Rotation as Seen From B Direction	CW	CCW	CCW	CW

The tightening torque to install HST is 1569 to 2058 N·cm.

Installation Drawings

BDU-10S/10L : Control Arm Location



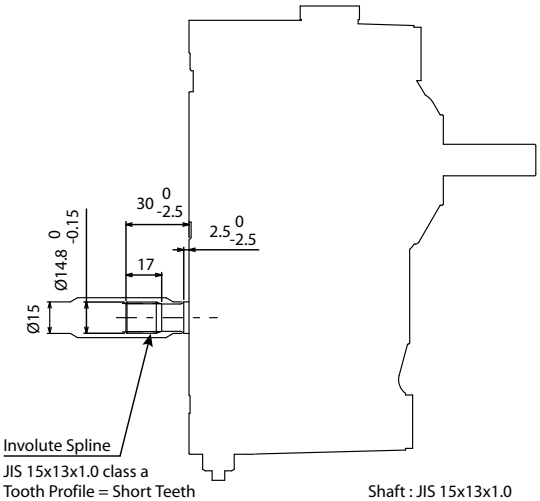
Left-hand side viewing from input shaft
(when pump located upside)
Option Code : L

Right-hand side viewing from input shaft
(when pump located upside)
Option Code : R

P400238

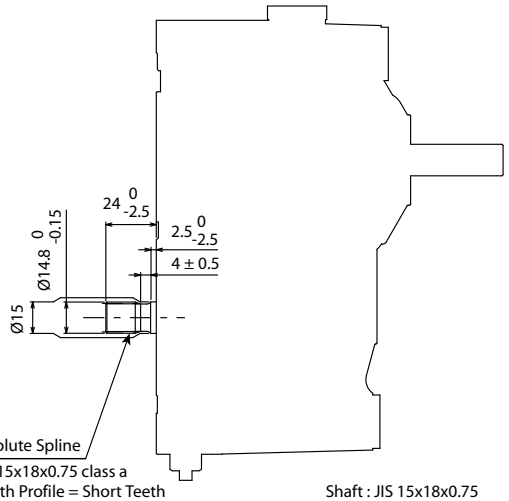
Installation Drawings

BDU-10S/10L : Motor Shaft



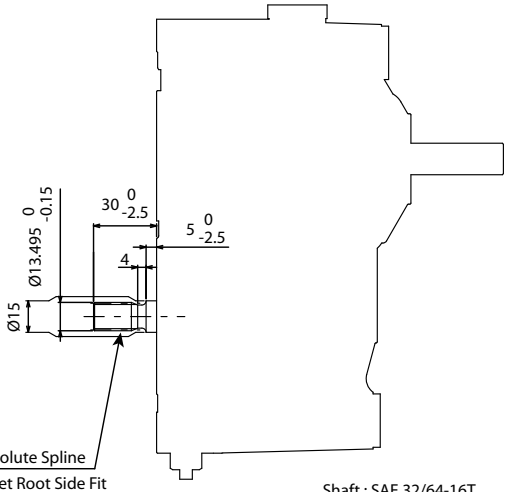
Involute Spline
JIS 15x13x1.0 class a
Tooth Profile = Short Teeth
Module = 1.0
Pressure Angle = 20°
Number of Teeth = 13
Pitch Diameter = Ø13.0
Addendum Modification Coefficient = 0.8

Shaft : JIS 15x13x1.0
Option Code : J13



Involute Spline
JIS 15x18x0.75 class a
Tooth Profile = Short Teeth
Module = 0.75
Pressure Angle = 20°
Number of Teeth = 18
Pitch Diameter = Ø13.5
Addendum Modification Coefficient = 0.5

Shaft : JIS 15x18x0.75
Option Code : K18



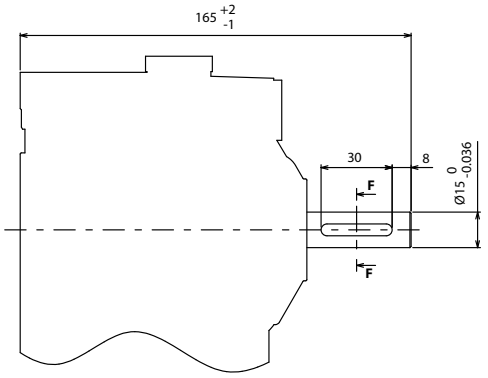
Involute Spline
Fillet Root Side Fit
SAE 1963 class 1
Pitch Diameter = 12.7
Pressure Angle = 30°
Number of Teeth = Ø16
Spline Pitch = 32/64

