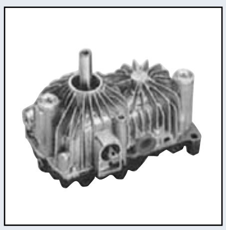
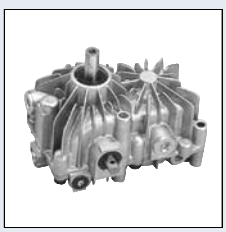
BD Series Hydrostatic Transmission

Technical Information


HISTORY OF REVISIONS

Table of Revisions

Date	Page	Changed	Rev.
Jan 2009	35	Correction - Text	AB
Jan 2006	-	The first edition	AA

Contents

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 spherical-nosed 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.

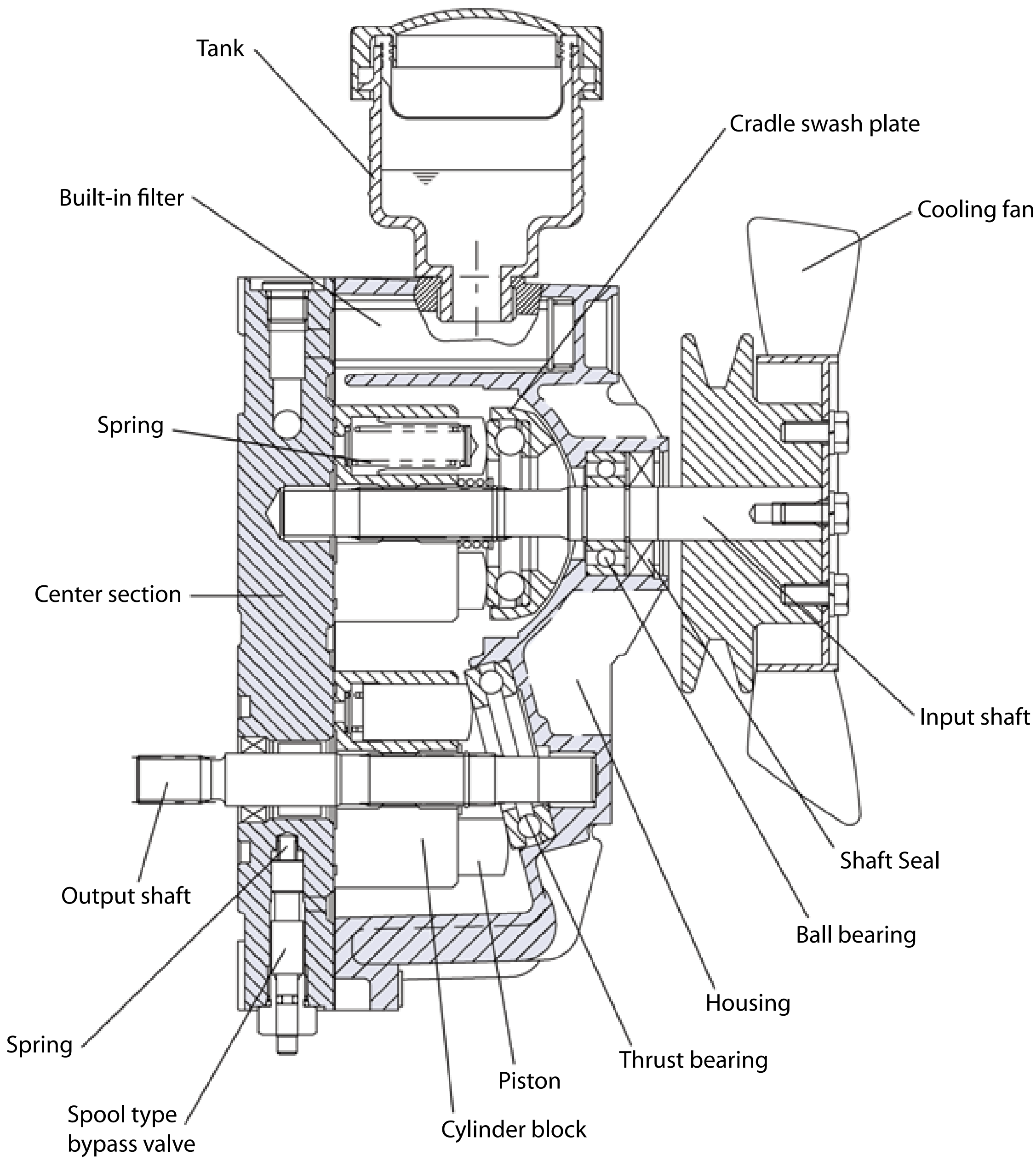
The BDP-10L is a variable displacement pump to utilize the pump kit **of the BDU-10L transmission** and designed for vehicle application which is for propel or for auxiliary functions where the system pressure requirements and design life can be met within pump rating.

- 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

DESIGN

BDU SERIES TRANSMISSION cross-section

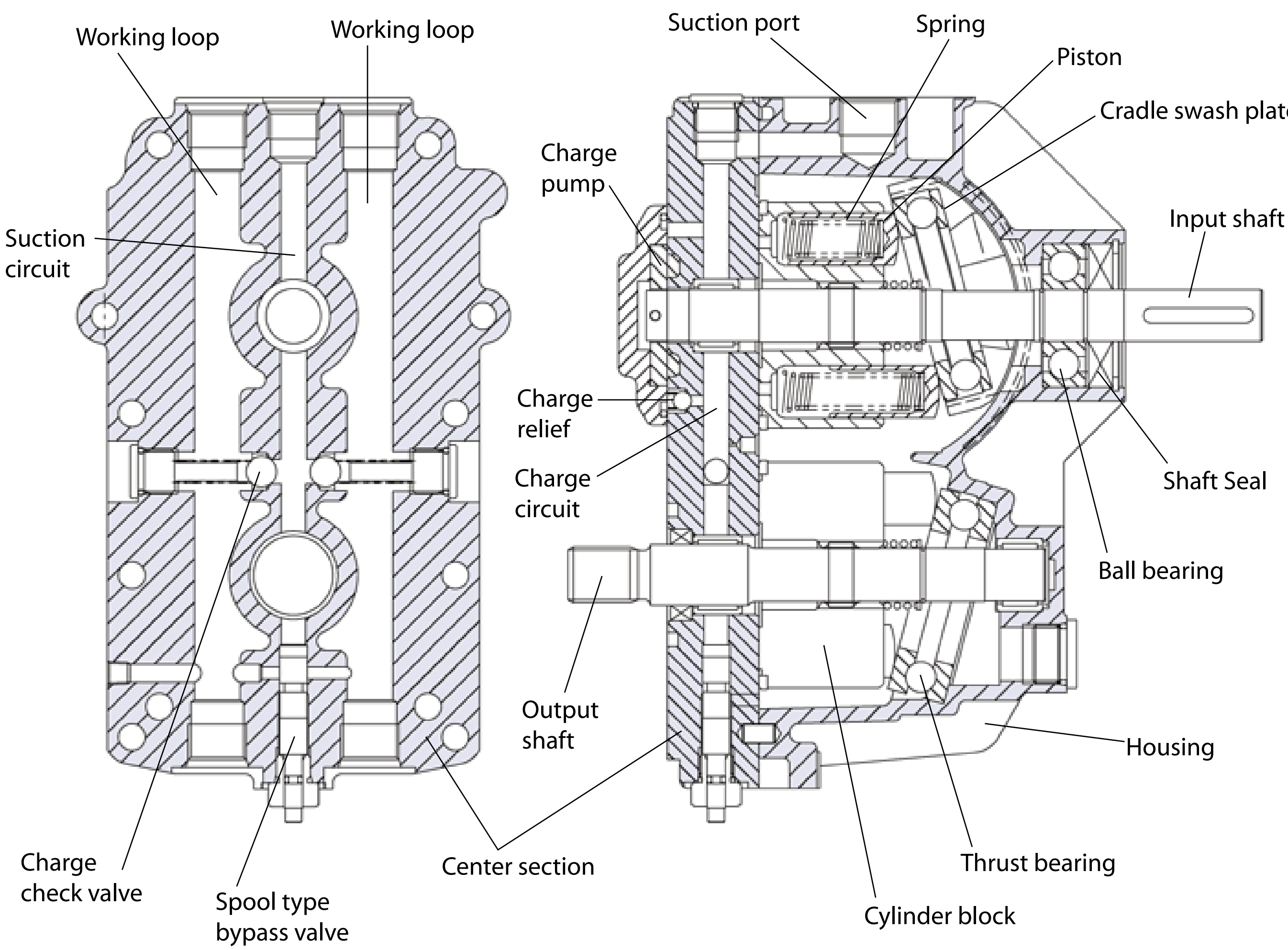
BDU-10S



DESIGN (continued)

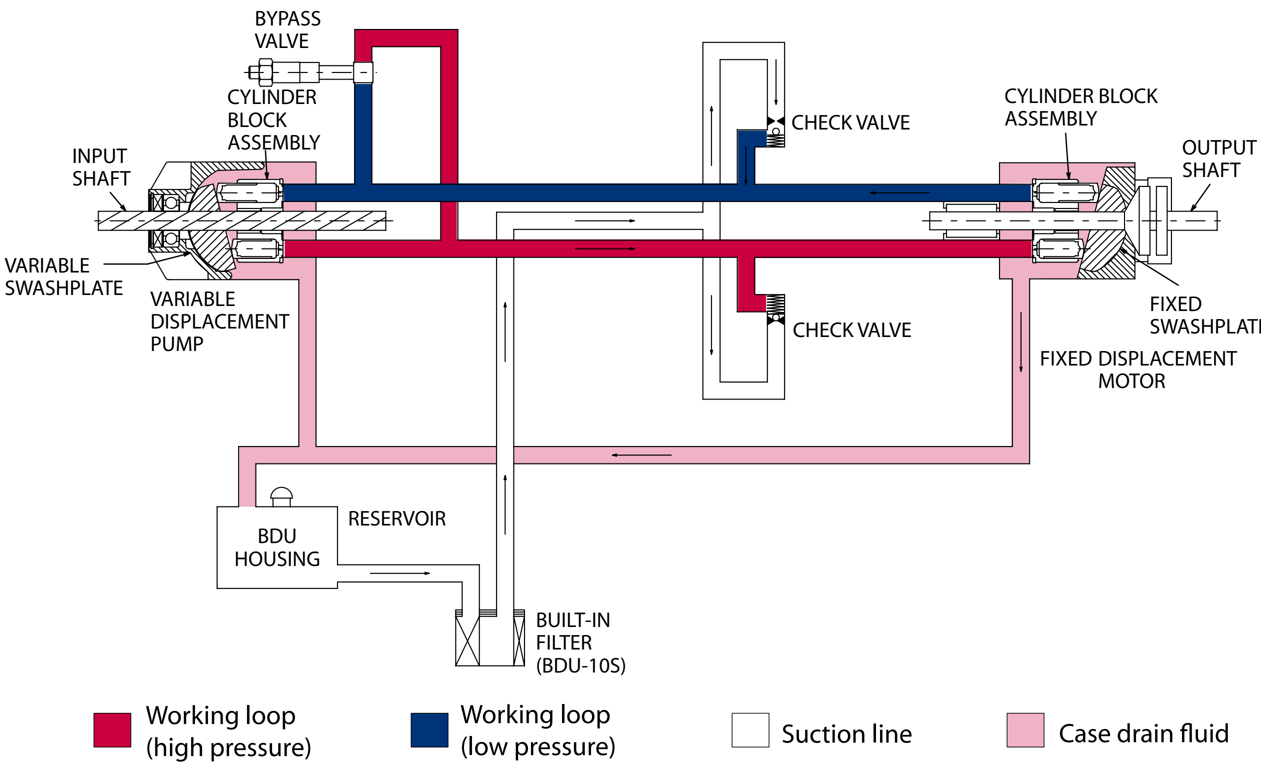
BDU SERIES TRANSMISSION cross-section

BDU-21L

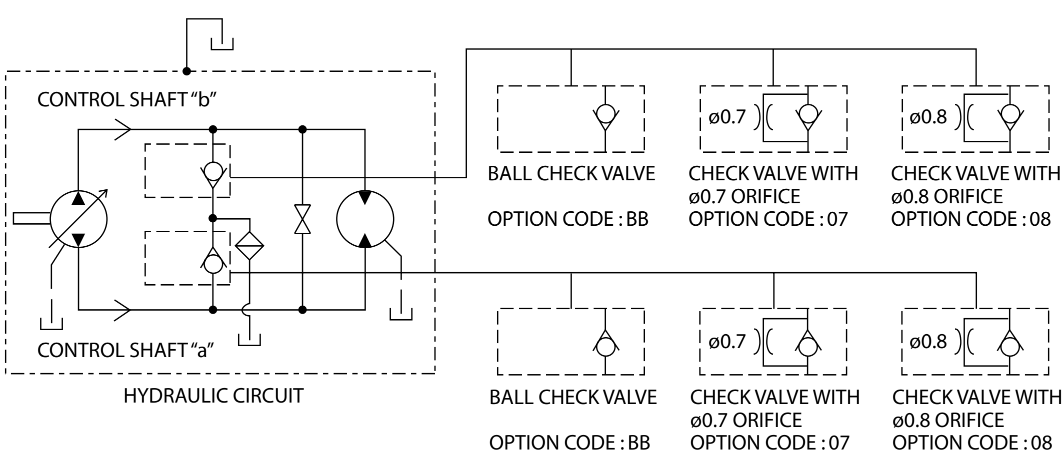


PICTORIAL CIRCUIT DIAGRAM

BDU-06S, BDU-10S

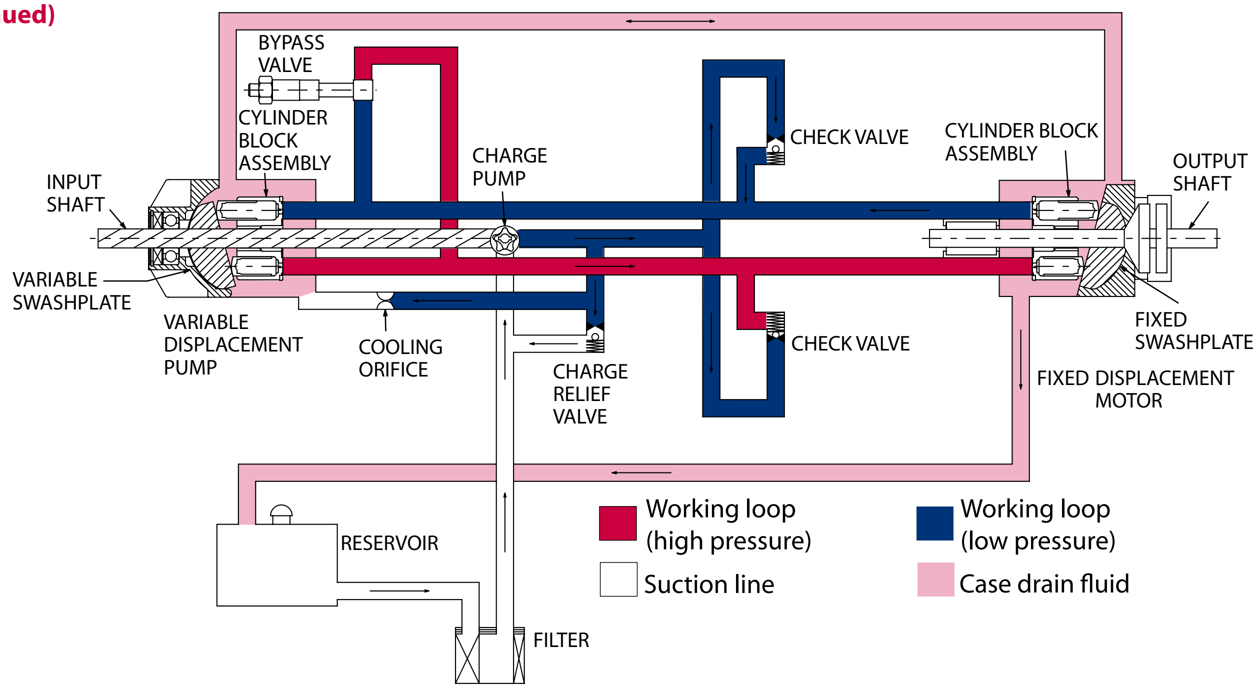


SYSTEM SCHEMATIC

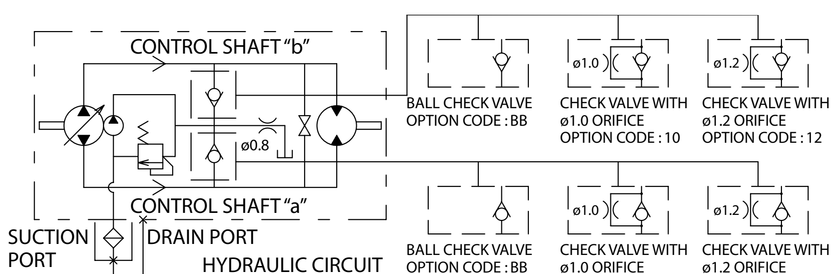


PICTORIAL CIRCUIT DIAGRAM (continued)

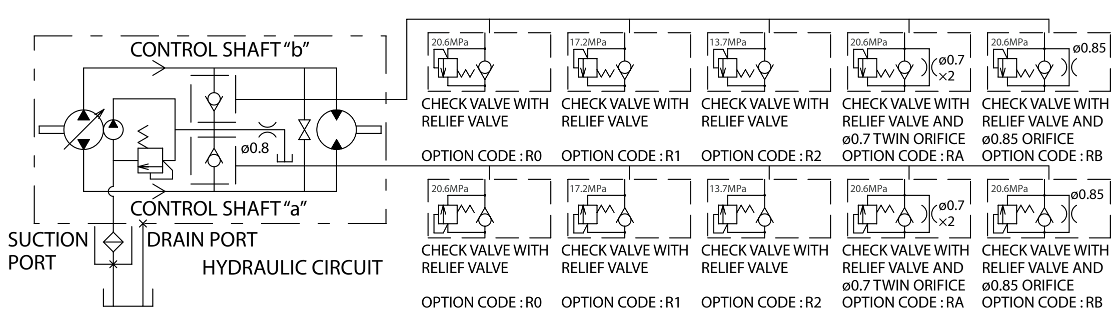
BDU-10L, BDU-21L, BDU-21H
BDP-10L (part of pump)



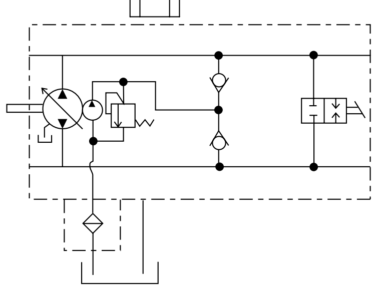
SYSTEM SCHEMATIC



21L



21H



BDP-10L

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]	N.A.	N.A.	1.9 [0.12]	2.1 [0.13]	3.0 [0.18]	1.9 [0.12]
Output Speed								
Rated		mini^{-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)			7/8-14UNF		7/16-20UNF	9/16-18UNF		7/16-20UNF
Other ports			See Installation Drawings					
Shaft			P34, 36 ~ 38, 40 ~ 42					
Bypass Valve			O.P.	STD	STD	STD	STD	STD
Neutral Valve / Orifice			N.A./N.A.	N.A./O.P.	N.A./O.P.	O.P./O.P.	O.P./O.P.	N.A./O.P.
High Pressure Relief Valve			N.A.	N.A.	N.A.	N.A.	STD	N.A.
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

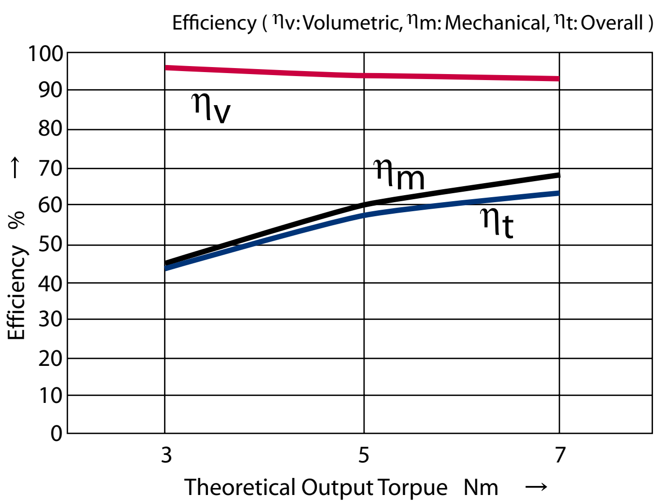
Parameter	Unit	Product type & Frame					
		BDU-06S	BDU-10S	BDU-10L	BDU-21L	BDU-21H	BDP-10L
Input Speed							
Minimum	min^{-1}	1000	600	600	600	600	600
Rated		3000	3000	3600	3600	3600	3600
Maximum		3200	3200	3800	3800	3800	3800
System Pressure							
Rated	bar [psi]	105 [1530]	150 [2185]			210 [3059]	150 [2185]
Maximum		150 [2185]	175 [2549]		210 [3059]	245 [3569]	175 [2549]
Charge Pressure	bar [psi]	N.A.		3 [44] ~ 5 [73]			
Charge Inlet Pressure	bar [psi]	N.A.		0.8 [12] abs			
Case Pressure	bar [psi]	0.3 [4]					
Rated	bar	0.3 [4]					
Maximum (Cold Start)	[psi]	0.7 [10]					

FLUID SPECIFICATIONS

Viscosity mm²/sec (cSt) [SUS]	
Minimum	7 [49]
Continous	12 [70] - 60 [278]
Maximum	1600 [7500]
Oil Temperature °C [°F]	
Minimum	–10 [14]
Maximum Continuous	82 [180]
Maximum Intermittent	104 [219]

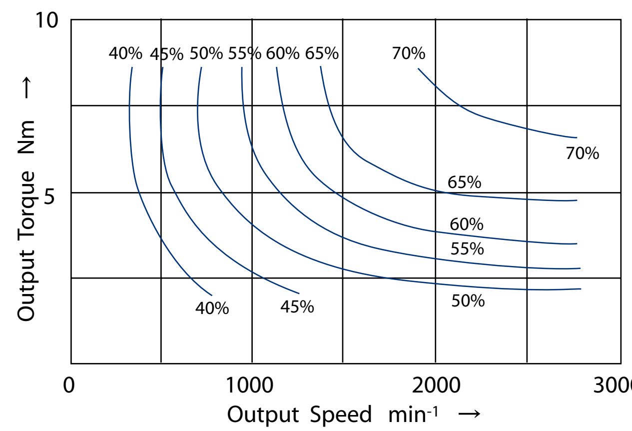
EFFICIENCY

BDU-06S



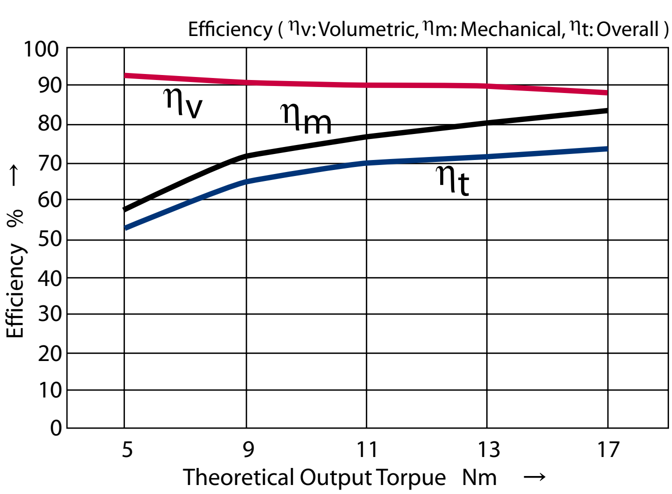
Input speed: 3000min-1
Oil temperature: 50°C
Full Displacement

BDU-06S



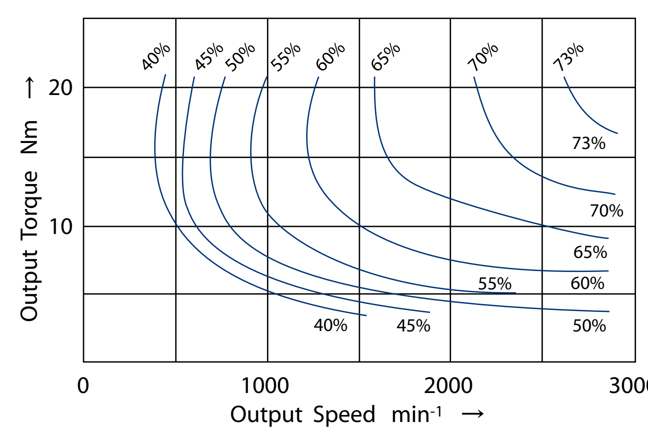
Input speed: 3000min-1
Oil temperature: 50°C

BDU-10S



Input speed: 3000min-1
Oil temperature: 50°C
Full Displacement

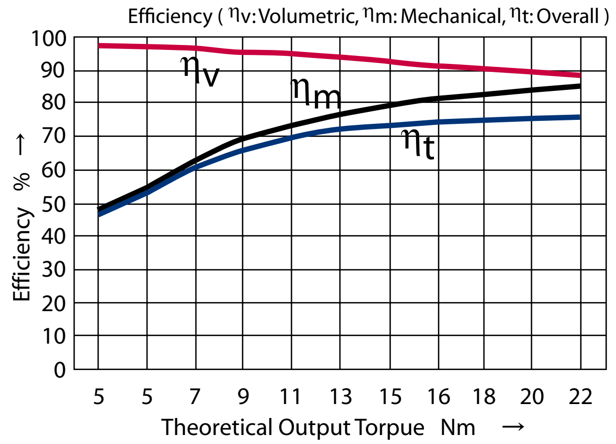
BDU-10S



Input speed: 3000min-1
Oil temperature: 50°C

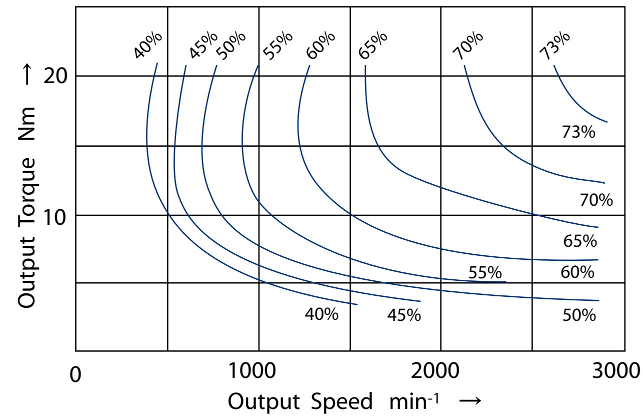
EFFICIENCY (continued)

BDU-10L



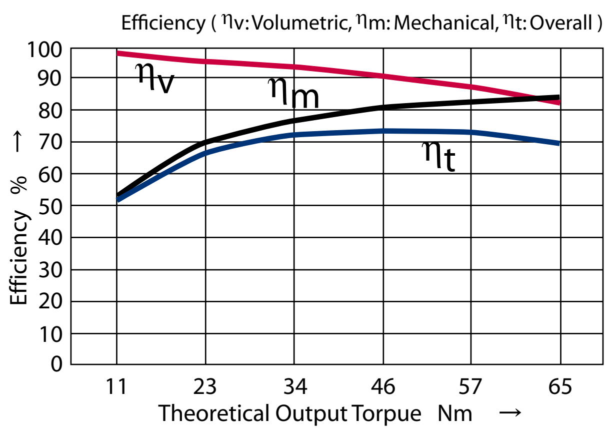
Input speed: 3000min-1
Oil temperature: 50°C
Full Displacement

BDU-10L



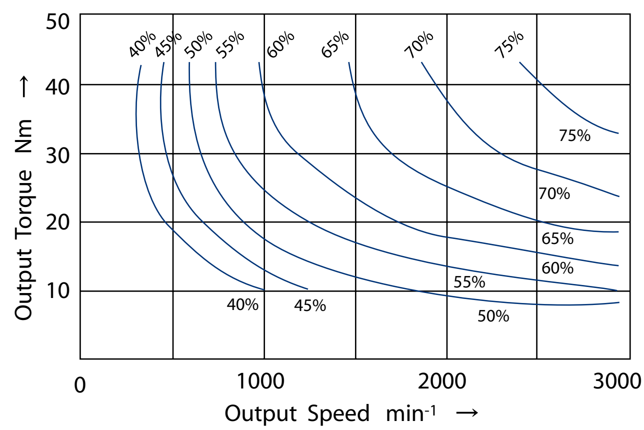
Input speed: 3000min-1
Oil temperature: 50°C

BDU-21L/21H



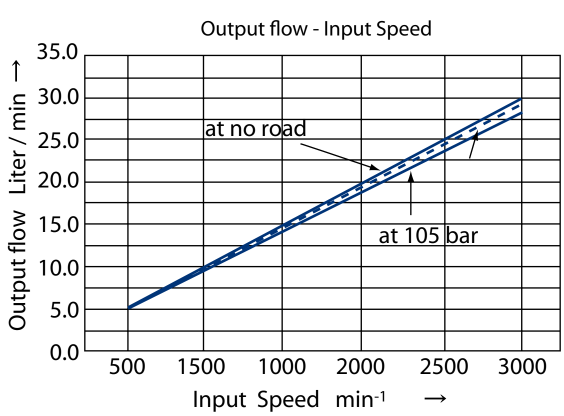
Input speed: 3000min-1
Oil temperature: 50°C
Full Displacement

BDU-21L/21H



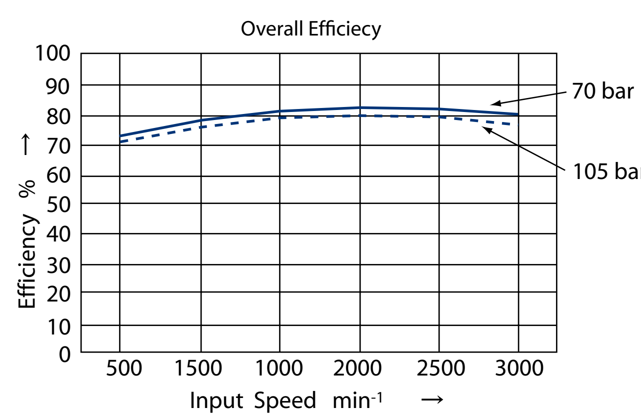
Input speed: 3000min-1
Oil temperature: 50°C

BDP-10L



Oil temperature: 50°C

BDP-10L



Oil temperature: 50°C
Full Displacement

OVERVIEW

Maintain operating parameters within prescribed limits during all operating conditions. This section defines operating limits given in the table *Operating parameters,* page 11.