Shaft : SAE 32/64-16T
Option Code : S16

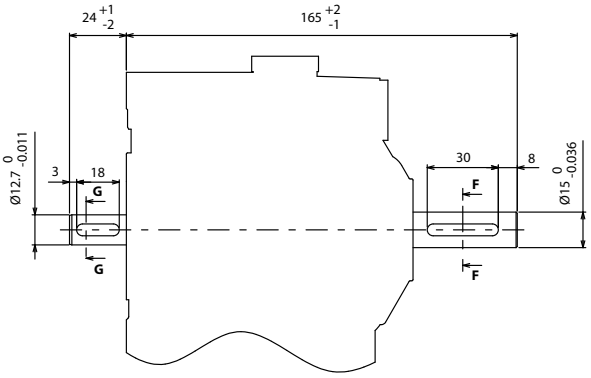
P400239

Installation Drawings

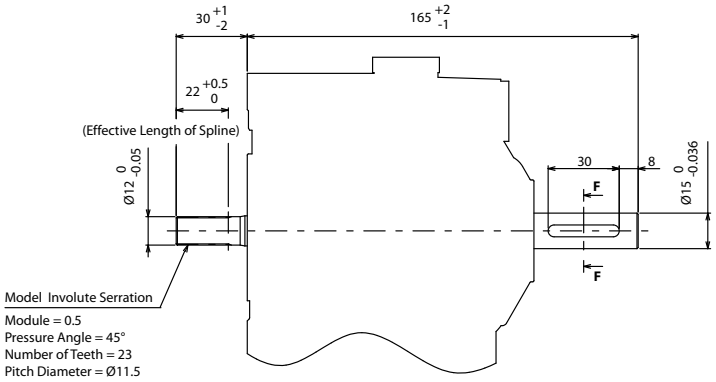
BDU-10S : Shaft Configuration



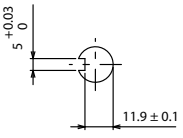
Pump Shaft : 15mm Straight Keyed
PTO Shaft : None
Charge Pump : None
Option Code : KB



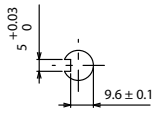
Pump Shaft : 15mm Straight Keyed
PTO Shaft : 12.7mm Straight Keyed
Charge Pump : None
Option Code : PB1



Pump Shaft : 15mm Straight Keyed
PTO Shaft : Serration 12x23x0.5
Charge Pump : None
Option Code : PB2