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 hydraulic power and braking capacity. Never exceed maximum speed limit under any operating 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 and B. It is the dominant operating variable affecting hydraulic unit life. High system pressure, which results from high load, reduces expected life. Hydraulic unit life depends on the speed and normal operating, or weighted average, pressure that can only be determined from a duty cycle analysis.
Applied pressure is the chosen application pressure found within the order code for the transmission unit. This is the pressure at which the driveline generates the maximum pull or torque in the application.
Rated pressure is the design pressure from the transmission unit. Applications with applied pressures at or below this pressure should yield satisfactory unit life given proper component selection guidelines.
Maximum pressure (Peak) is the highest intermittent pressure allowed under any ircumstances. Applications with applied pressures between rated and peak should be attempted only with application, duty cycles and life expectation analyses. This requires factory approval.

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.

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 of leakage.

Operation with case pressure in excess of these 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.

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 pump motor components. Never mix hydraulic fluids of different types.

The following fluids are suitable:

- Engine oils API Classification SL, SJ (for gasoline engines) and CI-4, CH-4, CG-4, CF-4, CF and CD (for diesel engines)
- Hydraulic Oil ISO11158-HM (Seal compatibility and vane pump wear resistance per DIN51524-2 must be met)
- Hydraulic Oil ISO11158-HV (Seal compatibility and vane pump wear resistance per DIN51524-3 must be met)
- Hydraulic Oil DIN51524-2 HLP
- Hydraulic Oil DIN51524-3 HVLP

TEMPERATURE AND VISCOSITY

Temperature and viscosity requirements must be concurrently satisfied. The data shown in the table, *Fluid Specifications,* page 11, assume petroleum-based fluids are used.

The high temperature limits apply at the hottest point in the transmission, which is normally the 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 over 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 accepted only during brief occasions of maximum ambient temperature and severe duty cycle operation. The **maximum viscosity** should be permitted only at cold start.

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

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 $\beta 20=1.4$ 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

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.

INDEPENDENT BRAKING SYSTEM

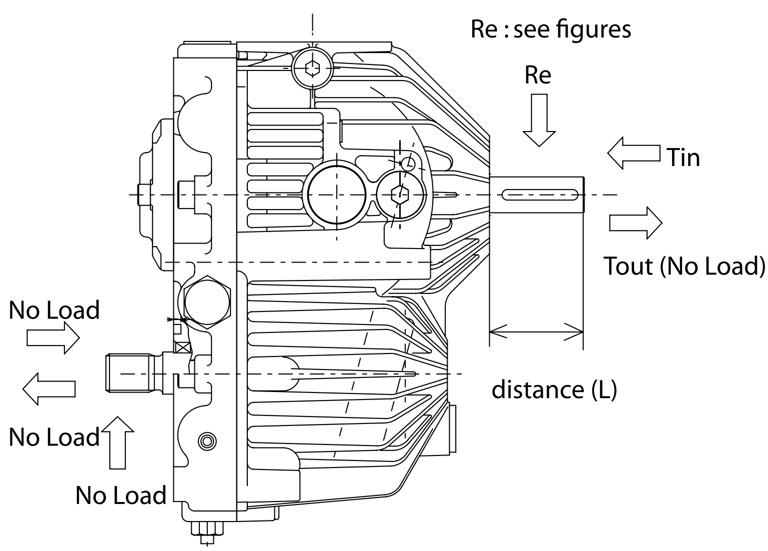
⚠ Warning

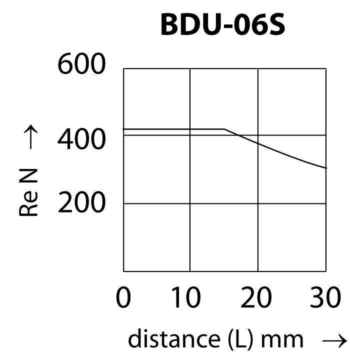
Unintended vehicle or machine movement hazard.

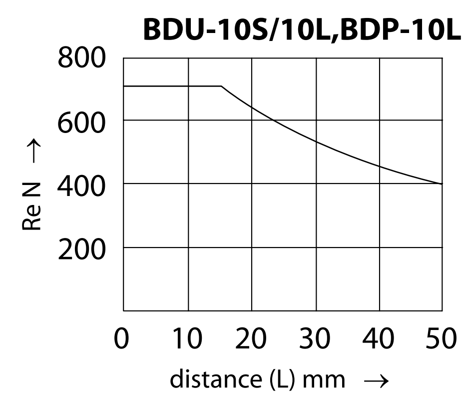
The loss of hydrostatic drive line power, in any mode of operation (forward, neutral, or reverse) may cause the system to lose hydrostatic braking capacity. You must provide a braking system, redundant to the hydrostatic transmission, sufficient to stop and hold the vehicle or machine in the event of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

SHAFT LOAD

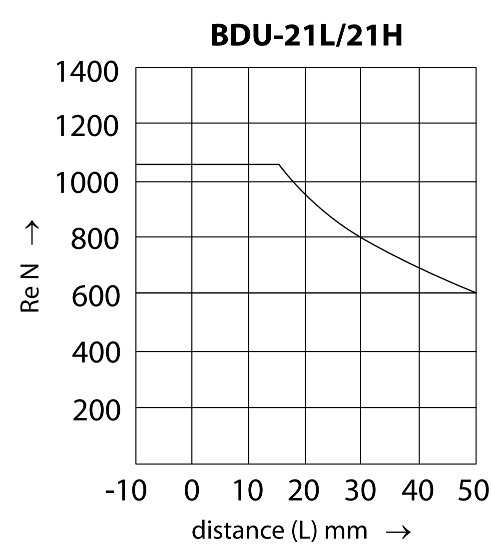
The maximum allowable radial road of input shaft (Re) is based on the maximum external moment and the distance from the housing surface to the input shaft.
The limit of radial load of input shaft is shown the figure below:





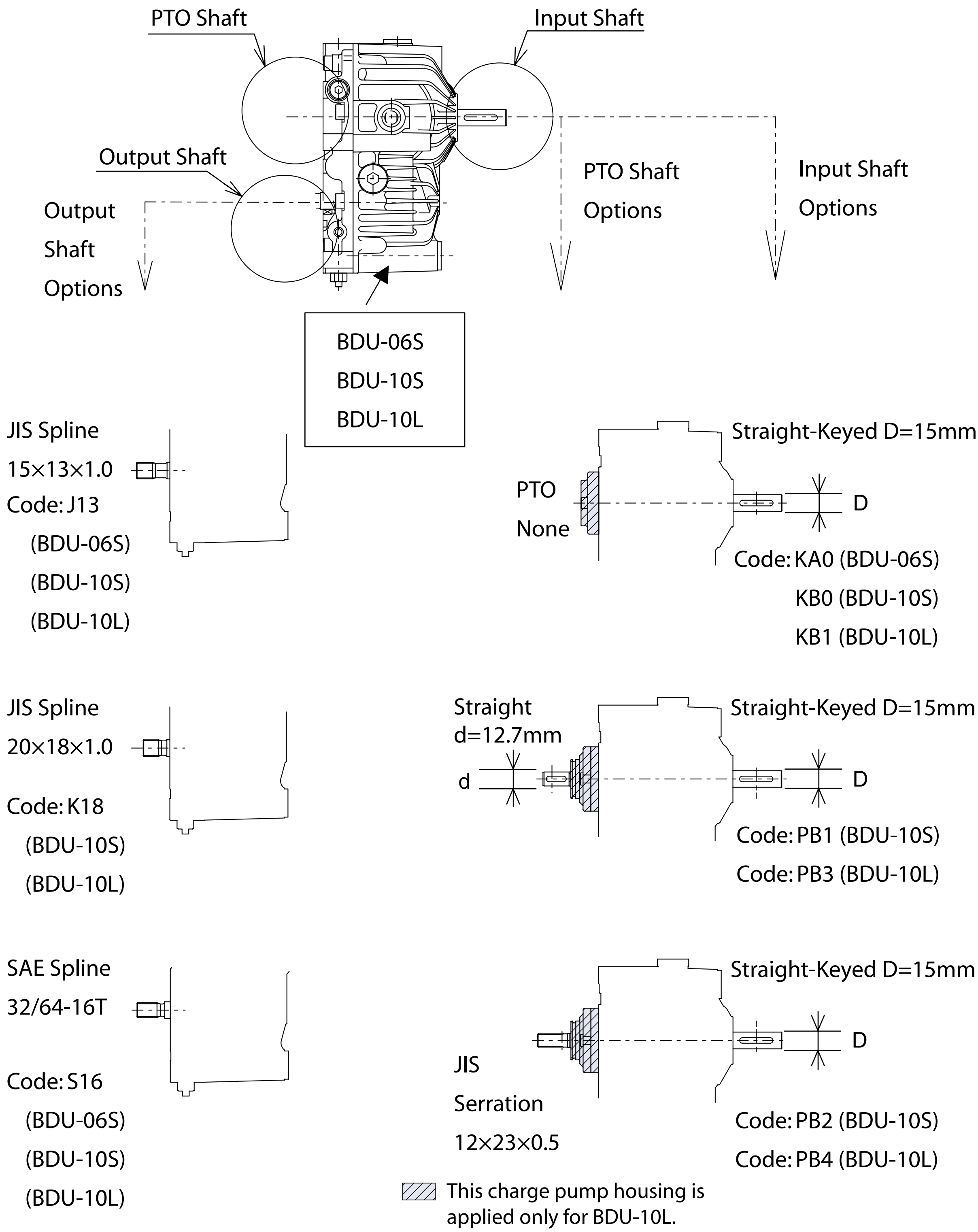


The maximum shaft thrust in (**Tin**) of input shaft is 18% of allowable radial road (**Re**) of the input shaft.
The shaft thrust out (**Tout**) of the input shaft should be no load.
The radial and thrust load of the output shaft should be no load.

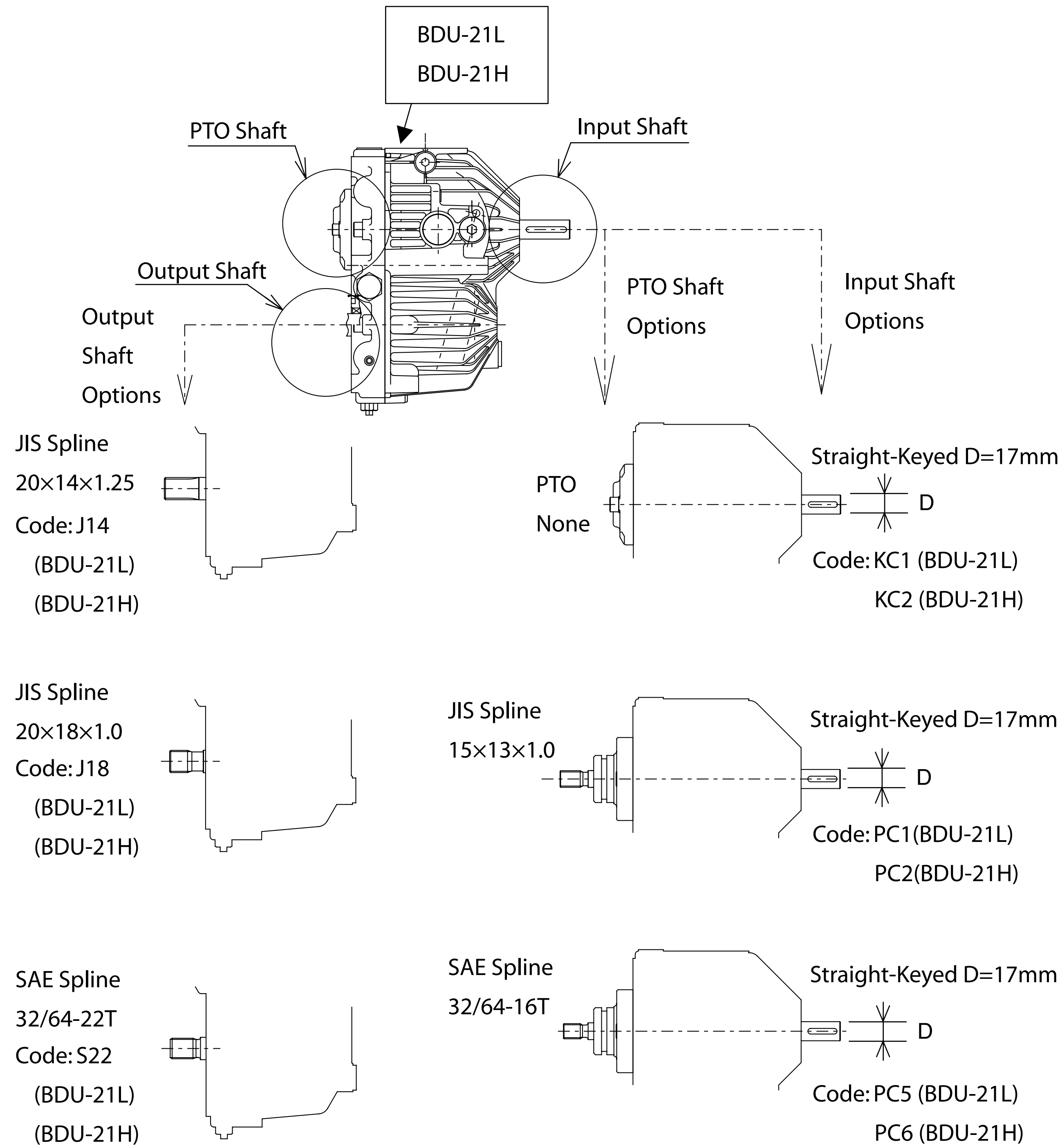


SHAFT OPTIONS

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*, page 33 through page 43.