Section F-F

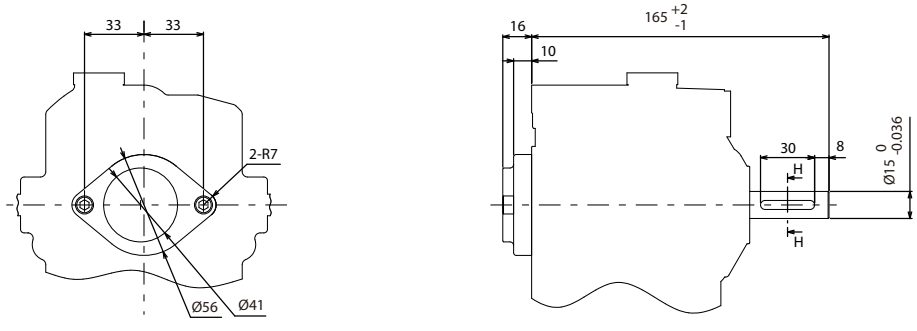


Section G-G

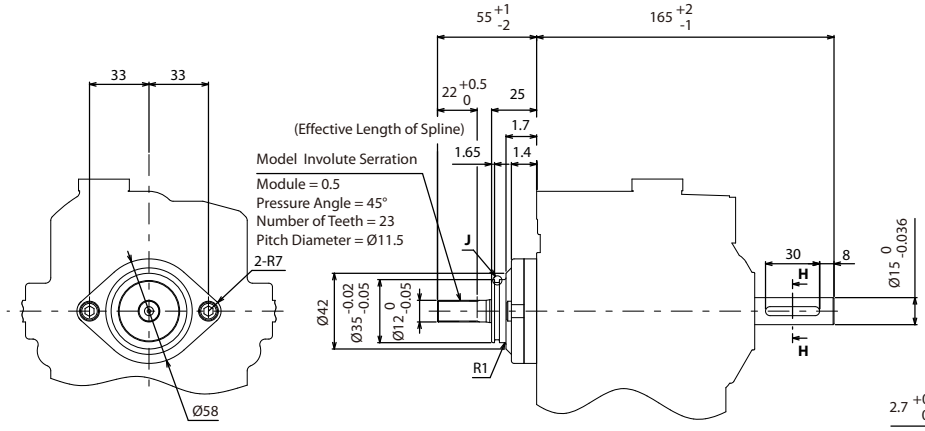
P400241

Installation Drawings

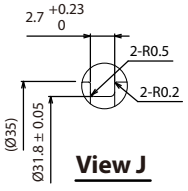
BDU-10L : Shaft Configuration and Charge Pumps Displacement



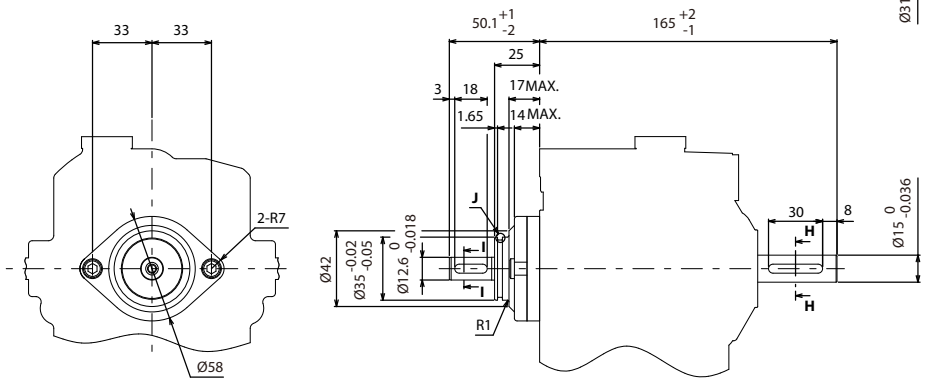
Pump Shaft : 15mm Straight Keyed
PTO Shaft : None
Charge Pump : 1.9 cc/rev
Option Code : KB1



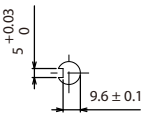
Pump Shaft : 15mm Straight Keyed
PTO Shaft : Serration 12x23x0.5
Charge Pump : 2.4 cc/rev
Option Code : PB4



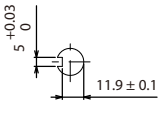
View J



Pump Shaft : 15mm Straight Keyed
PTO Shaft : 12.7mm Straight Keyed
Charge Pump : 2.4 cc/rev
Option Code : PB3