SHAFT OPTIONS CONTINUED

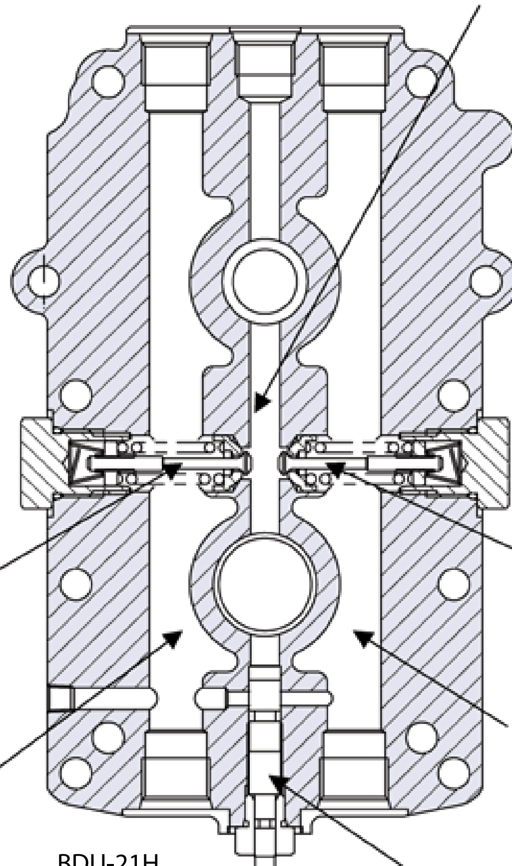


BYPASS VALVE

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 (OVER PRESSURE 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***, page29, 30 and 31. Individual port pressure settings may be specified. The high pressure relief valve settings are a differential pressure (referenced to charge pressure).

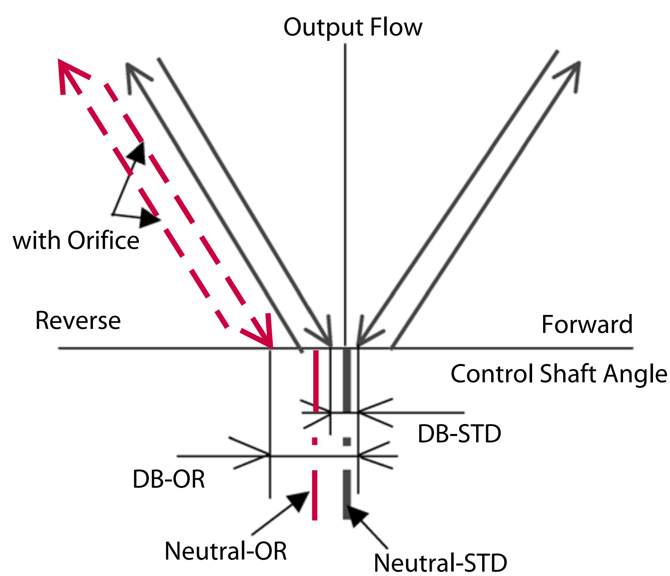


BDU-21H
Center section

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

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***, page 29, 30 and 31.



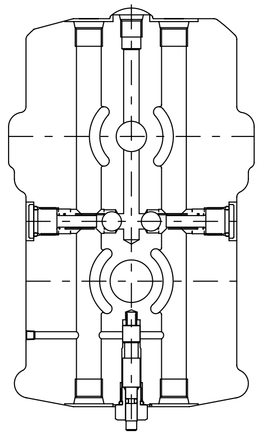
Input speed : 3000min^{-1}
Oil Temp : 50˚C
No load

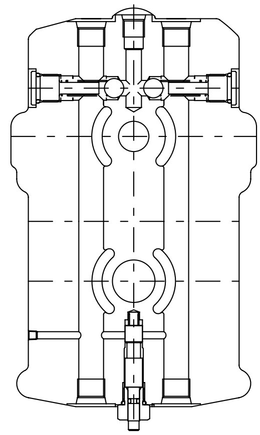
Features	Unit	BDU-10S/10L/21L/21H
		Without Orifice
Deadband of Control Shaft Angle (DB-STD)	[degree]	Approx. 0.1

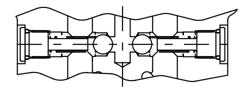
Features	Unit	BDU-10S/10L		BDU-21L		BDU-21LH	
		Orifice diameter [mm]					
		ϕ0.7	ϕ0.8	ϕ1.0	ϕ1.2	ϕ0.85	ϕ0.7 twin
Deadband of Control Shaft Angle (DB-OR)	[degree]	Approx. 0.5	Approx. 0.7	Approx. 0.5	Approx. 0.7	Approx. 0.35	Approx. 0.5

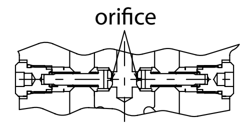
CHARGE CHECK WITH ORIFICE

BDU-10S/10L


BDU-10L Check Valve

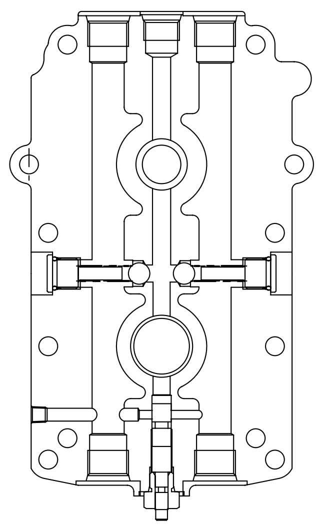

BDU-10S Check Valve

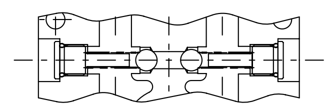

Check Valve (Ball) without orifice

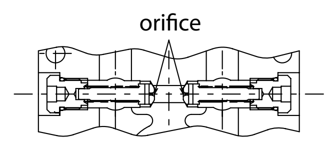


Check Valve with orifice

BDU-21L

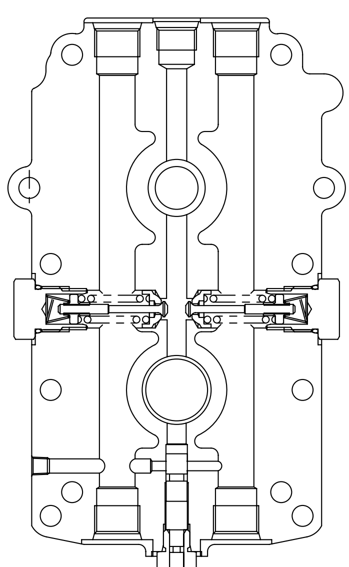


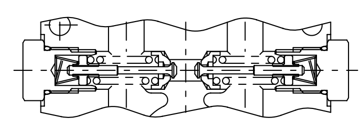

Check Valve (Ball) without orifice

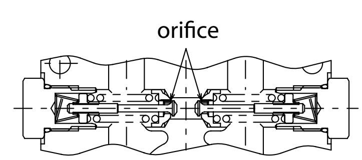


Check Valve with orifice

BDU-21H



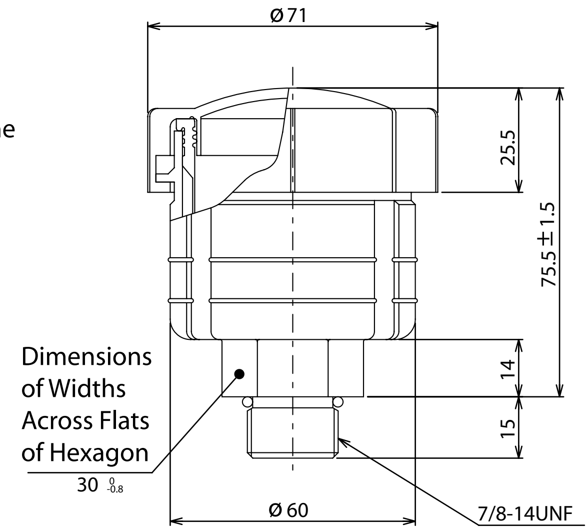

Check & Relief without orifice



Check & Relief with orifice

OPTIONAL INTEGRATED RESERVOIR

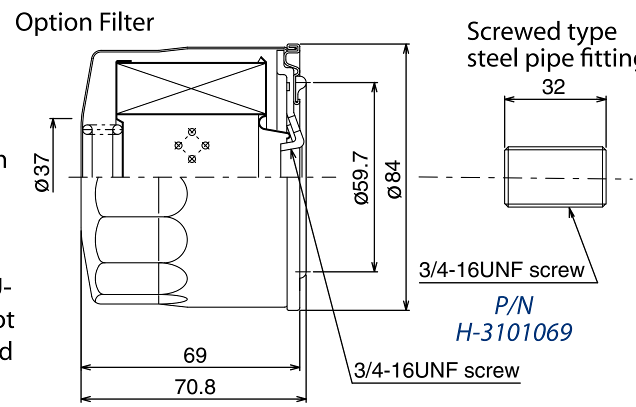
The BDU-06S and BDU-10S are designed with optional integrated reservoir. The optional Integrated reservoir is shown in the figure on the right.



P/N BDU-10S-TANK

FILTER

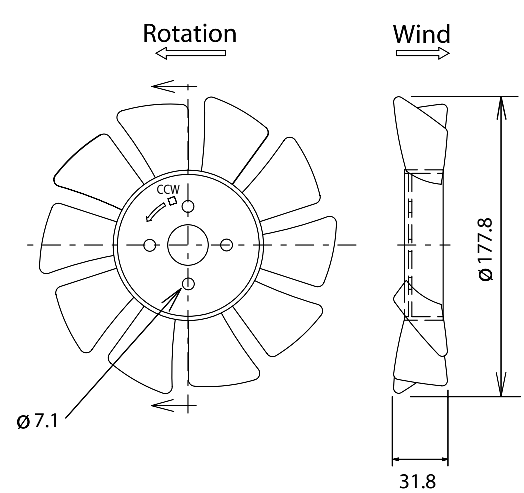
The BDU-10S is designed with Built-in filter. BDU-21L/H is designed with optional Integrated filter, which is shown in the figure on the right. The filter connection is designed with consideration given to the screwed type steel pipe fitting that is an option. An external filter is required in the charge 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 05EL-BD

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, page 43.



P/N H-1030826

Optional fan for cooling	
P/N	**Rotation**
H-1030826	CW
H-1030827E	CCW

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:

$$MTQ\_ME = \frac{PR\_ME \times VW\_ML \times LR \times 9.8}{FDR \times EFF\_FD} \quad \text{(Equation - 1)}$$

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:

$$PR\_ME = RR + GR + MF + DC \quad \text{(Equation -2)}$$

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:

$$SPR\_ME = \frac{MTQ\_ME \times 62.87}{DP \times MEF\_MO} \qquad \text{(Equation - 3)}$$

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.

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

$$MSP\_ME = \frac{VSP\_ME \times FDR \times 9.55}{LR} \qquad \text{(Equation - 4)}$$

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:

$$PW\_ME = MTQ\_ME \times MSP\_ME \times 0.000105 \,/\, OEF\_BDU \qquad \text{(Equation - 5)}$$

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:

$$MSP\_TR = \frac{VSP\_TR \times FDR \times 9.55}{LR}$$ (Equation - 6)

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

Note: 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:

$$PSP\_RIN = MSP\_TR / VEF\_BDU$$ (Equation - 7)

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.

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:

$$SPR\_AV = \sqrt[3]{\frac{((SPR\_ME)^3 \times T\_ME + (SPR\_NE)^3 \times T\_NE + (SPR\_TR)^3 \times T\_TR + ---)}{(T\_ME + T\_NE + T\_TR + ---)}}$$ (Equation - 8)

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:

$$LH = RH \times \left(\frac{SPR\_RH}{SPR\_AV} \right)^3 \times \left(\frac{3000}{PSP\_IN} \right) \qquad \text{(Equation - 9)}$$

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 Sauer-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	$mini^{-1}$	3000	3000	3000	3000	3000

BDU Master Model Code

O	Standard / Available
-	Not Available

BDU – A B C D E F G H J K

Product Type

		06S	10S	10L	21L	21H
A : Displacement						
06	6cm³	O	-	-	-	-
10	10cm³	-	O	O	-	-
21	21cm³	-	-	-	O	O

		06S	10S	10L	21L	21H
B : Design						
S	Standard	O	O	-	-	-
L	Long Life	-	-	O	O	-
H	High Pressure	-	-	-	-	O

		06S	10S	10L	21L	21H
C : Rotation						
W	Bi-directional rotation	O	O	-	-	-
R	Clockwise rotation	-	-	O	O	O
L	Counter-Clockwise rotation	-	-	O	O	O

		06S	10S	10L	21L	21H
D : Control Arm Location						
R	Right-hand side viewing from input shaft (pump located upside)	O	O	O	O	O
L	Left-hand side viewing from input shaft (pump located upside)	O	O	O	O	O

		06S	10S	10L	21L	21H
E : Output Shaft						
J13	JIS Spline 15×13×1.0	O	O	O	-	-
J14	JIS Spline 20×14×1.25	-	-	-	O	O
J18	JIS Spline 20×18×1.0	-	-	-	O	O
K18	JIS Spline 15×18×0.75		O	O	-	-
S16	SAE Spline 32/64 - 16T	O	O	O	-	-
S22	SAE Spline 32/64 - 22T	-	-	-	O	O

		06S	10S	10L	21L	21H
F : Check & Relief Valve (Left-hand side viewing from Housing)						
BB	Ball Check Valve	O	O	O	O	-
00	Poppet-type Check Valve	-	O	O	O	-
07	Check Valve w/dia = 0.7 orifice	-	O	O	-	-
08	Check Valve w/dia = 0.8 orifice	-	O	O	-	-
10	Check Valve w/dia = 1.0 orifice	-	-	-	O	-
12	Check Valve w/dia = 1.2 orifice	-	-	-	O	-
R0	Check and High Pressure Relief Valve 210 bar	-	-	-	-	O
R1	Check and High Pressure Relief Valve 175 bar	-	-	-	-	O
R2	Check and High Pressure Relief Valve 140 bar	-	-	-	-	O
RA	Check and High Pressure Relief Valve 210 bar w/dia=0.7 twin orifice	-	-	-	-	O
RB	Check and High Pressure Relief Valve 210 bar w/dia=0.85 orifice	-	-	-	-	O

BDU Master Model Code

O	Standard / Available
-	Not Available

BDU – A B C D E F G H J K

06S	10S	10L	21L	21H	G : Check & Relief Valve (Right-hand side viewing from Housing)
O	O	O	O	-	BB = Ball Check Valve
-	O	O	O	-	00 = Poppet-type Check Valve
-	O	O	-	-	07 = Check Valve w/dia=0.7 orifice
-	O	O	-	-	08 = Check Valve w/dia=0.8 orifice
-	-	-	O	-	10 = Check Valve w/dia=1.0 orifice
-	-	-	O	-	12 = Check Valve w/dia=1.2 orifice
-	-	-	-	O	R0 = Check and High Pressure Relief Valve 210 bar
-	-	-	-	O	R1 = Check and High Pressure Relief Valve 175 bar
-	-	-	-	O	R2 = Check and High Pressure Relief Valve 140 bar
-	-	-	-	O	RA = Check and High Pressure Relief Valve 210 bar w/dia=0.7 twine orifice
-	-	-	-	O	RB = Check and High Pressure Relief Valve 210 bar w/dia=0.85 orifice

06S	10S	10L	21L	21H	H : Input shaft / PTO shaft Configuration & Charge Pump Displacement
O	-	-	-	-	KAO = Straight-keyed D=15mm shaft / None & w/o Charge Pump
-	O	-	-	-	KBO = Straight-keyed D=15mm shaft / None & w/o Charge Pump
-	-	O	-	-	KB1 = Straight-keyed D=15mm shaft / None & w/1.9cm3 Charge Pump
-	-	-	O		KC1 = Straight-keyed D=17mm shaft / None & w/2.1cm3 Charge Pump
-	-	-	-	O	KC2 = Straight-keyed D=17mm shaft / None & w/3.1cm3 Charge Pump
-	O	-	-	-	PB1 = Straight-keyed D=15mm shaft /Straight 12.7 mm shaft & w/o Charge Pump
-	O	-	-	-	PB2 = Straight-keyed D=15mm shaft /JIS Serration 12x23x0.5 shaft & w/o Charge Pump
-	-	O	-	-	PB3 = Straigt-keyed D=15mm shaft /Straight 12.6 mm shaft & w/2.4cm3 Charge Pump
-	-	O	-	-	PB4 = Straight-keyed D=15mm shaft /JIS Serration 12x23x0.5 shaft & w/2.4cm3 Charge Pump
-	-	-	O	-	PC1 = Straight-keyed D=17mm shaft /JIS Spline 15x13x1.0 shaft & w/2.1cm3 Charge Pump
-	-	-	-	O	PC2 = Straight-keyed D=17mm shaft /JIS Spline 15x13x1.0 shaft & w/3.1cm3 Charge Pump
-	-	-	O	-	PC5 = Straight-Keyed D=17mm shaft /SAE Spline 32/64 -16T & w/2.1cm3 Charge Pump
-	-	-	-	O	PC6 = Straight-Keyed D=17mm shaft /SAE Spline 32/64 -16T & w/3.1cm3 Charge Pump

06S	10S	10L	21L	21H	J : Bypass & Nuetral Valve
O	-	-	-	-	N = None
-	-	-	O	O	A = w/Nuetral Valve Pressure 35 bar w/dia=1.0 orifice
O	O	O	O	O	B = w/Bypass Valve

06S	10S	10L	21L	21H	K : Special Hardware
O	O	O	O	O	NNN = None
O	O	-	-	-	WOL = Oil-filled in case

BDP Master Model Code

O	Standard / Available
-	Not Available

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

Product Type 10L	
	A : Displacement
O	10 = 10cm³

10L	
	B : Design
O	L = Long Life

10L	
	C : Rotation
O	R = Clockwise rotation
O	L = Counter-Clockwise rotation

10L	
	D : Control Arm Location
O	R = Right-hand side viewing from input shaft (main port located upside)

10L	
	E : Output Shaft
O	N = None

10L	
	F : Check & Relief Valve (Left-hand side viewing from Housing)
O	BB = Ball Check Valve
O	00 = Poppet-type Check Valve
O	07 = Check Valve w/dia=0.7 orifice
O	08 = Check Valve w/dia=0.8 orifice

10L	
	G : Check & Relief Valve (Right-hand side viewing from Housing)
O	BB = Ball Check Valve
O	00 = Poppet-type Check Valve
O	07 = Check Valve w/dia=0.7 orifice
O	08 = Check Valve w/dia=0.8 orifice

10L	
	H : Input / PTO shaft Configuration & Charge Pump Displacement
O	KB1 = Straight 15mm shaft/None & w/1.9cm³ Charge Pump

10L	
	J : Bypass Valve
O	B = w/Bypass Valve
O	C = w/Bypass Valve w/orifice dia=0.5

10L	
	K : Special Hardware
O	NNN= None

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, 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.
Note: 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.

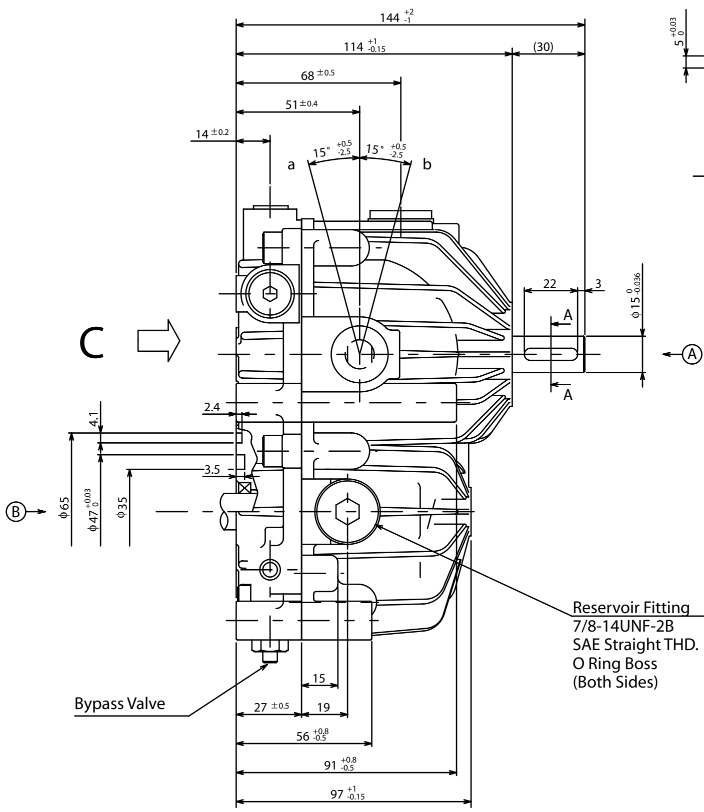
OPERATION

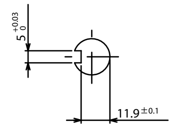
Check all joints and connections for leaks, and check that the oil tank or reservoir level is proper at the time of first operation and every day. Start the prime mover turning in the neutral position of the control shaft of the BDU transmission.

MAINTENANCE

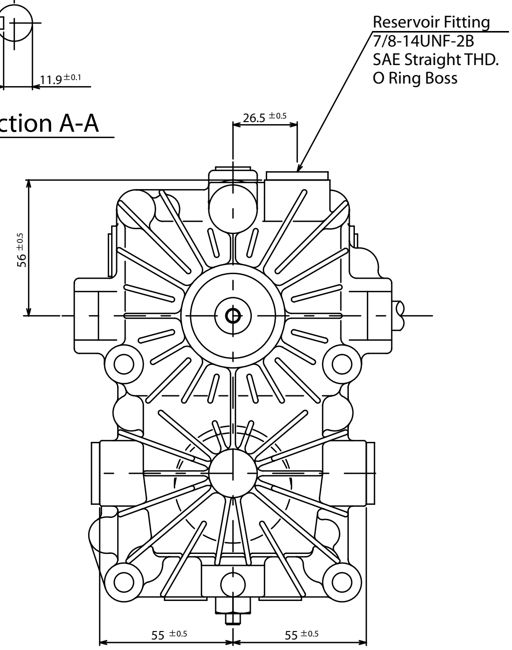
If some water, dust or grease are mixed in, with the transmission oil, change to new recommended oil. Always keep at less than 0.1 % water in the transmission oil.
It is recommended to change oil and filter every year or at the every 500 operating hours.

BDU-06S

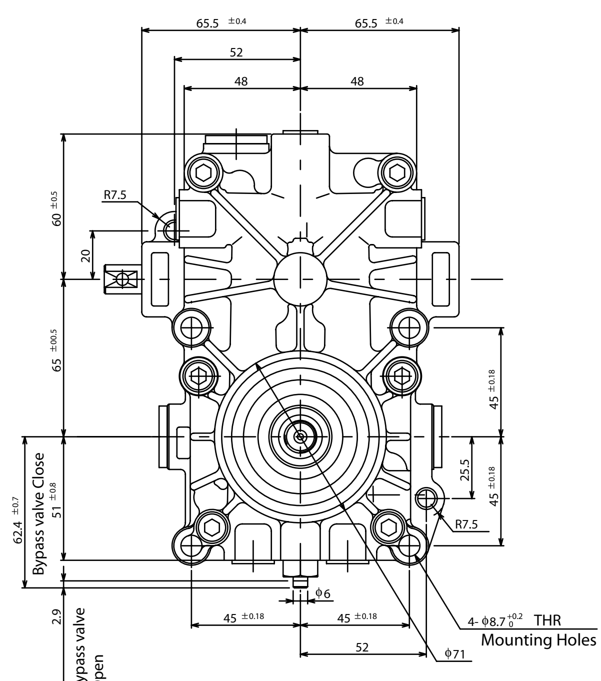




Section A-A



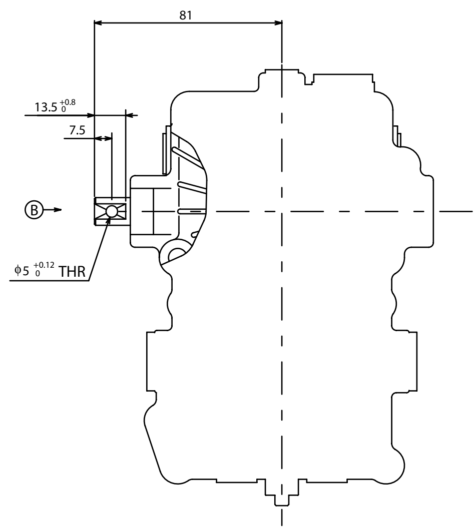
Option Code	R		L	
Input Rotation as Seen From Ⓐ Direction	CW		CCW	
Control Shaft Rotation	a	b	a	b
Output Rotation as Seen From Ⓑ Direction	CCW	CW	CW	CCW



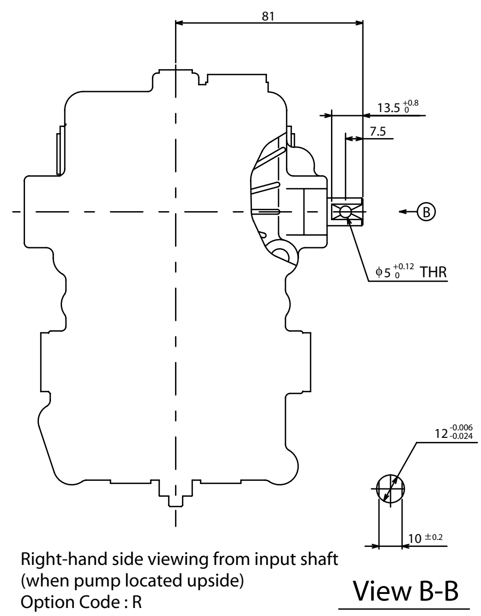
View C

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

BDU-06S

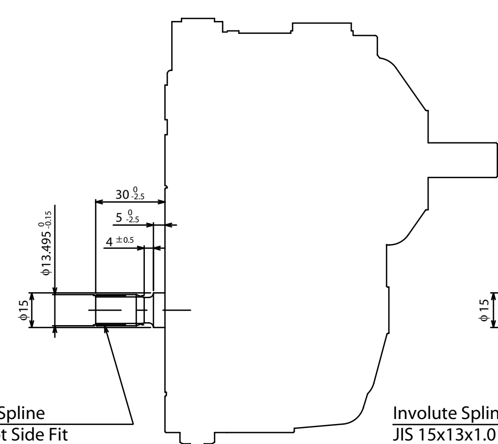


Left-hand side viewing from input shaft
(when pump located upside)
Option Code : L

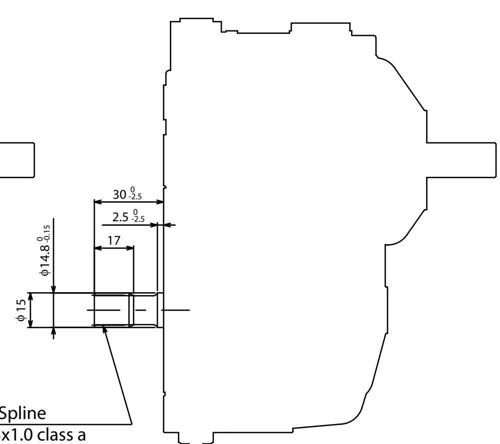


Right-hand side viewing from input shaft
(when pump located upside)
Option Code : R