Section I-I

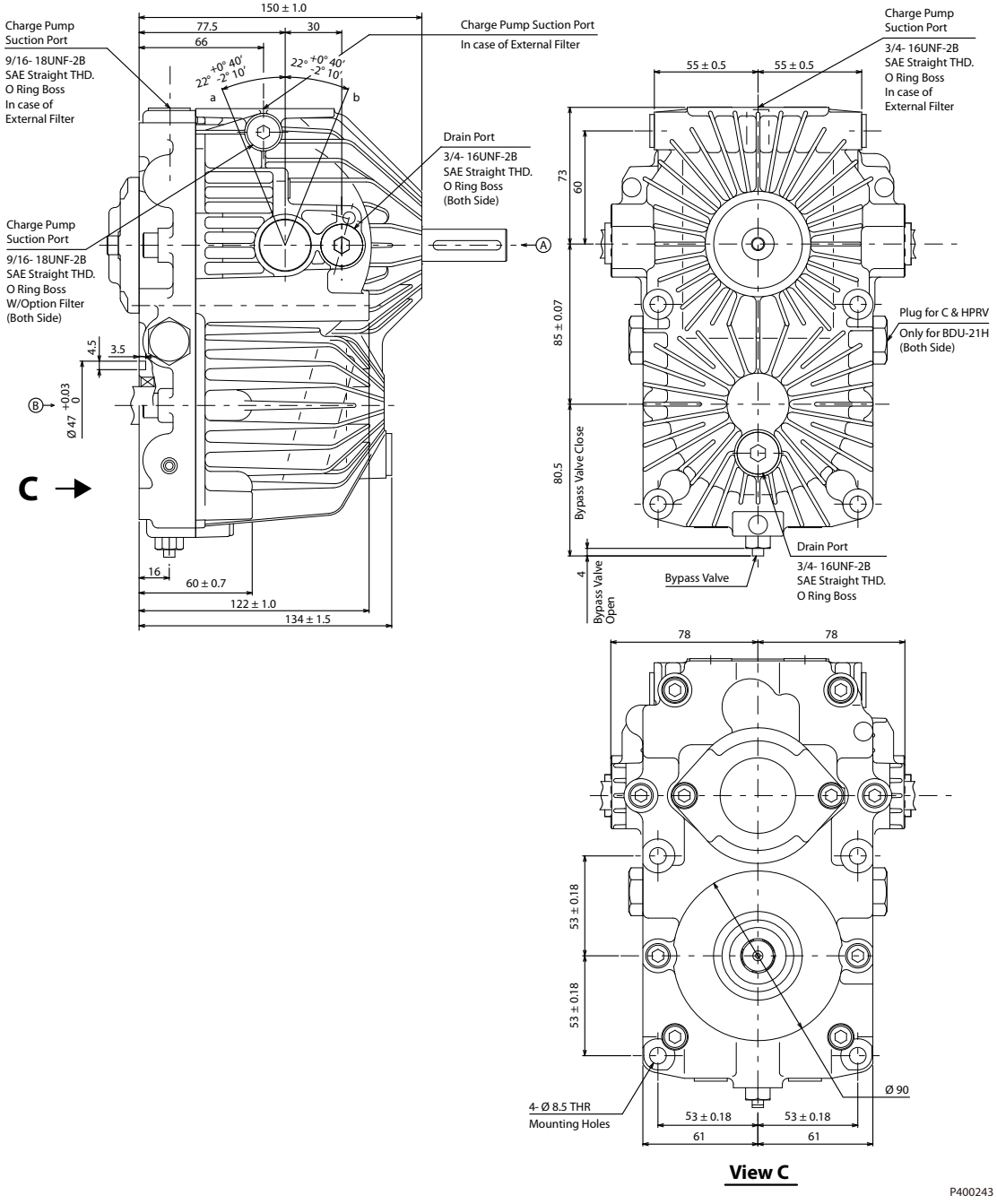


Section H-H

P400240

Installation Drawings

BDU-21L/21H : Ports and Dimensions

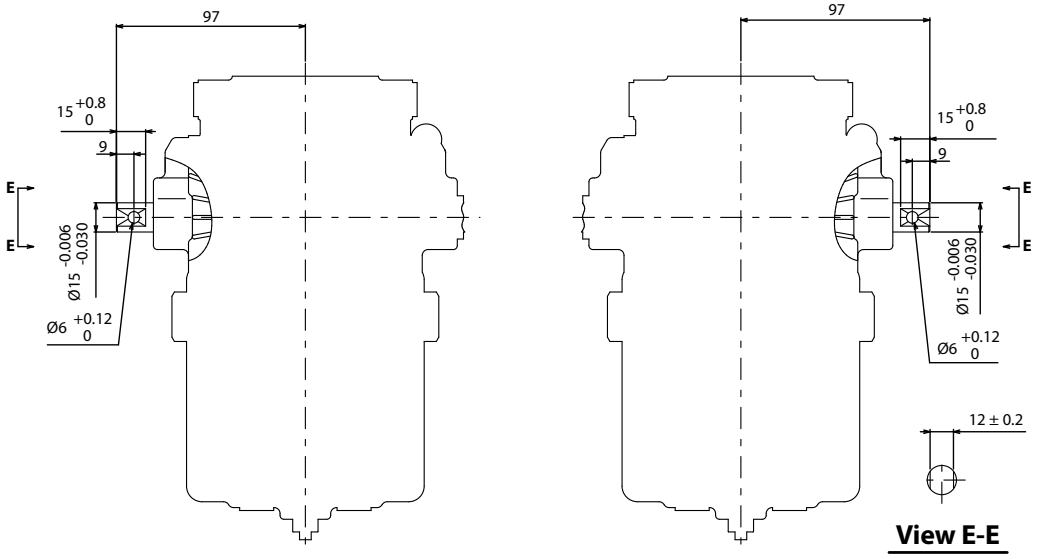


Option Code	R		L	
Input Rotation as Seen From A Direction	CW		CCW	
Control Shaft Rotation	a	b	a	b
Output Rotation as Seen From B Direction	CCW	CW	CW	CCW

The tightening torque to install HST is 1569 to 2058 N·cm.