Control Arm Location



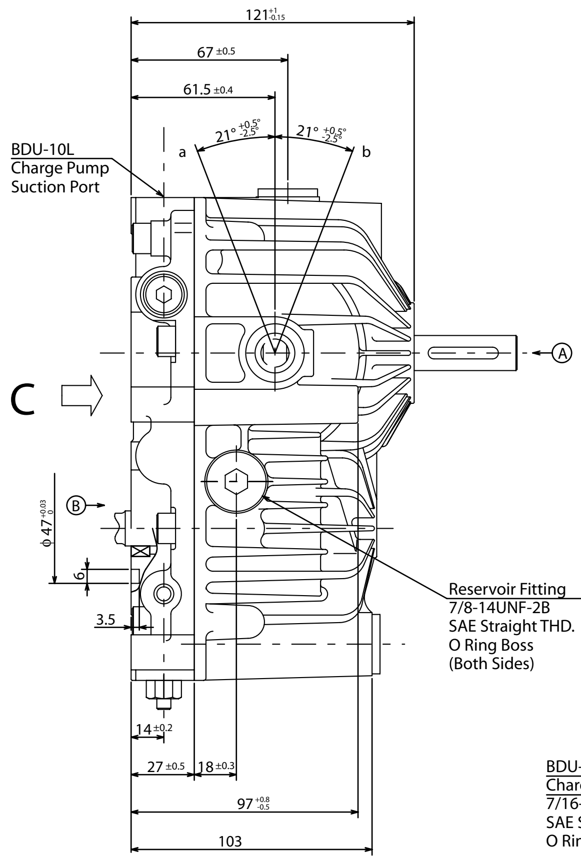
Involute Spline
Fillet Root Side Fit
SAE 1963 class 1
Pitch Diameter = ϕ12.7
Pressure Angle = 30°
Number of Teeth = 16
Spline Pitch = 32/64

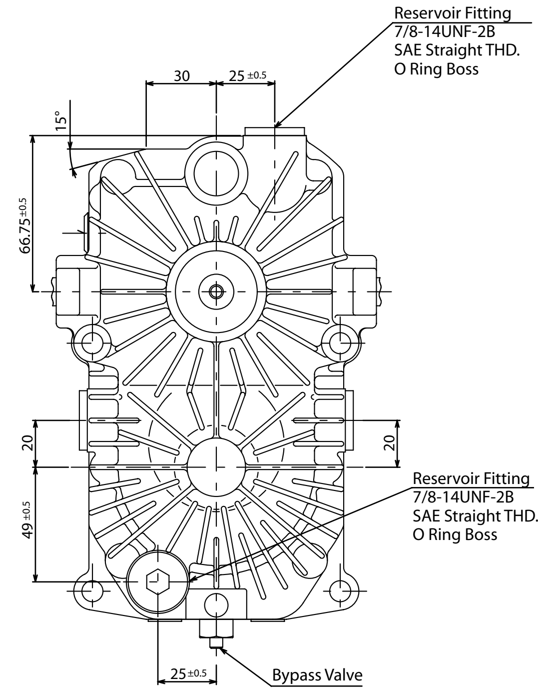


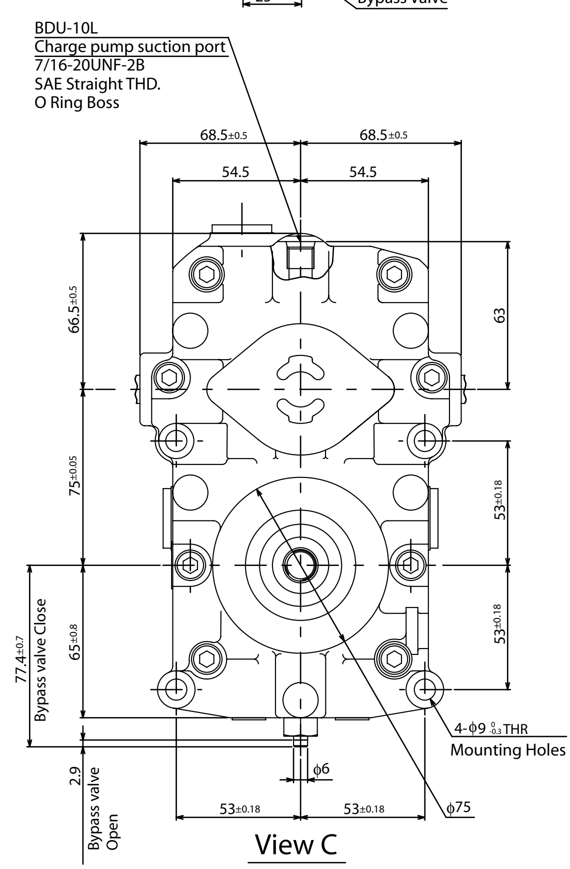
Involute Spline
JIS 15x13x1.0 class a
Tooth Profile Short Teeth
Module = 1.0
Pressure Angle = 20 °
Number of Teeth = 13
Pitch Diameter = ϕ13.0
Addendum Modification
Coefficient = 0.8

Motor Shaft

BDU-10S
BDU-10L



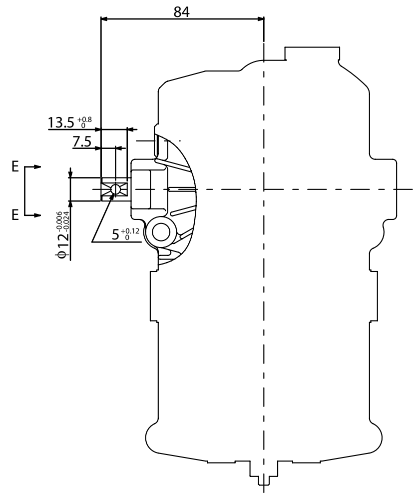




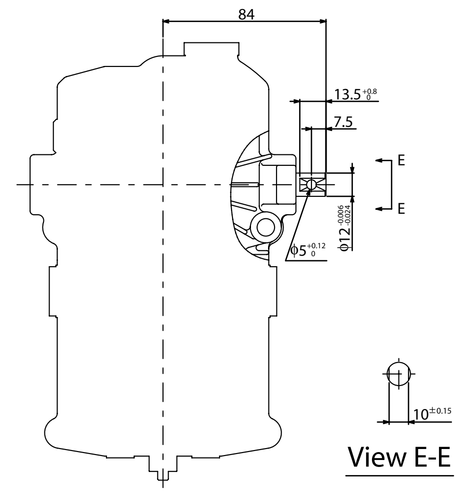
Option Code	R		L	
Input Rotation as Seen From Ⓐ Direction	CW		CCW	
Control Shaft Rotation	a	b	a	b
Output Rotation as Seen From Ⓑ Direction	CW	CCW	CCW	CW

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

BDU-10S
BDU-10L
Continued

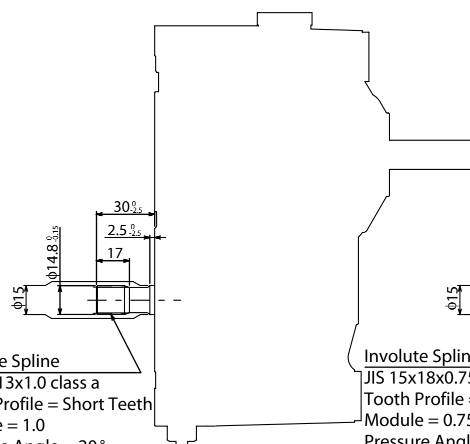


Left-hand side viewing from input shaft
(when pump located upside)
Option Code : L



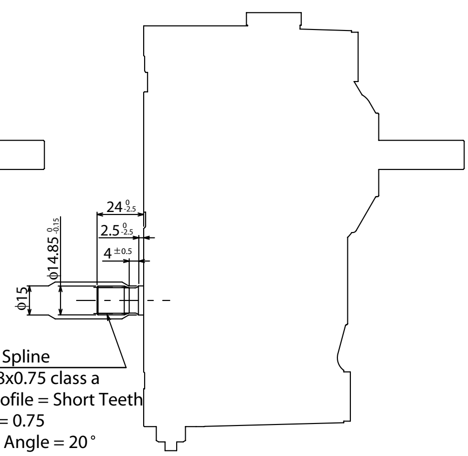
Right-hand side viewing from input shaft
(when pump located upside)
Option Code : R

Control Arm Location



Involute Spline
JIS 15x13x1.0 class a
Tooth Profile = Short Teeth
Module = 1.0
Pressure Angle = 20°
Number of Teeth = 13
Pitch Diameter = ϕ13.0
Addendum Modification
Coefficient = 0.8

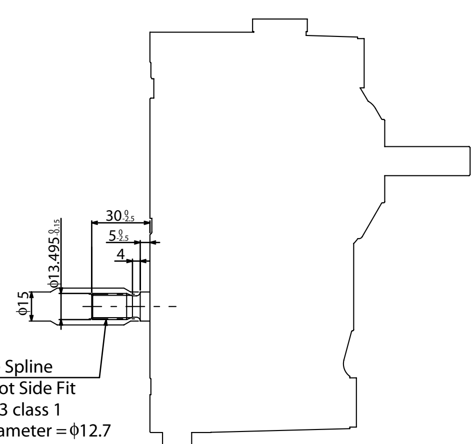
Shaft : JIS 15x13x1.0
Option Code : J13



Involute Spline
JIS 15x18x0.75 class a
Tooth Profile = Short Teeth
Module = 0.75
Pressure Angle = 20°
Number of Teeth = 18
Pitch Diameter = ϕ13.5
Addendum Modification
Coefficient = 0.5

Shaft : JIS 15x18x0.75
Option Code : K18

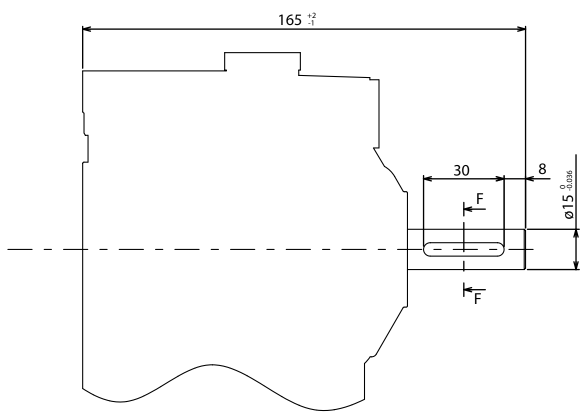
Motor Shaft



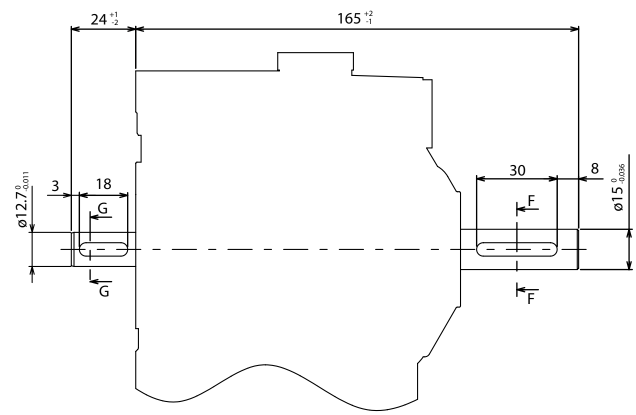
Involute Spline
Fillet Root Side Fit
SAE 1963 class 1
Pitch Diameter = ϕ12.7
Pressure Angle = 30°
Number of Teeth = 16
Spline Pitch = 32/64

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

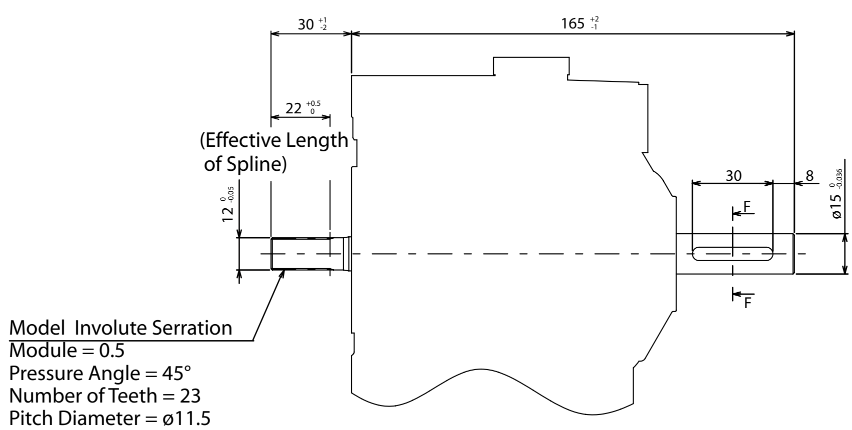
BDU-10S
Continued



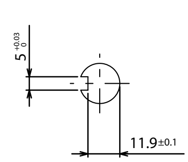
Pump Shaft : 15mm Straight Keyed
PTO Shaft : None
Charge Pump : None
Option Code : KB0



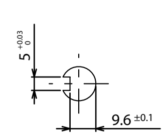
Pump Shaft : 15mm Straight Keyed
PTO Shaft : 12.7mm Straight Keyed
Charge Pump : None
Option Code : PB1



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



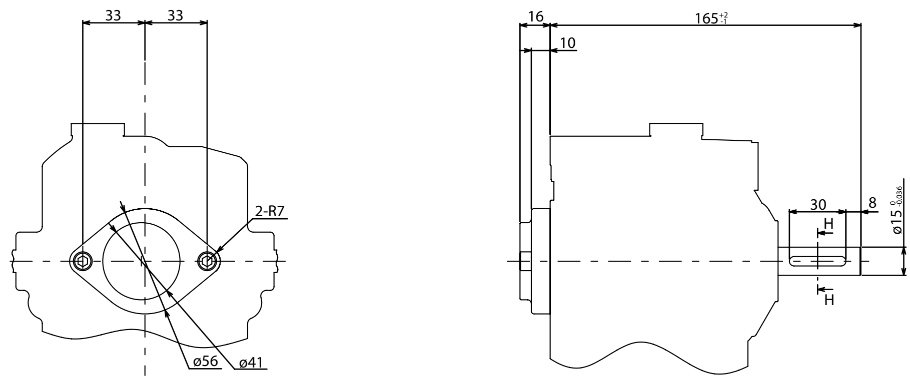
Section F-F



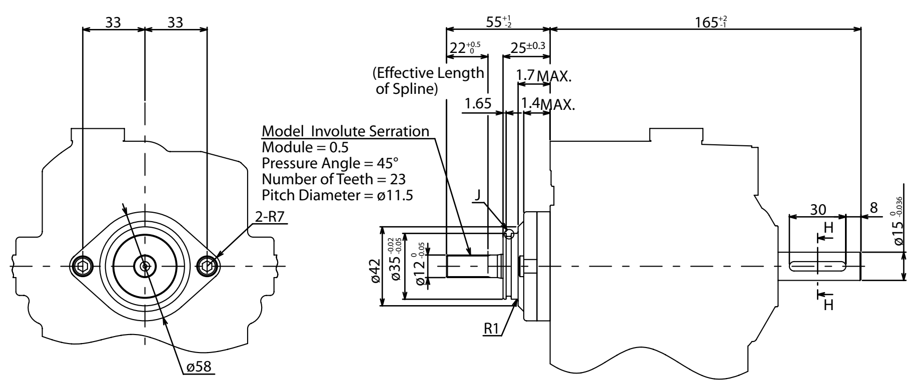
Section G-G

Shaft Configuration for 10S

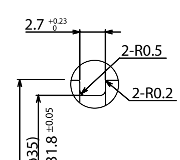
BDU-10L
Continued



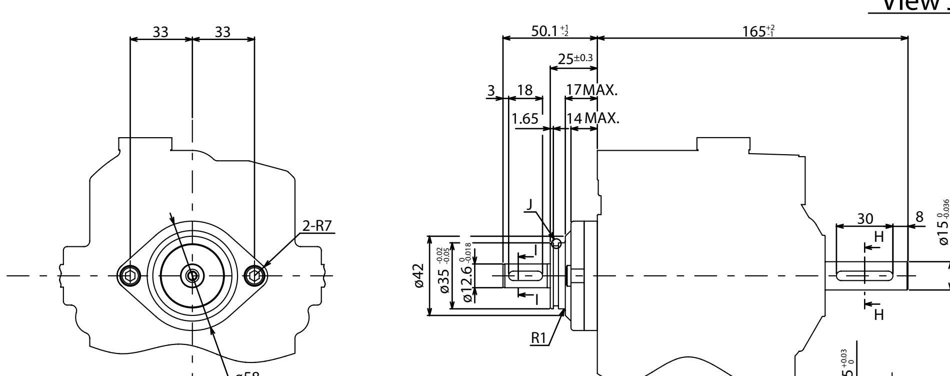
Pump Shaft : 15mm Straight Keyed
PTO Shaft : None
Charge Pump : 1.9cc/rev
Option Code : KB1

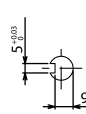


Pump Shaft : 15mm Straight Keyed
PTO Shaft : Serration 12x23x0.5
Charge Pump : 2.4cc/rev
Option Code : PB4



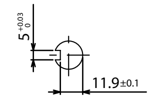
View J





Section I-I

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



Section H-H

Shaft Configuration & Charge Pump Displacement for 10L

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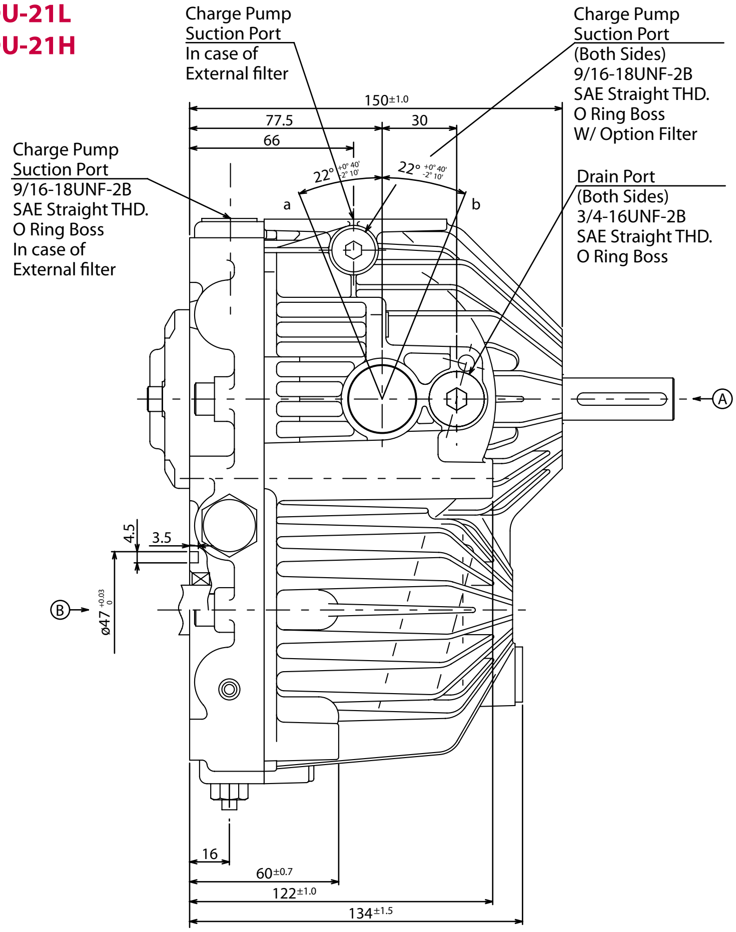
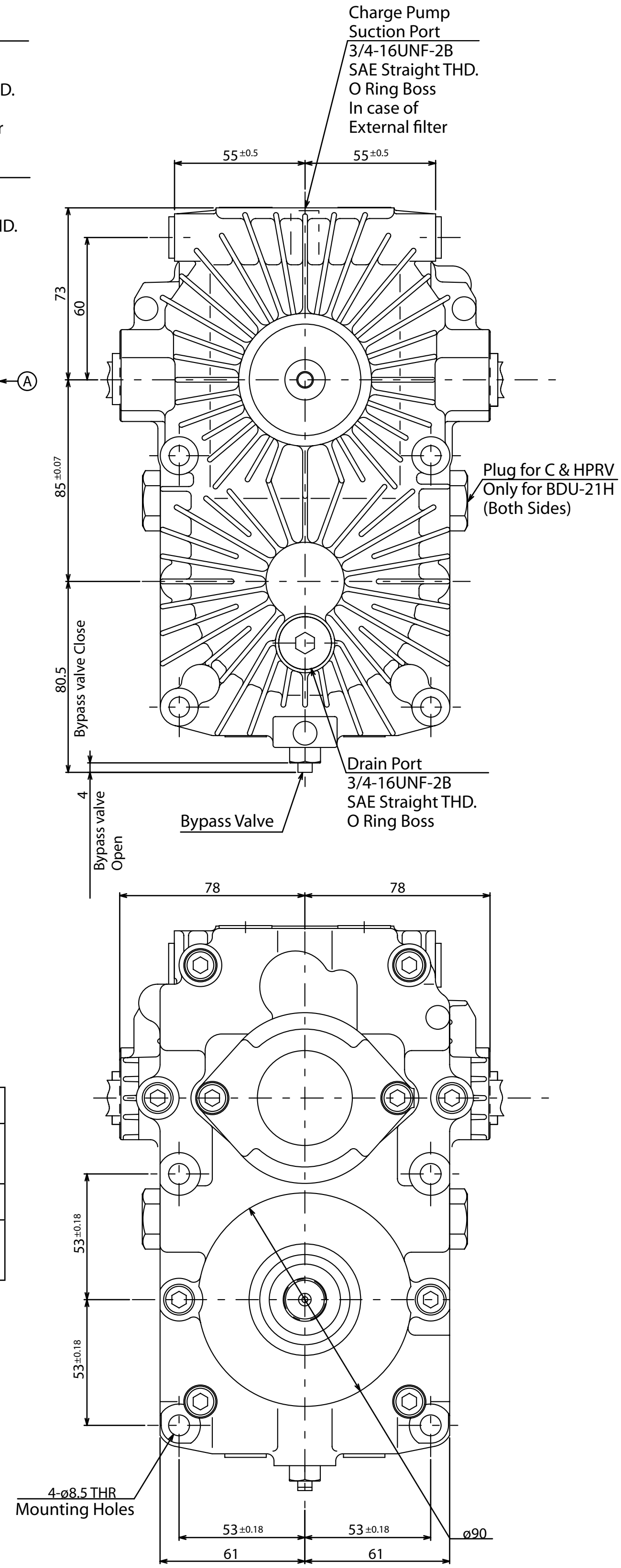
BDU-21L
BDU-21H

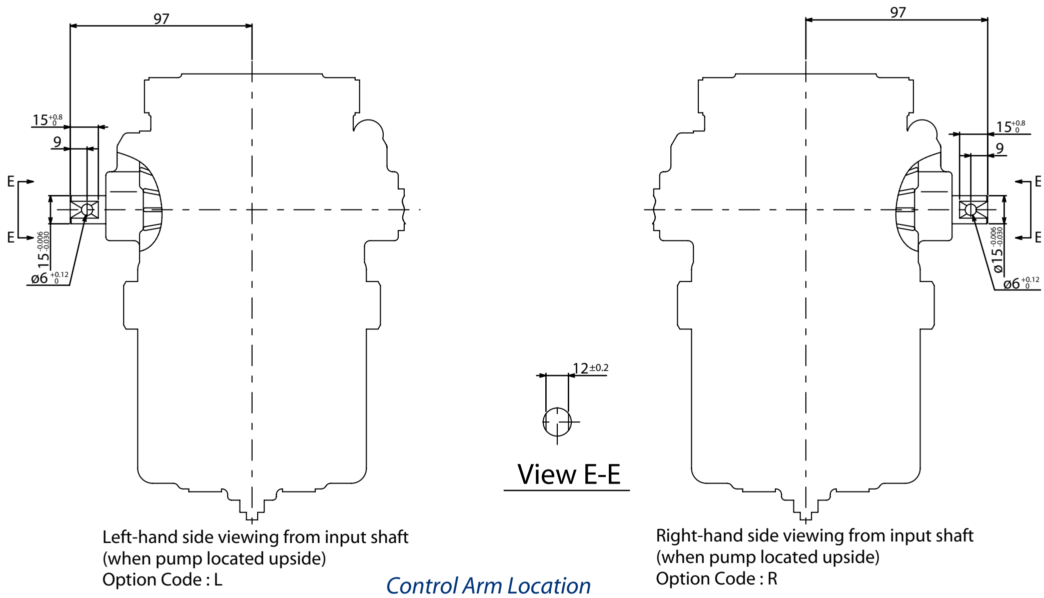




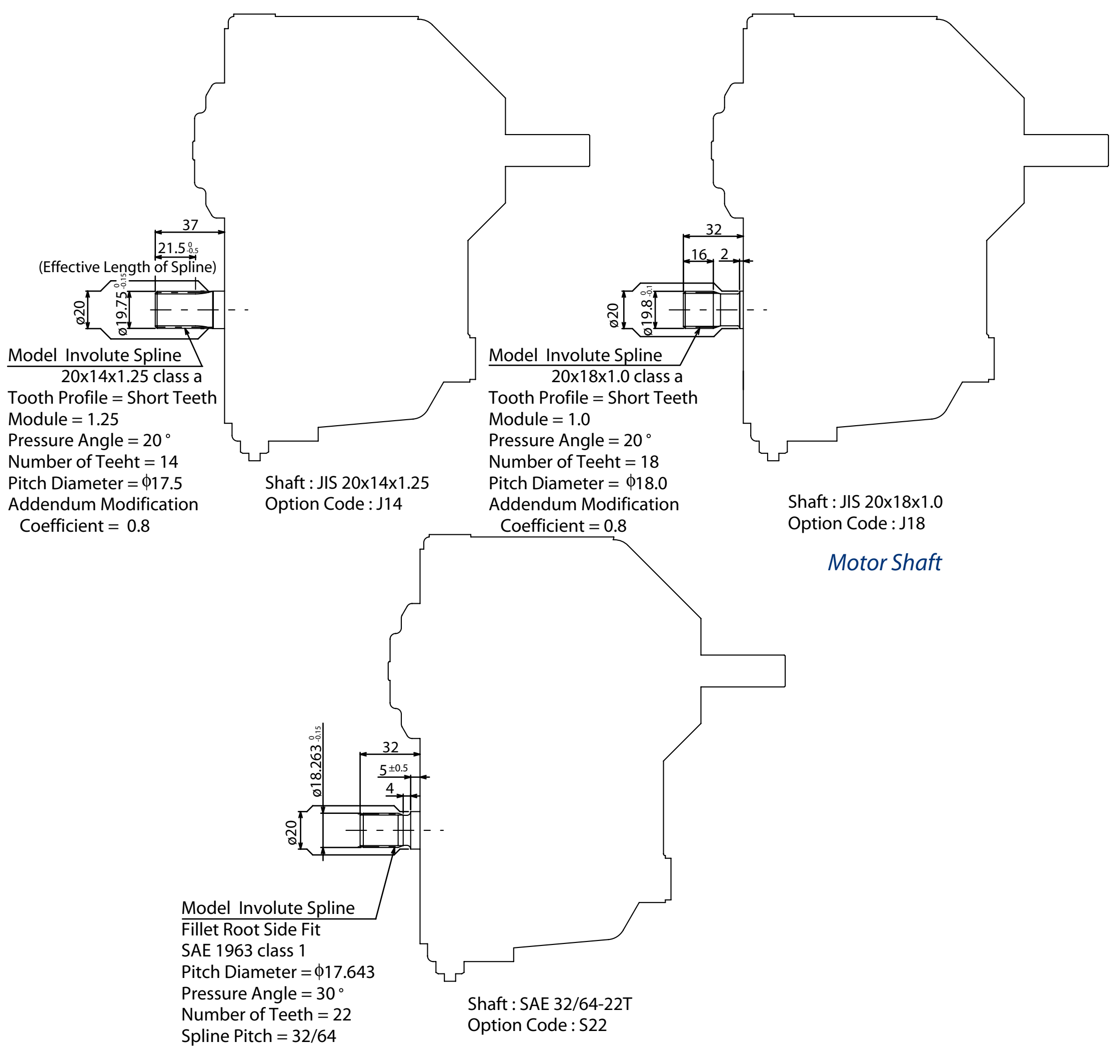
Option Code	R		L	
Input Rotation as Seen From Ⓐ Direction	CW		CCW	
Control Shaft Rotation	a	b	a	b
Output Rotation as Seen From Ⓑ Direction	CCW	CW	CW	CCW