Installation Drawings

BDU-21L/21H : Control Arm Location



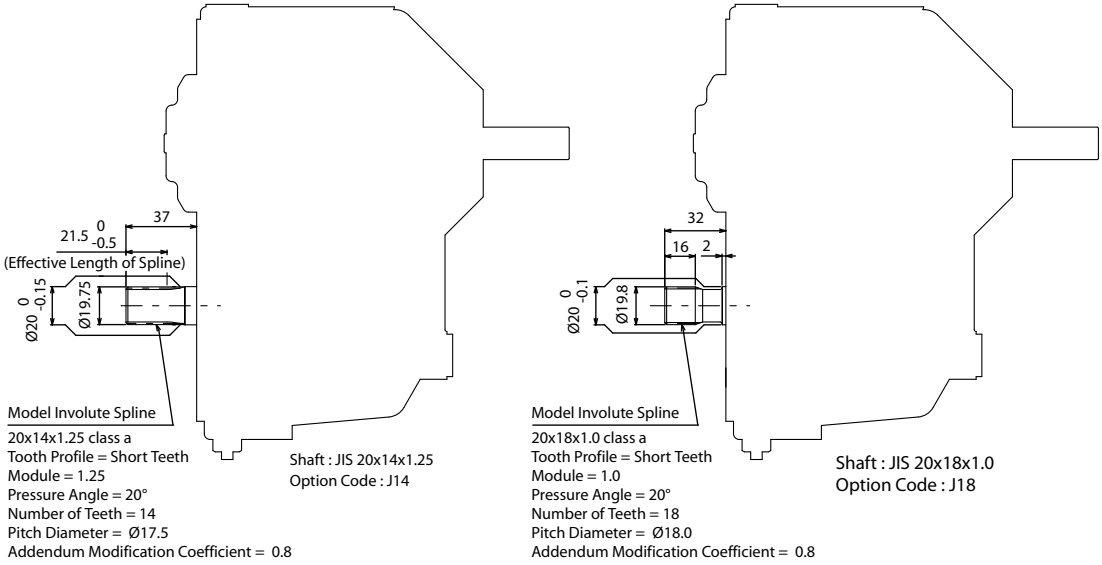
Left-hand side viewing from input shaft
(when pump located upside)
Option Code : L

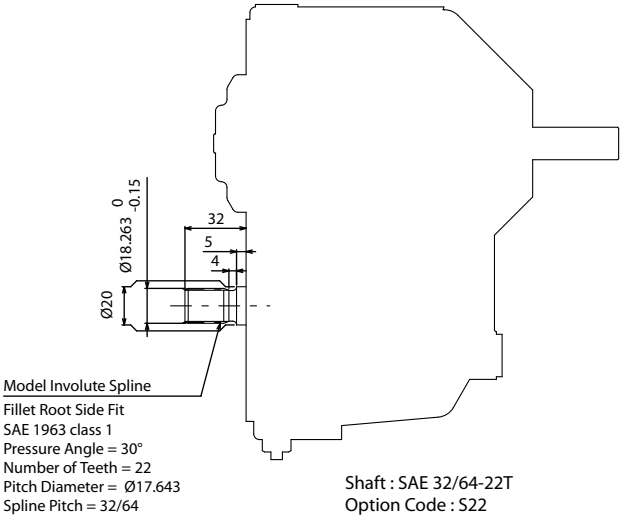
Right-hand side viewing from input shaft
(when pump located upside)
Option Code : R

P400242

Installation Drawings

BDU-21L/21H : Motor Shaft

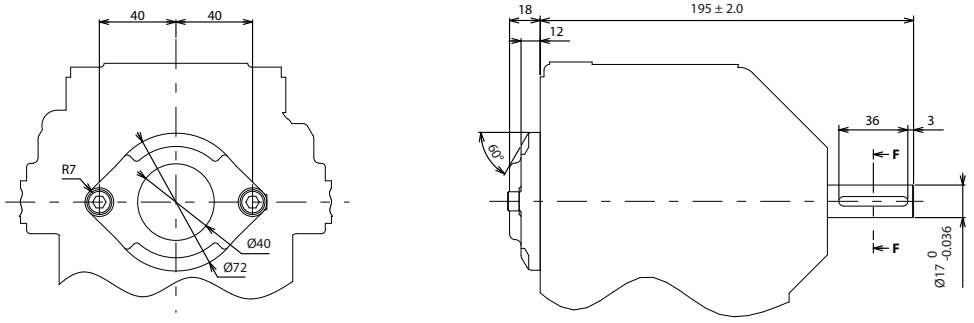




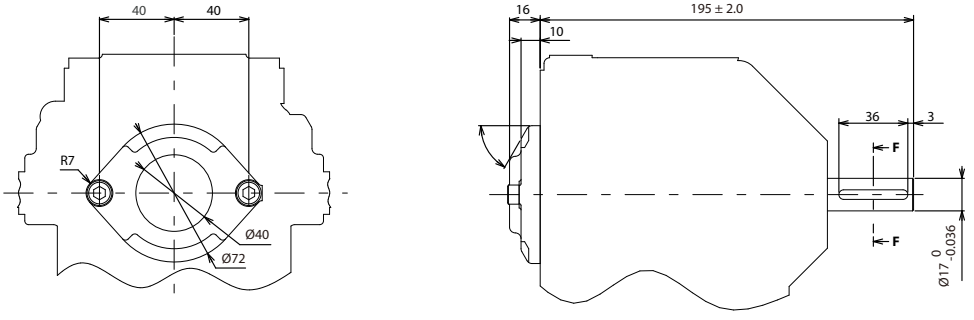
P400244

Installation Drawings

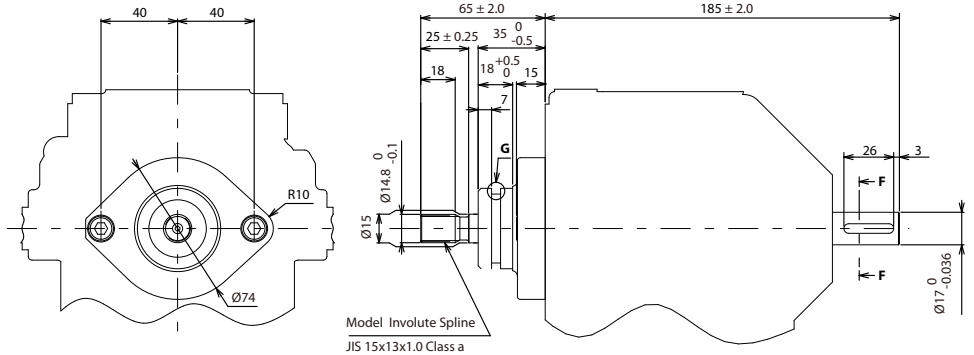
BDU-21L/21H : Shaft Configuration and Charge Pump Displacement



Pump Shaft : 17mm Straight Keyed (Key Length 36mm)
PTO Shaft : None
Charge Pump : 3.1cc/rev (for 21H)
Option Code : KC2



Pump Shaft : 17mm Straight Keyed (Key Length 36mm)
PTO Shaft : None
Charge Pump : 2.1cc/rev (for 21L)
Option Code : KC1



Model Involute Spline
JIS 15x13x1.0 Class a
Tooth Profile = Short Teeth
Module = 1.0
Pressure Angle = 20°
Number of Teeth = 13
Pitch Diameter = Ø13.0
Addendum Modification
Coefficient = 0.8