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

BDU-21L
BDU-21H
Continued

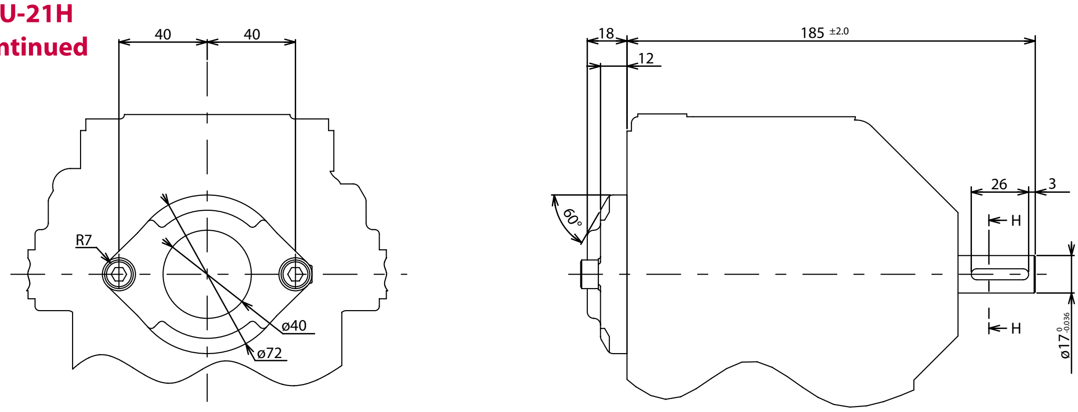


Control Arm Location

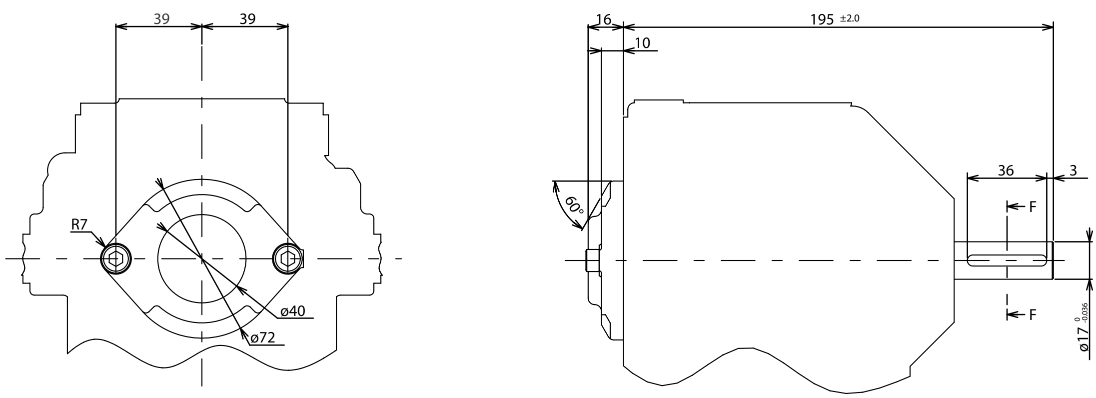


Motor Shaft

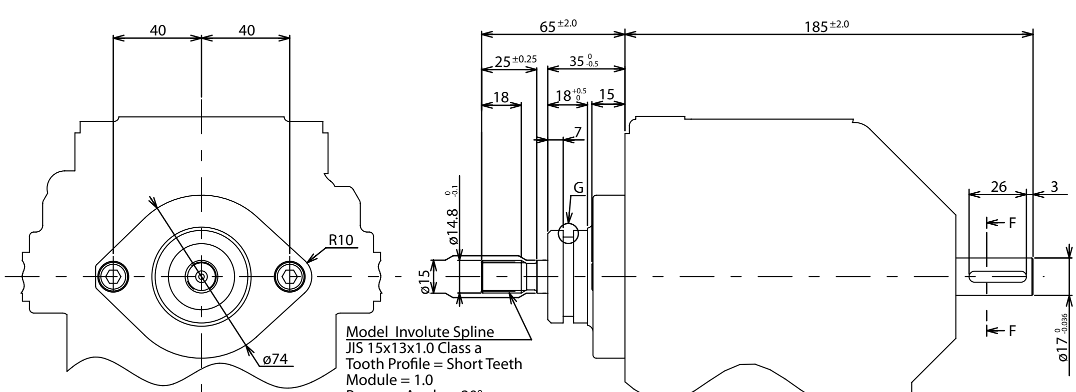
BDU-21L
BDU-21H
Continued



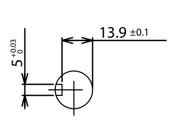
Pump Shaft : 17mm Straight Keyed (Key Length 36mm)
PTO Shaft : None
Charge Pump : 3.1cc/rev (for 21H)
Option Code : KC2



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

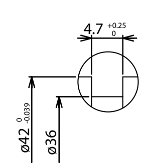


Model Involute Spline
JIS 15x13x1.0 Class a
Tooth Profile = Short Teeth
Module = 1.0
Pressure Angle = 20°
Number of Teeth = 13
Pitch Diameter = ø13.0
Addendum Modification
Coefficient = 0.8



Section F-F

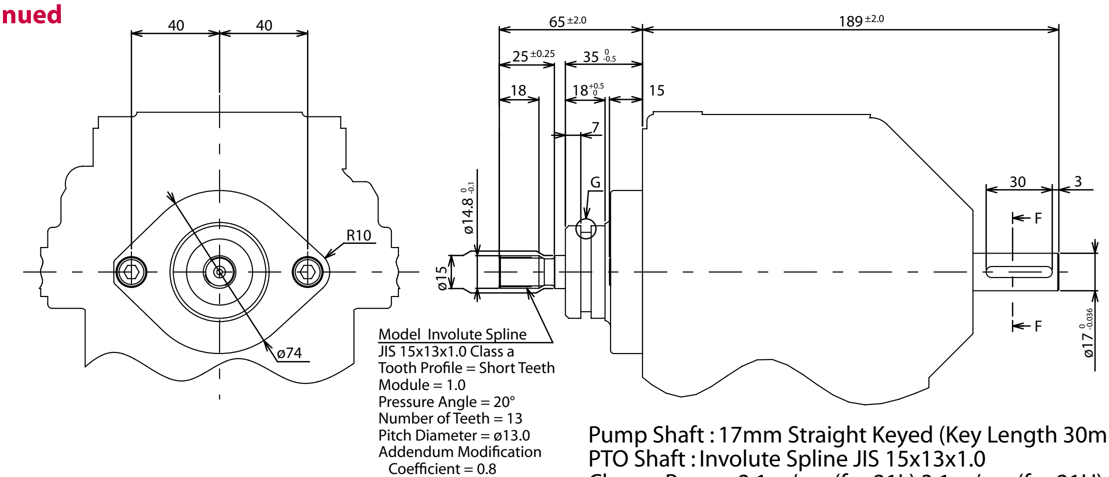
Pump Shaft : 17mm Straight Keyed (Key Length 26mm)
PTO Shaft : Involute Spline JIS 15x13x1.0
Charge Pump : 2.1cc/rev (for 21L) 3.1cc/rev (for 21H)
Option Code : PC1(2.1cc/rev)   PC2(3.1cc/rev)



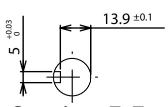
View G-G

Shaft Configuration & Charge Pump Displacement for 21L & 21H

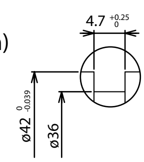
BDU-21L
BDU-21H
Continued



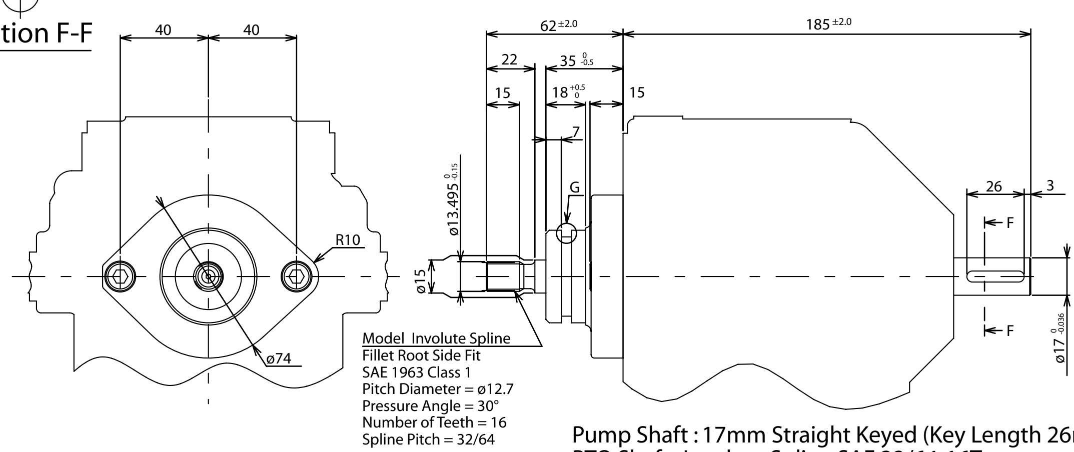
Pump Shaft : 17mm Straight Keyed (Key Length 30mm)
PTO Shaft : Involute Spline JIS 15x13x1.0
Charge Pump : 2.1cc/rev (for 21L) 3.1cc/rev (for 21H)
Option Code : PC3(2.1cc/rev) PC4(3.1cc/rev)



Section F-F



View G-G

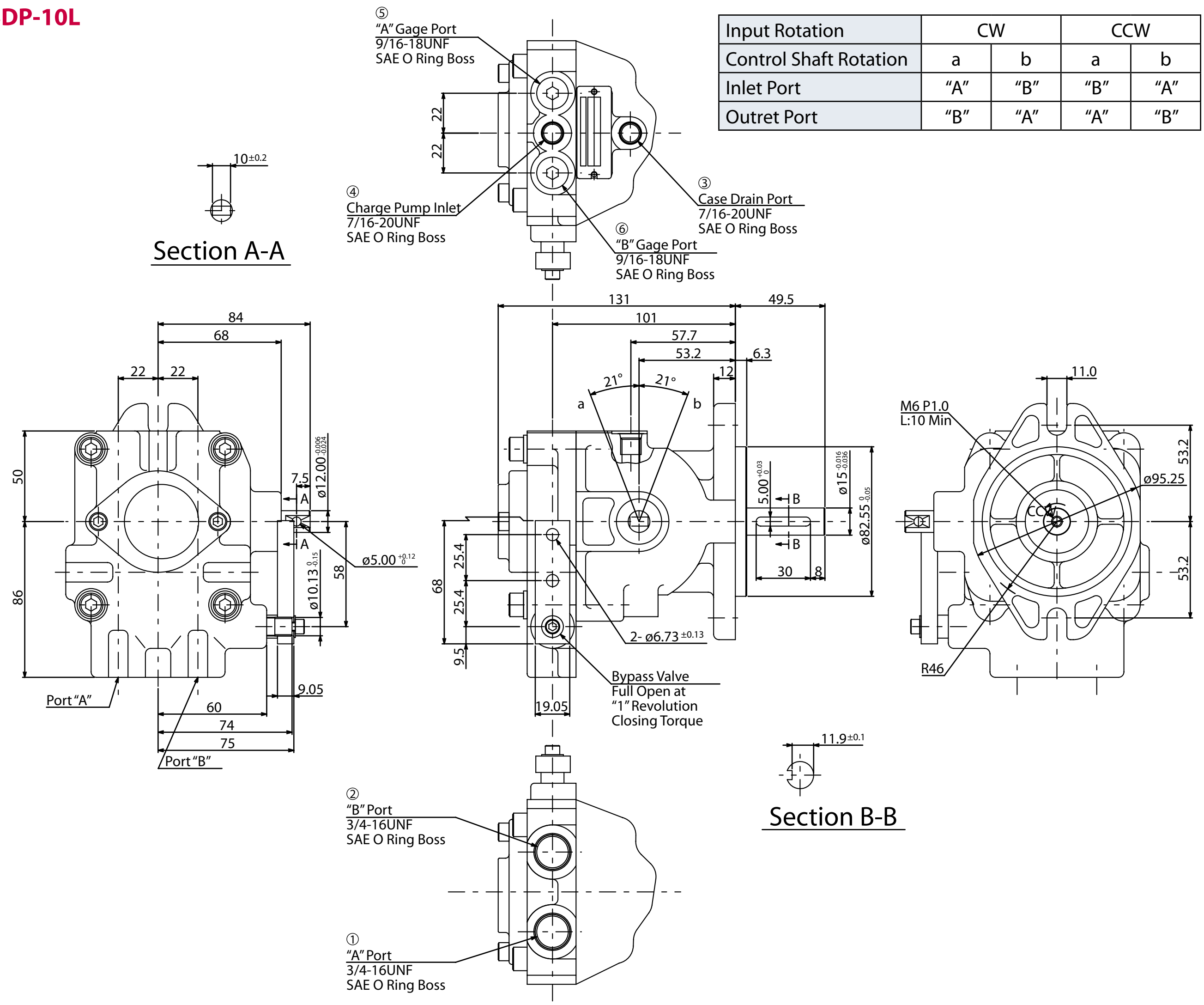


Pump Shaft : 17mm Straight Keyed (Key Length 26mm)
PTO Shaft : Involute Spline SAE 32/64-16T
Charge Pump : 2.1cc/rev (for 21L) 3.1cc/rev (for 21H)
Option Code : PC5(2.1cc/rev) PC6(3.1cc/rev)

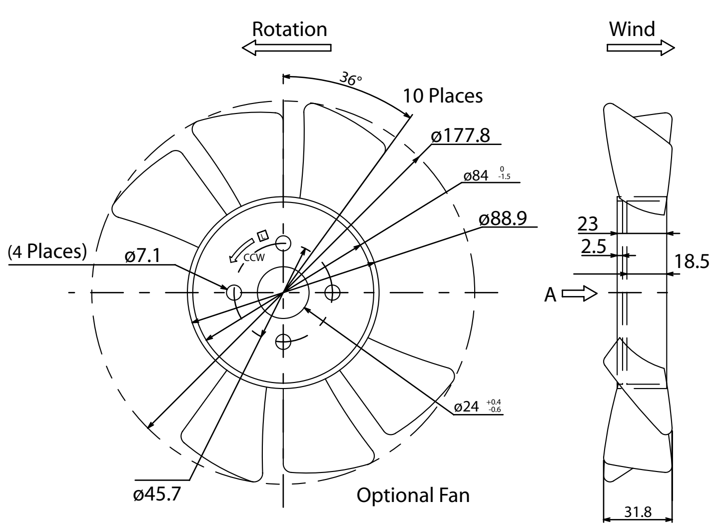
Shaft Configuration & Charge Pump Displacement for 21L & 21H

BDP-10L

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



Optional Fan



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