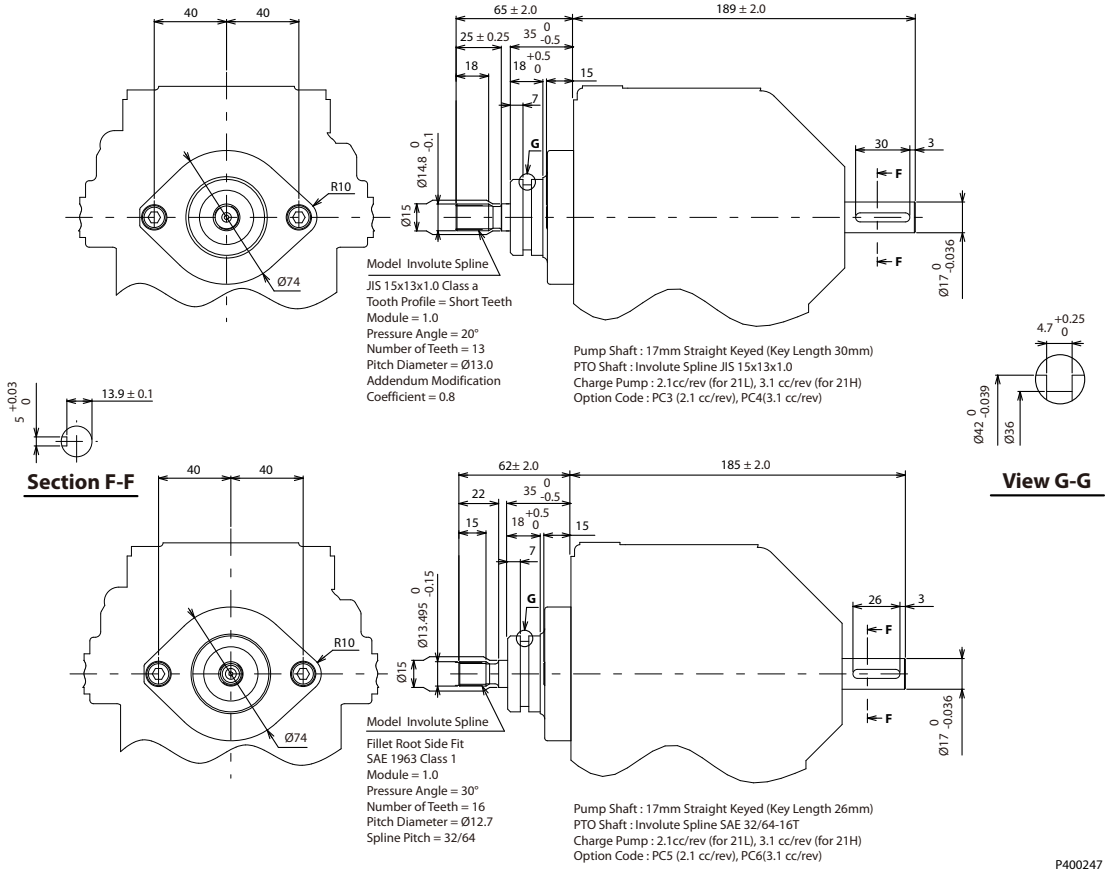
Pump Shaft : 17mm Straight Keyed (Key Length 26mm)
PTO Shaft : Involute Spline JIS 15x13x1.0
Charge Pump : 2.1cc/rev (for 21L), 3.1 cc/rev (for 21H)
Option Code : PC1 (2.1cc/rev), PC2(3.1 cc/rev)

Section F-F

View G-G

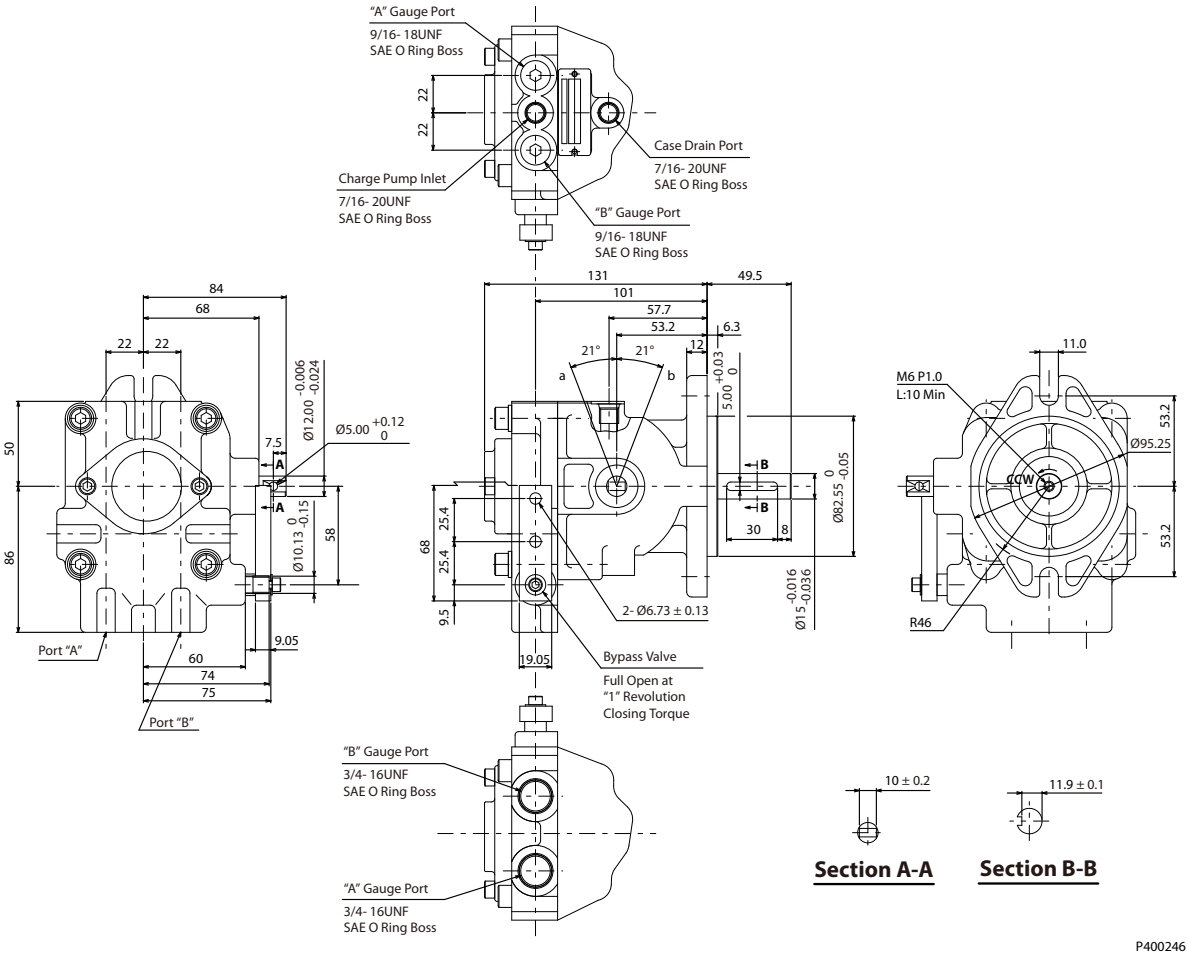
P400245

Installation Drawings



Installation Drawings

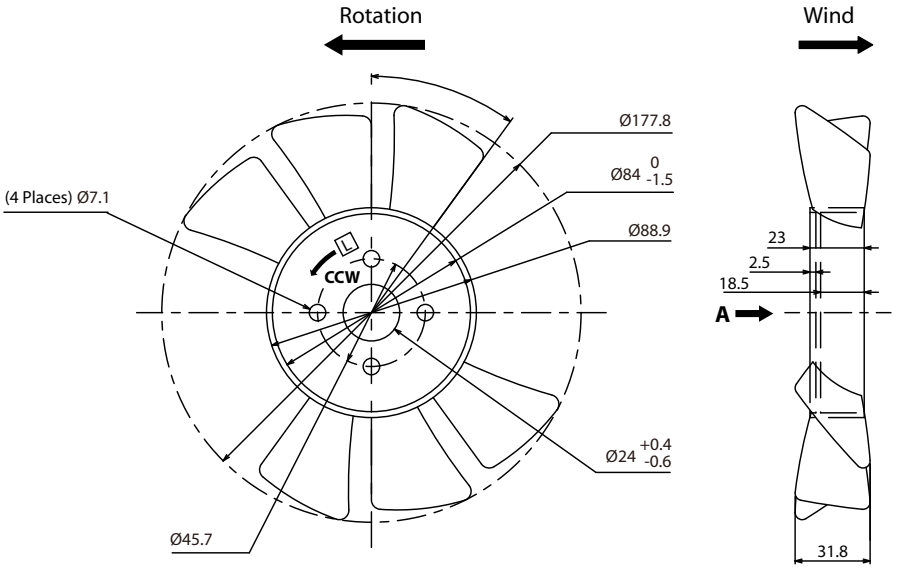
BDP-10L : Ports and Dimensions



Input Rotation	CW		CCW	
Control Shaft Rotation	a	b	a	b
Inlet Port	"A"	"B"	"B"	"A"
Outret Port	"B"	"A"	"A"	"B"

Installation Drawings

Optional Fan



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